OVERALL: SPECIFIC AIMS

We live in a transformative time for clinical and translational science, with a convergence of patient-centeredness, digital health, and computational power that is revolutionary in scope and impact. The University of California, San Francisco Clinical and Translational Science Institute (UCSF CTSI) has a long tradition and strong track record of providing infrastructure to accelerate clinical and translational research. UCSF CTSI now proposes a comprehensive plan for advancing this infrastructure based on the current landscape of clinical and translational research nationally and at UCSF, with a focus on creating a transdisciplinary community that fully leverages this unique moment in science for the betterment of health.

In this renewal application, UCSF CTSI presents seven overall Specific Aims organized around the seven core themes of the CTSA network: **methods and processes, collaboration and engagement, informatics, integration across the lifespan, workforce development, integration of health care and research,** and **workforce heterogeneity.** Each Aim proposes to develop, demonstrate, and disseminate high-impact, innovative ideas that address specific requirements of the CTSA Funding Opportunity Announcement (FOA) and position CTSI for continued success.

Overall Aim 1. CTSA Theme: Methods and processes

Focus: solutions to roadblocks that currently limit the efficiency and effectiveness of clinical and translational research.

Overall Aim 2. CTSA Theme: Collaboration and engagement

Focus: principles and practices of engagement with stakeholders that make research translation maximally efficient, focused, and relevant.

Overall Aim 3. CTSA Theme: Informatics

Focus: informatics and information technology-based innovations that accelerate the science and operations of clinical and translational research.

Overall Aim 4. CTSA Theme: Integration across the lifespan

Focus: scientific insights and operational processes to ensure scientific advances are realized in all populations.

Overall Aim 5. CTSA Theme: Workforce development

Focus: innovations in the process and culture of workforce development to create and sustain a robust clinical and translational research workforce.

Overall Aim 6. CTSA Theme: Integration of health care and research

Focus: synergy and early engagement with the health care delivery system to improve dissemination of research advances into clinical care and prioritize clinical and translational research problems identified in the health care delivery context.

Overall Aim 7. CTSA Theme: Workforce heterogeneity

Focus: development and maintenance of a diverse, equitable, and inclusive workforce from varied professional, cultural, gender, ethnic, racial, and underrepresented minority backgrounds.

Impact: Since the first round of funding in 2006, UCSF CTSI has been a national leader in transforming the clinical and translational research community through the development, demonstration, and dissemination of innovative tools and resources (ctsi.ucsf.edu). In the current grant cycle, UCSF CTSI has achieved high-impact success across the CTSA network's core themes. Examples include a patient-facing clinical trials search platform generating direct-to-investigator queries from over 6,500 interested patients this calendar year; a successful collaboration with San Francisco community stakeholders to translate evidence on the harmful effects of sugary beverages into a voter-approved soda tax; an EHR-enabled research informatics and technical support program facilitating over 3,500 research requests this cycle; 29 pilot awards supporting special populations research resulting in over $25 million in follow-on funding; and 20 K-supported early career faculty with a KL2-to-individual-K success rate of 45% and growing.

UCSF CTSI is well-positioned and fully committed to leading UCSF and the larger clinical and translational science community into this exciting future. In the following pages, each Aim presents theme-focused accomplishments and strategic goals for the next five years, with reference to the Core sections and Aims in which the methods are described in more detail. We believe this approach best demonstrates how UCSF CTSI is achieving its vision of "accelerating research to improve health".

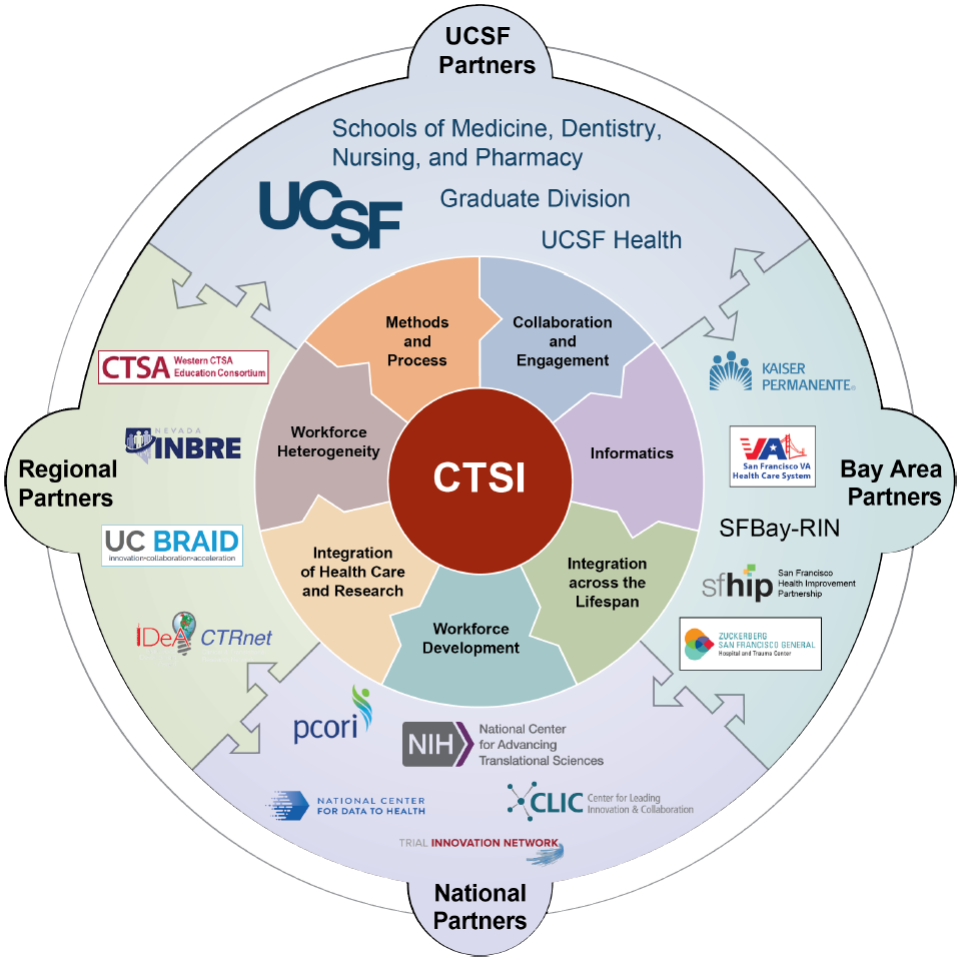
OVERALL: RESEARCH STRATEGY

VISION AND STRATEGIC GOALS

University of California San Francisco's Clinical and Translational Science Institute (UCSF CTSI)

UCSF CTSI's mission is to accelerate research to improve health by creating a clinical and translational science environment that fosters collaboration and is committed to the core themes of the CTSA network (**Overall Figure 1**). UCSF CTSI has been a national leader in this effort since the beginning of the CTSA network in 2006. Over the last 14 years, UCSF CTSI has partnered with the CTSA network and a diverse group of stakeholders to develop, demonstrate, and disseminate innovative methods and technologies that improve efficiency and quality across the clinical and translational research spectrum. The impact of UCSF CTSI on the local, regional, state, and national community has been profound. (See **Letters of Support from cross-institute stakeholders in Overall section; core-specific letters are listed by core.)**

UCSF CTSI's vision is to "accelerate research to improve health". We are committed to training and sustaining the next generation of clinical and translational scientists. This is a transformative time in science and medicine, with a convergence of patient-centeredness, digital health, and computational power that is unprecedented. With this renewal, UCSF CTSI is positioning itself to help lead the CTSA community into this exciting future, and in the following pages of the Overall section, we describe the strategic goals and Aims that will assure this success.



Overall Figure 1. UCSF's Clinical and Translational Science Institute (CTSI): Accelerating research to improve health through collaboration and a commitment to the core themes of the CTSA network.

UCSF CTSI's overarching strategic goals

UCSF CTSI undertook a yearlong strategic planning process in preparation for this renewal, engaging staff and faculty, institutional leadership, and external stakeholders to refine its plan for accelerating research to improve health. This process identified the following overarching strategic goals:

- Renewing UCSF CTSI's commitment to integrating the CTSA network's seven core themes into all activities: methods and processes, collaboration and engagement, informatics, integration across the lifespan, workforce development, integration of health care and research, and workforce heterogeneity
- Increasing UCSF CTSI's leadership in the Trial Innovation Network (TIN), National Center for Data to Health (CD2H), Common Metrics and other network-wide initiatives (e.g., SMART IRB, master contracts) to develop, demonstrate, and disseminate innovations across the network
- Enabling the revolution in science and medicine brought on by the unprecedented convergence of patient-centeredness, digital health, and computational power
- Expanding UCSF CTSI's efforts to develop, demonstrate, and disseminate innovation and excellence in workforce development and workforce heterogeneity across the clinical and translational research spectrum

- Building on institutional expertise in translating research findings into health care policy and clinical practice to create a new UCSF CTSI Core designed to move evidence beyond clinical practice to policy innovations

UCSF CTSI's significance and impact

UCSF CTSI provides critical leadership and resources to the UCSF clinical and translational research community that are highly impactful (**Overall Table 1 below**). UCSF has a combined 3,300 faculty members across its four top-ranked professional schools (Dentistry, Medicine, Nursing, and Pharmacy) and graduate programs and has a combined total of nearly $650 million in NIH funding, making it the second-ranked recipient of NIH funding nationwide. UCSF's primary health system partner, UCSF Health, is consistently ranked one of the top ten health systems in the country, and along with San Francisco's county health system and the Veteran's Administration health system, it provides UCSF CTSI with outstanding partnership for health care innovation and impact (see **Letters of Support from UCSF executive leadership, UCSF Health, Zuckerberg San Francisco General, and San Francisco Veteran's Administration** in Overall section**)**.

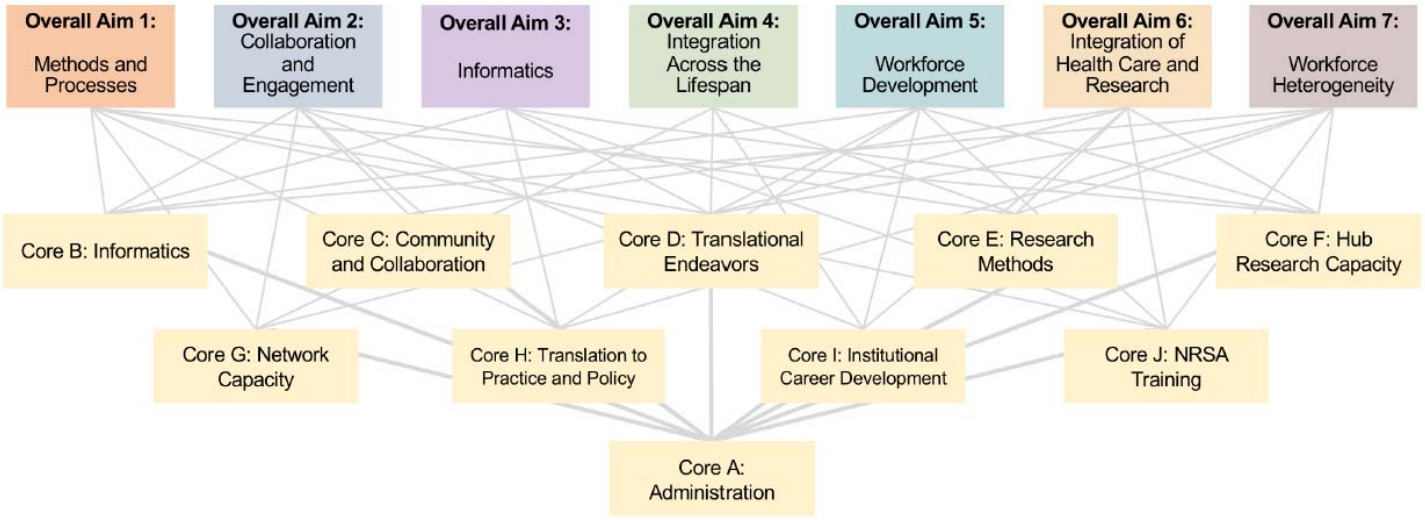
As a large and established CTSA Hub, UCSF CTSI provides important resources and opportunities to smaller and newer Hubs in support of the CTSA network's mission. In 2010, UCSF CTSI organized with the other four University of California CTSA Hubs (Davis, Irvine, Los Angeles, and San Diego) to form the University of California Biomedical Research, Acceleration, Integration, and Development (UC BRAID) consortium with the express goal of cross-institutional collaboration, resource-sharing, and governance in support of clinical and translational research. Leveraging the tremendous power of the University of California system, UC BRAID has successfully built network-wide resources for supporting innovation in drug and device development, EHR data searches, access, and governance for researchers, central regulatory review of clinical research protocols, and clinical trial participant recruitment. UC BRAID exemplifies UCSF CTSI's ongoing commitment to active participation in and stewardship of CTSA network-wide collaboratives like the TIN and CD2H (see **Letter of Support from UC BRAID** in Overall section).

Overall Table 1. Select Areas of Impact in the Last 5 Years (additional impact listed in Cores A-J)

CTSA theme	Impact
Methods and processes	• 1,595 unique consultations provided in biostatistics, epidemiology, and study design • 668 trials supported by UCSF CTSI's Participant and Clinical Interactions Core • 26 TIN studies supported through UCSF CTSI's Hub Liaison Team • 1,269 CTSI-linked research publications during this grant cycle
Community and collaboration	• Development of UCSF's Center for Community Engagement and establishment of UCSF as an anchor institution for San Francisco • 8.1 million visits to UCSF CTSI's Profiles (primary UCSF resource for networking), and expansion of Profiles across all five UC CTSA institutions
Informatics	• Self-service access to deidentified EHR data, high-performance computational infrastructure, and data visualization tools provided to over 3,500 researchers • Informatics support to 74 projects requiring EHR system modification
Integration across the lifespan	• 29 pilot awards (67%) involved special populations, enabling 38 subsequent grant awards and ~$25 million in follow-on funding
Workforce development	• 20 UCSF CTSI KL2 awardees supported, with 45% successfully transitioned to individual K awards and an additional 40% in process • Development of implementation science curriculum and institutional K award
Integration of health care and research	• Implemented UCSF Clinical Trial Management System supporting 1,002 clinical trials • 75 unique EHR-enabled direct-to-participant recruitment plans for clinical trials
Workforce heterogeneity	• 47 undergraduate trainees supported by UCSF CTSI (66% women, 83% underrepresented minority (URM) • UCSF CTSI co-development of UCSF-wide NIH diversity supplement program (143% increase in awards received by UCSF)

Overall section structure

In the following pages of this Overall section, seven Aims are presented that summarize UCSF CTSI's (referred to in the core sections simply as "CTSI") plans for the renewal. Each is organized around one of the seven CTSA network's themes. Within each Aim, we present thematically-engaged accomplishments and new activities, pulling from the Core components (Cores A-J) and, where appropriate, citing the Core Aim(s) in which relevant methods are described in more detail. The intent of this approach is to demonstrate how the seven CTSA themes drive synergies and collaboration across the institute (**Overall Figure 2**).



Overall Figure 2. The seven CTSA network themes serve as an organizing principle in UCSF CTSI's renewal application, driving synergy and collaboration across Cores.

OVERALL AIM 1. CTSA THEME: Methods and Processes

Focus: solutions to roadblocks that currently limit the efficiency and effectiveness of clinical and translational research.

The **Methods and Processes** theme is central to CTSI's mission to develop infrastructure and services that enable clinical and translational research. This theme is about process - improving the efficiency and effectiveness of the clinical and translational research enterprise through operational innovation, evaluation, and improvement. CTSI works to address the methods and processes theme across all of its Cores. During the current cycle, CTSI has demonstrated a strong track record of achievement in this theme and has had an important impact at the local and national level (**Overall Table 2** and **vignette**).

Overall Table 2. Track Record in METHODS AND PROCESSES in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Developed **UCSF Catalyst**, a product and device accelerator program partnering researchers with industry experts and providing pilot funding to move toward invention disclosure and commercialization.	Sixty-one researchers have received Catalyst awards and together with industry partners, UCSF has generated more than 25 invention disclosures and $151 million in additional follow-on research funding *(see vignette below).* Financial support for Catalyst has successfully transitioned to the institution given its substantial impact and return on investment. Catalyst has been a model program for other CTSA institutions.
Created **UCSF BIOS**, an enterprise-wide research biobanking program to standardize and provide services across the biospecimen lifecycle in support of clinical and translational research.	UCSF BIOS provides centralized specimen collection, processing, and distribution to 8 major surgical groups and interventional radiology and has been asked by UCSF to take on responsibility for all surgery-derived research specimen collection and management. BIOS has implemented a universal biospecimen consent form now in use to facilitate precision medicine-based research. Like for Catalyst, financial support for BIOS has successfully transitioned to the institution.
Designed and built a clinical trial search platform for patients and researchers called **UCSF Trial Finder;** expanded it to serve the entire 5-campus University of California CTSA network.	In 2019, UC-wide Trial Finder had over 6,500 interested people use the site to contact study teams. Over a quarter of a million people visited specific trial pages.
Implemented the **Trial Innovation Network (TIN) Hub Liaison Team** and improved UCSF's administrative and technological support for clinical trials.	CTSI successfully led the implementation of OnCore, an enterprise-wide clinical trial management system, that now manages over 1000 active trials, and created a new Office of Clinical Trial Activation that has reduced time to trial activation by 24%. The TIN Hub Liaison Team has assisted 26 investigators with TIN clinical trials.

Vignette: *In 2016, CTSI's Catalyst program provided funding and advisors to Dena Dubal, MD, PhD, Professor of Neurology, to study a protein with potentially revolutionary implications for neurological diseases like Alzheimer's. Dr. Dubal's research suggested that this protein, called Klotho, slowed aging-related changes, and that injecting Klotho into mice protected or even enhanced cognitive performance. Catalyst supported in vivo studies with Klotho, performing pharmacokinetic and proteomic analyses and enabling a successful collaboration between Dr. Dubal, UCSF, and Unity Biotechnology.* ***"CTSI guided me closely in the therapeutic development of Klotho,"*** *writes Dr. Dubal,* ***"and established partnerships that have enabled studies in humans."***

New METHODS AND PROCESSES strategic goals in renewal

High-impact clinical and translational research requires strong collaborative relationships, robust and efficient infrastructure and support, and attention to the entire spectrum of translation - from discovery to clinical practice. For the renewal period, CTSI has identified four distinct strategic goals under the methods and processes theme that address these elements in support of rigorous, high-impact science.

Strategic goal 1: Expand CTSI's network of regional partners to foster team science.

CTSI operates across three San Francisco health systems (UCSF Health, Zuckerberg San Francisco General, and San Francisco Veterans Administration), and partners closely with the other four University of California CTSA-funded institutions (UC BRAID). Missing largely have been health system partners that serve the greater San Francisco Bay Area and California community and regional network partners that serve predominantly community and rural populations in the western US. In this renewal, CTSI will expand its research network to include four community-based Bay Area health systems with recently established UCSF Health affiliations to form the SF Bay Research Infrastructure Network (SFBay-RIN), and two Western-region NIGMS-funded IDeA network Hubs, both focused on community and rural health (**Core A, Aim 1.3**).

Strategic goal 2: Improve regulatory efficiency and effectiveness in digital health-enabled research.

CTSI has developed innovative informatics infrastructure to provide researchers with access to data assets, tools, and services in support of digital health. In this renewal, CTSI will work closely with UCSF's data and regulatory governance to develop, demonstrate, and disseminate methods and processes for highly efficient access to and oversight of EHR-linked data assets (**Core B, Aim 1**), a regulatory framework for data interoperability, sharing, and reuse (**Core E, Aim 2.2**), and regulatory compliance with clinical trial start-up (e.g., single institutional review board) and reporting (e.g., clinicaltrials.gov) requirements (**Core E, Aim 2.1**).

Strategic goal 3: Implement more robust institutional oversight and stewardship of clinical trials.

A major focus of the current cycle for CTSI has been establishing a strong foundation for support of multi-center clinical trials and leveraging the CTSA-wide TIN to identify site investigators and develop protocols. In this renewal, CTSI intends to build on these efforts to greatly expand its oversight and stewardship of the clinical trials operations at UCSF through a variety of methods and processes:

- Implementing organizational and technology-enabled solutions to ensure innovation, rigor, quality, and efficiency across the clinical trial lifecycle (**Core A, Aim 3.1**).
- Creating a clinical trial design unit to liaise with and support the TIN by providing comprehensive design support for investigator-initiated trials ensuring rigor, reproducibility, and mitigation of bias (**Core E, Aim 1.3**).
- Enhance the stewardship of clinical trial review and conduct (**Core F, Aim 2.2**) and fully integrate TIN engagement into UCSF's clinical trial operations (**Core G, Aim 1.1**).

Strategic goal 4: Strengthen support for translation of research to practice and policymakers.

CTSI has provided methods and processes in support of dissemination of evidence since its inception in 2006, and many important evidence-driven policy initiatives have been led by UCSF investigators (e.g., tobacco legislation, sugary beverage legislation). In this renewal, CTSI proposes a new optional Core to institutionalize the evidence to policy pathway called Impacting Practice and Policy by Accelerating Translation (IMPACT). Modeled on CTSI's successful efforts in the product development space (with UCSF Catalyst), IMPACT will provide a center for policy translation work anchored by a corps of faculty and policy maker advisors who work with UCSF researchers to develop and demonstrate evidence to policy impact for their research findings (**Core H, Aim 1**). Evidence to policy education and training will also be developed (**Core H, Aim 2**), and further development and dissemination of IMPACT methods and processes in partnership with the ten University of California campuses and the national CTSA network (**Core H, Aim 3**).

OVERALL AIM 2. CTSA THEME: Collaboration and Engagement

Focus: principles and practices of engagement with stakeholders that make research translation maximally efficient, focused, and relevant.

The **collaboration and engagement** theme is foundational to CTSI. This theme incorporates the activities within the CTSI that foster collaborations among investigators across UCSF and nationally and creates environments that support and encourage collaborative team science work. This theme also incorporates activities that allow for broader collaboration with industry, policy, and community partners and facilitates engagement with such stakeholders to assure effective dissemination and impact of scientific findings.

UCSF and the greater San Francisco Bay Area community are vibrant and diverse, and serve as an industrial epicenter of innovation and technology. CTSI is well-positioned in its community, leveraging its strong track record and UCSF's designation as an "anchor institution" in San Francisco, committed to improving the health of the city's diverse communities. During the current cycle, CTSI has had many high-impact accomplishments (**Overall Table 3** and **vignette**).

Overall Table 3. Track Record in COLLABORATION AND ENGAGEMENT in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Expanded UCSF Profiles (the main institutional resource for collaboration and networking) to serve the entire 5-campus University of California CTSA network.	In 2019, over 1.6 million people used the UC-wide Profiles system to learn about research and researchers (profiles.ucbraid.org/search/).
Enabled investigators at UCSF to **engage with CTSI's community stakeholders** at all stages in the research process.	CTSI has supported more than 200 investigators this cycle in engaging with community stakeholders. These include many investigator- and community-initiated research studies as well as high-profile initiatives such as NIH's All of Us, NHLBI's sickle cell registry and evidence-based care guidelines program, and citywide efforts related to violence and cancer prevention (SFCAN).
Partnered with UCSF and community leaders to **promote recruitment of diverse participants** in clinical and translational research through direct-to-participant technology.	Through a UCSF initiative called Diverse eCohorts co-led by African American, Chinese, and Latinx community leaders, CTSI helped institutionalize recruitment methods focused on ensuring diverse representation in clinical and translational research and is currently piloting these methods in two mobile health-enabled research studies focused on the relationship between maternal stress and early birth, and improving cancer care for Asian Americans.
Facilitated **institutional recognition of team science** in workforce development at UCSF, including the faculty promotions process.	CTSI created and awarded team science pilot grants to support and recognize collaborative multidisciplinary research; formally integrated team science into K training curricula; held team science faculty training workshops; and piloted broadened criteria for faculty promotion within the Department of Medicine to specifically recognize team science.

Vignette: *CTSI partnered with Malia Cohen (at the time an elected member of the San Francisco Board of Supervisors and now Chair of the California Board of Equalization), community members, and a team of UCSF investigators to translate the evidence of poor health outcomes from high consumption of sugary beverages into policy. In 2016, this work culminated in 64% of San Francisco voters voting to approve a 1 cent per fluid ounce "Soda Tax" and the prohibition of sugary beverage sales by UCSF.* ***"CTSI worked tirelessly to inform and educate leaders in our communities,"*** *writes Ms. Cohen.* ***"This helped us build the broad-based coalition that culminated in the passage of the Soda Tax. CTSI skillfully translated science into sound policy."***

New COLLABORATION AND ENGAGEMENT strategic goals in renewal

CTSI is committed to strengthening collaboration and engagement with a wide range of stakeholders, public and private, to ensure that its future efforts continue to be appropriately positioned and prioritized, are multidisciplinary in approach, ensure the elimination of bias in the design and implementation of research and public health initiatives, and allow all members of the community to participate and benefit. For the renewal period, CTSI has identified three distinct thematic strategic goals:

Strategic goal 1: Fully incorporate community stakeholders into clinical and translational research.
CTSI will develop a CTSI Community Advisory Board (CAB, **Core A, Aim 2.1**) that will be fully integrated into the leadership and will participate in formal evaluation of CTSI activities (**Core A, Aim 2.2**; see **Letter of Support from CTSI CAB** in Overall section) and review of CTSI's pilot grants (**Core D, Aim 2.2**). In partnership with the Hub CAB, CTSI will enhance integration of community partners into UCSF's broad array of clinical and translational research activities. This will be accomplished through the development and standardization of institution-wide policies and procedures for operating study-specific CABs, the training of new CAB members to build capacity, and outreach to researchers and the community to deepen mutual understanding of the value of partnership in clinical and translational research (**Core C, Aim 1.1**). Leveraging its expanded network of partner institutions (**Core A, Aim 1.3**), CTSI will develop a pipeline of community-based leaders with training in practice-based research through the Training in Practice-based Research program (**Core C, Aim 1.2**).

Strategic goal 2: Promote and catalyze the translation of research into policy and clinical practice through the development of CTSI's new IMPACT Core.
CTSI will create the Impacting Practice and Policy by Accelerating Translation (IMPACT) Core to address gaps in current tools and resources for policy and practice translation (**Core H, Aim 1**), provide education and training in dissemination and policy through leveraging CTSI's programs in implementation science and community engagement and UCSF's Institute for Health Policy Studies (**Core H, Aim 2**), and disseminate IMPACT's model

across the UC campuses and the larger CTSA network (**Core H, Aim 3**). Central to the IMPACT program will be the IMPACT grant supplements and IMPACT Training Cohort program, providing financial resources and diverse learning opportunities to trainees, staff, and faculty across the CTSI community who are interested in achieving dissemination and policy translation success.

Strategic goal 3: Expand CTSI's engagement with CTSA network initiatives including the TIN, CLIC, and CD2H
CTSI will build on its strong history of collaboration with the CTSA network through active engagement of the UCSF community by the Hub Liaison Team (HLT). Engagement will occur through regular presentations at the division, department, and school level, and with particular focus on the TIN through targeted outreach to investigators planning multicenter clinical trials (**Core G, Aim 1.1**). The HLT will also develop, demonstrate, and disseminate technology-enabled participant recruitment tools that leverage the EHR and digital app-based methods to identify eligible participants for TIN trials (**Core G, Aim 1.2**). A new collaboration between CTSI and CD2H will disseminate a cutting-edge biomedical informatics platform called BioCatalyst across the CTSA network (**Core G, Aim 2.3**). BioCatalyst allows institutional biobanks across the CTSA network to connect both clinical attributes and biological/molecular data to existing biospecimens in a central, easy-to-use virtual ecosystem for research use.

OVERALL AIM 3. CTSA THEME: Informatics

FOA focus: informatics and information technology-based innovations that accelerate the science and operations of clinical and translational research.

The **Informatics** theme addresses the transformational change that technology and the digitization of health care data have brought to clinical and translational research. The EHR now provides researchers with the potential to access millions of individual patient records, and technology provides researchers with real-time access to patient-generated data through wearables and smartphone-based apps. In the current cycle, CTSI has aggressively invested in informatics-based solutions to support the clinical and translational research community, and has worked closely with the CTSA network through the domain task forces (now enterprise committees) and the NCATS-funded CD2H to collaborate and disseminate solutions (**Overall Table 4** and **vignette**).

Overall Table 4. Track Record in INFORMATICS in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Enabled **access to EHR data** at UCSF and across the entire 5-campus University of California CTSA network through the creation of the UC Clinical Data Warehouse (CDW).	At UCSF, CTSI supported over 3,500 EHR data users and reduced time to data delivery by 70% *(see vignette below).* CTSI provides self-service access to deidentified EHR data, high performance computational infrastructure, and data visualization tools. A cross-institutional University of California CTSA OMOP data warehouse is now operational and accessible to all five CTSAs.
Created a **digital service unit** that provides intake, design, budgeting, software development, and project management for research projects requiring EHR system modification (e.g., SMART on FHIR).	CTSI has supported 74 projects requiring EHR system modifications (from 65 different PIs), of which 17 have been deployed in clinical production (3 with SMART on FHIR functionality). UCSF Health partners with CTSI to support this high-profile service and provide strategic oversight and guidance.
Developed and launched two **platforms enabling direct-to-participant informatics-powered research:** Eureka and CommonHealth. These tools have been disseminated across the CTSA network.	The Eureka platform has supported 26 research projects led by investigators from across the nation, enabling electronic survey and mobile health data collection. CommonHealth, a new Android-based app (similar to Apple Health) collects EHR data via FHIR and makes it available under multi-stakeholder governance to consumer-facing apps (commonhealth.org).

Vignette: *In 2017, CTSI assisted Jinoos Yazdany, MD, MPH, Professor of Medicine, to perform a deep learning-based study to predict disease behavior in rheumatoid arthritis. EHR data from two CTSI-affiliated institutions were assembled, cleaned, and provided to Dr. Yazdany's team for analysis. The model was predictive of disease behavior in the derivation cohort (AUC 0.91) and validation cohort (0.74), despite marked differences between the two populations.*[1] ***"Our work using EHR data relies heavily on UCSF's CTSI,"*** *writes Dr. Yazdany.* ***"CTSI helps bridge the natural silos that occur within UCSF to create a multiplier effect for clinical informatics research."***

New INFORMATICS strategic goals in renewal

Progress in data access and interoperability, EHR-enabled, informatics-driven research innovation, and the workforce's knowledge and skills in informatics and data science will transform the clinical and translational research environment over the next decade. For the renewal period, CTSI has identified three distinct strategic

goals under the informatics theme and will work closely with CD2H to develop, demonstrate, and disseminate informatics solutions across the CTSA network.

Strategic goal 1: Enhance data interoperability across regional and national CTSA networks.
CTSI has committed substantial resources to providing UCSF clinical and translational researchers with access to EHR and other data assets. In addition, CTSI has worked closely with CD2H to develop, demonstrate, and disseminate informatics solutions across the CTSA network. In this renewal, CTSI plans to expand its investment in operationalizing data interoperability standards and expanding access to data across our Bay Area region (including safety net hospitals), the five University of California CTSA Hubs, and the larger CTSA network (**Core G, Aim 2.2**). Emphasis will be placed on improving the utility of UCSF's EHR data (**Core B, Aim 1**) and integrating socioeconomic, environmental, and regulatory datasets with EHR-based patient-level data to enhance population health research (**Core C, Aim 1.3**).

Strategic goal 2: Expand informatics support for digital health research.
Researchers are increasingly interested in using digital tools (e.g., the EHR, wearables, mobile health apps) in clinical and translational research, and CTSI has developed programs to provide the substantial informatics-driven support necessary to do this work. In this renewal, CTSI plans to expand and disseminate these programs, in particular:

- CTSI will expand its Digital Services Unit that provides oversight and management of EHR-enabled research projects (e.g., decision support tools, SMART on FHIR powered integrations; **Core B, Aim 2**)
- CTSI will develop, demonstrate, and disseminate a modular platform called the SMART Health Apps Rapid Platform (SHARP) to support development and hosting of digital intervention apps that integrate with the EHR and mobile health tools (e.g., smartphones and wearables; **Core B, Aim 2**)
- CTSI will collaborate with CD2H to demonstrate and disseminate biomedical informatics solutions to integrating biospecimen-derived and EHR data in research-ready data warehouses (**Core G, Aim 2.3**)

Strategic goal 3: Develop informatics competencies for the clinical and translational science workforce.
CTSI supports extensive clinical and translational research training and career development programs in partnership with the UCSF Department of Biostatistics and Epidemiology. In this renewal, CTSI will co-develop a Master's program in data science and expand its offerings to include a clinical informatics track with new courses on working with EHR data, introduction to informatics systems, human-centered design, consumer technology and digital health, and cloud platforms (**Core B, Aim 4 and Institutional Career Development Core I**). The CTSI **NRSA Training Core J** will also develop a 2-year program for post-doctoral trainees, the Clinical Research Informatics Program (CRISP), leveraging the above coursework and providing mentoring from faculty with applied clinical research informatics projects (**Core D, Aim 1.1**).

OVERALL AIM 4. CTSA THEME: Integration Across the Lifespan

Focus: scientific insights and operational processes to ensure scientific advances are realized in all populations.

The **integration across the lifespan** theme aligns with CTSI's commitment to ensuring that the scientific advances supported by the CTSI are realized in all populations. Children and older adults are often excluded from research studies leaving substantial gaps in the evidence. Integration across a diversity of populations based on race, ethnicity, and geography is also an emphasis of this theme. This renewal makes a substantial investment in bolstering CTSI's commitment to special populations through the incorporation of activities across Cores to eliminate bias in the design and implementation of studies and encourage the inclusion of special populations in clinical and translational research (**Overall Table 5** and **vignette**).

Overall Table 5. Track Record in INTEGRATION ACROSS THE LIFESPAN in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Collaborated with the UCSF Pepper Center to develop **resources and mentoring opportunities to trainees in aging research.**	In this cycle, CTSI collaboratively established the Vulnerable Aging Research Core to promote engaging and enrolling populations of older persons typically underrepresented in aging research. Examples include research on older homeless persons, advance care planning in safety net hospitals, and outcomes of cancer care in older persons with lung cancer. CTSI also supported the development of two R24 research networks funded by NIA and multiple NIA Beeson Awards.

Partnered with pediatric leadership to establish **best practices in equitable community-based pediatric research**.	Provided tools and support into research methodologies to effectively conduct pediatric research in the community in areas identified as important by community stakeholders.
Increased the number of **pediatric and geriatric research studies**.	From the beginning of the cycle to the current grant year, the number of pediatric studies increased 22% (from 70 to 85) and the number of geriatric studies increased 14% (158 to 180).
Funded pilot projects involving pediatrics, geriatrics, and other special populations.	During this cycle, 29 of CTSI's pilot awards (67%) have funded research involving special populations. This has resulted in 38 subsequent grant awards and ~$25 million in follow-on funding.
Made **tools for research in special populations** more widely available.	CTSI created a collection of validated translational research survey instruments applicable to NIH "special populations" (see ctsi.ucsf.edu/news/new-resource-special-populations-measures). CTSI co-sponsors an annual symposium focused on health disparities. In 2019, this research symposium had 471 attendees and 110 research abstracts.

Vignette: *A UCSF team led by Tippi MacKenzie, MD, Professor of Surgery, is pioneering fetal gene therapy to repair genes before birth using in utero hematopoietic cell transplantation. To translate this approach from the laboratory to the clinic, Dr. MacKenzie received pilot funding and mentorship from CTSI's Catalyst program. Her clinical trial successfully transplanted a mother's stem cells into her growing fetus diagnosed in utero with alpha thalassemia major, a normally fatal fetal condition, resulting in the birth of a healthy baby girl.*[2] ***"Taking the leap to a clinical trial was huge and involved a body of knowledge I didn't have,"*** *writes Dr. MacKenzie.* ***"CTSI provided that knowledge. Having the team hold my hand through the process was great."***

New INTEGRATION ACROSS THE LIFESPAN strategic goals in renewal

By the year 2030, the population ratio of adults over age 65 years to those under will reach 1:4 Americans. By 2044, it is estimated that non-Hispanic whites will become a minority population in the US. Research in special populations (defined as minors younger than age 18 years, elderly adults older than age 65 years, underrepresented ethnic and racial groups, and people who live in rural areas) is critical to design, demonstrate, and disseminate targeted strategies. For the renewal period, CTSI has identified three lifespan-themed strategic goals building on its prior successes in integration across the lifespan research.

Strategic goal 1: Increase integration of special populations into clinical and translational research.
In this renewal, CTSI will launch a comprehensive, innovative special populations program led by a multi-stakeholder committee entitled Special Populations and Health Equity in Research and Education (SPHERE; **Core F, Aim 1.1**). SPHERE will directly engage academic and community-based faculty and community leaders in clinical research design, implementation, evaluation, and training. Key elements of SPHERE are the development of a core set of diverse and inclusive educational materials; a cultural/language/linguistic assistance program; access to community reviewers; a consultation service for researchers seeking to optimize the participation of special populations; and a recruitment service to identify special population study participants.

Strategic goal 2: Incentivize research across the lifespan through targeted subsidies to investigators.
CTSI Core F's Participant and Clinical Interactions (PCI) program supports research at UCSF's Benioff Children's Hospital, San Francisco's safety net hospital Zuckerberg San Francisco General, and the San Francisco Veterans Administration Hospital. To encourage researchers at each of these sites to conduct research across the lifespan, CTSI will establish a PCI management program that provides financial and operational subsidies targeted at special populations research (**Core F, Aim 2.3**). Additional incentives for special populations research will be incorporated into the Pilot Translational and Clinical Studies (PTC) Core D grant program through targeted subsidies to pilot awardees focused on engaging special populations in their funded project (**Core D, Aim 2.1**). The PTC Core has also proposed a PCORI-based stakeholder review process for pilot award applications to provide broad-based feedback and directly encourage community-engaged research (**Core D, Aim .2.2**).

Strategic goal 3: Collaborate with regional partners serving pediatric and rural populations.
In the renewal, CTSI has established research relationships with several regional health systems and research networks that serve pediatric and predominantly underrepresented rural populations (**Core A, Aim 1.3**). Through regular engagement with these partners, in particular Benioff Oakland Children's Hospital and two NIGMS-funded Institutional Development Award (IDeA) programs - the Mountain West Clinical and Translational Research Infrastructure Network and the Nevada IDeA Network of Biomedical Research Excellence, CTSI will develop collaborative initiatives aimed at better engaging with and serving special populations.

OVERALL AIM 5. CTSA THEME: Workforce Development

FOA focus: innovations in the substance and culture of workforce development to create and sustain a robust clinical and translational research workforce.

The **workforce development** theme is essential to ensuring that clinical and translational science stakeholders (e.g., investigators, community members, patients, research staff) have the skills and resources necessary to advance knowledge in an ethical and inclusive manner. CTSI's training and career development Cores (**Cores I and J**) are at the heart of these efforts. In coordination with **Core D1 Translational Workforce Development**, they provide resources and training for workforce development at all levels of learners. CTSI has been highly successful in disseminating its workforce development resources to other CTSA Hubs and the national clinical and translational science community and has been a leader in the CTSA training community. In the current cycle, particular attention has been given to engaging women and URM stakeholders in clinical and translational science workforce development (**Overall Table 6** and **vignette**).

Overall Table 6. Track Record in WORKFORCE DEVELOPMENT in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Provided **career development support to junior faculty** pursuing clinical and translational science careers.	CTSI funded 20 KL2 Scholars this cycle (75% women, 25% URM) and supports an infrastructure for the larger K Scholar community at UCSF. Since its inception in 2006, 93% of KL2 scholars have remained in academic medicine and 59% have received an R01 or equivalent.
Supported **programs in clinical and translational research for trainees.**	CTSI has supported 45 undergraduates (50% women, 83% URM), 30 predoctoral trainees, and 26 postdoctoral trainees in programs designed to teach clinical and translational research skills and develop a pipeline for the future (90% continue in health care).
Expanded **didactic courses in clinical and translational science** and extended access to these courses through **remote learning platforms**.	In partnership with the UCSF Department of Biostatistics and Epidemiology (DEB) Training in Clinical Research Program (TICR), CTSI provided 40 courses and 4 certificate or degree-granting programs in clinical and translational science. Six new online courses and training programs (Mentoring Training and Implementation Sciences) have reached a national audience.
Expanded the **clinical research coordinator workforce** with development of curriculum and professionalization activities.	CTSI's clinical research coordinator curriculum has been taken by 457 coordinators this cycle. In collaboration with other CTSA Hubs, CTSI established a "Clinical Trials Day" to provide professional development for clinical research coordinators and support staff.
Enhanced **education on regulatory requirements** and expanded access to these courses through **remote learning platforms**.	CTSI partnered with the School of Medicine to develop curriculum and concierge services to students conducting summer research projects; this reduced IRB submission errors by 20% from baseline. CTSI's remote learning lectures have been viewed more than 1,200 times since their development.

Vignette: *Jason Flatt, PhD, MPH, Associate Professor of Nursing, was funded by CTSI to study risk of Alzheimer's disease among sexual and gender minorities (SGM) or individuals who identify as LGBTQ+. As a KL2 Scholar, Dr. Flatt expanded his research to examine the importance of affordable and inclusive housing on health and the potential cognitive health benefits for low-income SGM seniors.* ***"CTSI provided me with incredible opportunities for my career development and obtaining a K01 from the National Institute on Aging,"*** *writes Dr. Flatt. "****Our works-in-progress sessions and grantsmanship training supported me in receiving a perfect score on my revised career development award.****"*

New WORKFORCE DEVELOPMENT strategic goals in renewal

Essential to the future success of clinical and translational research is developing and expanding the workforce of tomorrow. CTSI's workforce development efforts remain critically important in this effort, and its programs must continue to adapt to meet the rapidly changing needs of the community. In this renewal, CTSI has identified three important strategic goals in workforce development.

<u>Strategic goal 1: Develop training programs in clinical informatics and data science.</u>

In response to the transformational advances in digital health and computing, CTSI is investing heavily in clinical informatics and data science workforce development programs to ensure that the workforce of tomorrow has the skills, rigor, and knowledge necessary to lead in these areas. CTSI will work with campus partners to develop curricula and a new Master's program in clinical informatics (**Core B, Aim 4**). Data science and clinical informatics will also be one of the central themes in CTSI's Career Development Core (**Core I, Aim 2**) and its NRSA Training Core (**Aim J2**). The latter will develop a new program: Clinical Research Informatics Program (CRISP) to train researchers in clinical informatics and data science and provide mentorship in applied clinical informatics research.

Strategic goal 2: Build skills in translating evidence to policy and practice.
Translating evidence from clinical and translational research into policies that change practice is a major focus of this renewal reflected by the development of CTSI's aforementioned optional Core called IMPACT (**Core H**). The IMPACT Core will create a formal internship program open to trainees at all levels which will provide competencies for successfully collaborating with policy- and decision-makers in order to accelerate real-world impact, curricula to teach these competencies, seminars and visiting lectures highlighting the impact of research on policy, practice, and systems, and mentorship from UCSF investigators skilled in these activities (**Core H, Aim 2**). All of CTSI's training and career development activities in the renewal will leverage the IMPACT Core (**Core D, Aim 1.1, Core I, Aim 1**) as well as CTSI's existing implementation science programs (**Core I Aim 3**).

Strategic goal 3: Collaborate across CTSA Hubs to enhance workforce development resources and opportunities for trainees.
Working with other CTSA workforce development programs and the CLIC-supported workforce development enterprise committee is essential to building a strong, integrated, clinical and translational scientific workforce at the national level. It also allows for more frequent and effective exchange of ideas. In this renewal, CTSI proposes to emphasize collaboration and dissemination of CTSI workforce development activities across the national CTSA network (**Core B, Aim 4; Core D, Aim 1.1; Core I, Aim 4; Core H, Aim 3).**

OVERALL AIM 6. CTSA THEME: Integration of Health Care and Research

Focus: synergy and early engagement with the health care delivery system to improve dissemination of research advances into clinical care and prioritize clinical and translational research problems identified in the health care delivery context.

The **integration of health care and research** theme is exemplified by the close, collaborative relationship between CTSI and UCSF Health, CTSI's primary health system partner. UCSF Health is committed to advancing, applying, and disseminating knowledge as a core organizational pillar and strategic priority; this has led to substantial investments in efforts to educate and engage patients and staff in the research enterprise. Accomplishments in the current cycle demonstrate real impact (**Overall Table 7** and **vignette**).

Overall Table 7. Track Record in INTEGRATION OF HEALTH CARE AND RESEARCH in the Current Cycle

Selected thematic accomplishment	Impact at local and national level
Developed an **implementation science training program** to promote the relevance and uptake of research-based knowledge in real-world settings.	The UCSF DEB now supports this program, providing a spectrum of training opportunities from a 2-day intensive to a 6-unit Certificate program. Over 300 students have participated in these trainings. The program has successfully competed for NHLBI-funded R25 and AHRQ-funded Learning Health System K12 programs to support postdoctoral scholars and junior faculty pursuing implementation science careers.
Piloted **Learning Health System demonstration projects** to test EHR-enabled interventions through health care system-embedded clinical trials.	Seven projects were supported at UCSF Health, focusing on a diverse set of topics (e.g., delirium management, advanced care planning, and newborn weight gain). Findings have led to changes in practice at UCSF and methods improvement.
Provided targeted **pilot funding for "health care innovation"** to engage clinicians at UCSF Health in the clinical and translational research enterprise.	A broad range of projects were supported at UCSF Health including: "Real-time precision melanoma screening using deep neural networks"; "Digital support for frail elderly preparing for surgery"; and "Rapid head CT analysis in neurological emergencies."[3]
Created a **system-wide participant recruitment tool** to automate screening of and outreach to all eligible UCSF Health patients through the EHR-based patient portal regarding participating in research.	In pilot studies of this tool, an estimated 40% of enrolled participants were identified through this EHR-based method. CTSI has now provided EHR-based recruitment support to 46 studies across UCSF, and efforts are underway to disseminate this tool across the entire 5-campus University of California CTSA network.

Vignette: *In 2017, CTSI partnered with Ari Hoffman, MD, Assistant Professor of Medicine, to test whether evidence-based order sets for COPD admissions reduced length of stay and subsequent readmission rates. Patients were identified and randomized through an EHR-based algorithm, and the order template was delivered as part of the normal process of care. Patients randomized to the intervention received evidence-based orders more frequently but unexpectedly had a trend toward higher 30-day readmission rates, demonstrating potential harm from the "evidence-based" intervention. "**The support from CTSI was critical,"** Dr. Hoffman writes, **"both for my professional development and the success of the project."***

New INTEGRATION OF HEALTH CARE AND RESEARCH strategic goals in renewal

Patients, clinicians, and health care leaders are increasingly focused on improving health care quality and recognize the critical role that rigorous, scientific discovery plays in that process.[4] For the renewal period, CTSI

has developed two distinct strategic goals that will provide high-impact change in the integration of health care and research theme.

Strategic goal 1: Expand CTSI's engagement in developing a learning health system.
CTSI will build on its partnership with UCSF Health and campus leadership to create an enterprise-wide learning health system (LHS) leadership group (**Core A, Aim 1.2)**. UCSF Health is committed to advancing, applying, and disseminating knowledge through the LHS pillar of its strategic plan. CTSI's LHS leadership group will provide continued direction and coordination to campus-wide efforts to support clinician-driven innovation (**Core D Aim 2.1**) and to develop informatics-driven infrastructure that enables health care system-embedded research (**Core B, Aims 2** and **3**). By convening consensus-building efforts, this group will work with stakeholders (patients, providers, administrators, and researchers) to identify and support priority areas for LHS investment at UCSF, leverage existing institutional informatics and administrative resources to develop a coordinated infrastructure for LHS activities, and promote the consistent integration of LHS activities into institution-wide efforts to improve health care quality and value.

Strategic goal 2: Bolster CTSI's efforts to translate research into practice and policy.
As noted, the IMPACT Core (**Core H**) will establish an institutional home and champion for evidence-to-practice and policy-based research (**Core H, Aim 1**), provide training and mentorship in institutional and public policy making (**Core H, Aim 2**), and create a community of IMPACT investigators with pilot funding and strategic partnerships with health care leaders and policy makers to catalyze system-wide health care quality improvement efforts (**Core H, Aim 3**).

OVERALL AIM 7. CTSA THEME: Workforce Heterogeneity

Focus: development and maintenance of a diverse, equitable, and inclusive workforce from varied professional, cultural, gender, ethnic, race, and underrepresented minority backgrounds.

The **workforce heterogeneity** theme is closely aligned with UCSF's institutional priorities to advance diversity, equity, and inclusion for the campus and health system embodied in the UCSF Office of Diversity and Outreach. Leadership in scientific discovery and innovation depends on developing a pool of highly talented scientists from varied backgrounds (professional, educational, age, culture, gender, ethnicity, and race). CTSI has worked hard to improve representation of URM researchers in all of its workforce development activities (**Overall Table 8** and **vignette**).

Overall Table 8. Track Record in WORKFORCE HETEROGENEITY in the Current Cycle

Selected thematic accomplishment	*Impact at local and national level*
Partnered with institutional leadership to **promote applications for NIH diversity supplements** to funded research grants.	CTSI helped increase the number of NIH diversity supplements received from 7 in 2016 to 17 in 2019 (a 143% increase), resulting in an additional nearly $1.3M in funding.
Prioritized **workforce development support for URM trainees** through the NRSA and career development awards.	During this cycle, 39 of 47 (83%) undergraduates in CTSI's NRSA training program have been URM, and 90% have continued in the field. Across all training and career development programs supported by CTSI, approximately 20% of awardees have been URM, and the broader K Scholar infrastructure supported by CTSI has been expanded to include junior faculty supported by diversity supplements.
Supported an intramural **pilot grant RFA for URM faculty**.	CTSI has awarded 9 pilot awards to URM faculty during this cycle, representing 20% of total pilot awards.

Vignette: *As a clinical research fellow, Valy Fontil, MD, MAS, MPH, Assistant Professor of Medicine, was funded by CTSI to study protocols for hypertension management in safety net settings. His findings demonstrated that health care systems with limited resources could successfully adopt health services interventions and achieve quality care. As a current CTSI KL2 Scholar, Dr. Fontil is expanding this work to study the effectiveness of technology-enabled hypertension management interventions. "**CTSI provided me with support pivotal to launching my research career,"** writes Dr. Fontil, **"and continues to provide funding and mentoring to further advance my work. CTSI has been instrumental to my career development."***

New WORKFORCE HETEROGENEITY strategic goals in renewal

CTSI has a strong track record of training a diverse population of students, trainees, and faculty and is committed to creating a clinical and translational science workforce that reflects the population it serves. Despite recent improvements, UCSF remains a predominantly White (non-Hispanic) and Asian faculty, with 87% of School of Medicine faculty identifying as one of these two racial/ethnicity categories. In this renewal, CTSI proposes a

multipronged approach to engaging with a heterogeneous pipeline of trainees, providing them with resources and opportunities to enter the clinical and translational science workforce.

Strategic goal 1: Actively develop URM trainees through targeted initiatives.
The Translational Workforce Development Core D1, in collaboration with the Integrating Special Populations Core F1, proposes several enhancements to opportunities in clinical and translational research for URM trainees (**Core D, Aim 1.2**). These include targeted recruitment strategies to engage URM undergraduate students in careers in research, promotion of NIH diversity supplements for all eligible NIH awards, provision of formal peer-to-peer mentoring and sponsorship opportunities for URM trainees, and organization of URM trainee interest groups and professional seminars. CTSI will also develop a community-academic collaborative to enhance inclusion of URM individuals in clinical and translational science and leverage UCSF's institutional initiatives to increase diversity of the research workforce at UCSF (**Core F, Aim 1.1**).

Strategic goal 2: Partner with the NIGMS-funded IDeA network to expand CTSI's rural health impact.
This strategic goal will build strong, formal partnerships between CTSI and two NIGMS-funded IDeA programs - the Mountain West Clinical and Translational Research Infrastructure Network (MW CTR-IN) and the Nevada IDeA Network of Biomedical Research Excellence (NV INBRE). This partnership will leverage two NIH-funded clinical and translational science communities to share best practices on research training and infrastructure support across a broad and diverse community of clinical and translational scientists (**Core A, Aim 1.3**). Initial activities will include co-sponsoring outreach activities aimed at engaging rural and underserved populations in research, sharing of training and career development opportunities to encourage workforce diversity, and encouraging community-academic partnerships in clinical trial design and conduct through engagement of joint research teams with CTSI resources such as the SFBay-Collaborative Research Network (**Core A, Aim A1.2**) and the TIN (**Core G, 1.1).**

CONCLUSION

These seven Overall Specific Aims describe a comprehensive strategy for training and sustaining the next generation of the clinical and translational workforce at UCSF. The strategic goals proposed demonstrate CTSI's commitment to the CTSA program's mission of developing, demonstrating, and disseminating tools and resources in support of its seven core themes: methods and processes, collaboration and engagement, informatics, integration across the lifespan, workforce development, integration of health care and research, and workforce heterogeneity. As a leader of the CTSA network since its inception in 2006, CTSI will continue to work with its CTSA network partners to transform the clinical and translational research environment. At this time of transformative change in medicine, CTSI is well-positioned to carry out its mission to accelerate research to improve health for all patients and communities, in San Francisco and nationwide.

CORE A. ADMINISTRATION: SPECIFIC AIMS

The University of California, San Francisco (UCSF) CTSA Hub, called the Clinical and Translational Science Institute (CTSI), was established in 2006 with the goal of transforming clinical and translational science research across the UCSF enterprise to improve the health of our community. CTSI has succeeded in that goal, led by an experienced Administrative Core that is fully integrated into UCSF's executive leadership, receives unwavering institutional support, and serves as a single point of contact for clinical and translational science needs of the UCSF community. In the next funding period, the Administrative Core will leverage its resources and institutional relationships to lead CTSI, successfully complete its Aims across Cores, and contribute to NCATS's mission to advance innovation in clinical and translational science research. Particular emphasis will be placed on expanding collaborative relationships with regional health systems and community stakeholders, supporting an organizational culture of transdisciplinary team science and continuous improvement, and integrating CTSA's seven themes (methods and processes, collaboration and engagement, informatics, integration across the lifespan, workforce development, integration of health care and research, workforce heterogeneity) into all aspects of CTSI's work.

Section A1: Organization, Governance, Collaboration, and Communication

Aim A1.1. Provide administrative oversight and coordination of CTSI Cores and functions to support clinical and translational science research.

This Aim describes a comprehensive approach to strengthening the Administrative Core's organization and governance. Oversight of operations, annual planning, and budgeting represent central functions of the Core.

Aim A1.2. Enhance collaboration and communication between CTSI and institutional leadership.

The Administrative Core will develop a new internal council of domain experts (the Strategic Advisory Council) to provide strategic counsel on CTSI's activities, and significantly expand CTSI's partnership with UCSF Health.

Aim A1.3. Expand CTSI's research network to include regional health systems and networks to reach a broad and diverse translational science community.

This Aim will formalize a network of regional health system partners, allowing CTSI to serve a larger and more diverse population of constituents, enhance collaboration, and expand the reach and impact of CTSI's activities.

Section A2: Evaluation and Continuous Improvement

Aim A2.1. Strengthen CTSI's Community Advisory Board and expand CTSI's External Advisory Committee.

The Administrative Core will integrate its Community Advisory Board consisting of diverse stakeholder groups including patients, UCSF's neighborhood leaders, community clinicians, municipal government, industry, and foundations into CTSI's governance structure. The Core will facilitate expansion and engagement of the External Advisory Committee in the evaluation of CTSI's performance and deliverables.

Aim A2.2. Standardize CTSI's evaluation and process improvement activities.

This Aim describes the enhancement of the Administrative Core's evaluation and continuous process improvement activities. As part of a comprehensive evaluation program, the Core will participate fully in NCATS's Common Metrics tracking and Turn-the-curve planning, will expand evaluation methods for CTSI Cores to align with the CTSA network's core domains, and will integrate continuous process improvement more fully into the organizational culture of CTSI.

Section A3: Quality and Efficiency

Aim A3.1. Implement organizational and technology-enabled solutions to ensure quality and efficiency of the patient-oriented research lifecycle.

This Aim describes CTSI's commitment to high-quality and innovative clinical and translational research by leveraging UCSF's clinical trial management system and other enterprise-wide technology solutions to enable comprehensive oversight of clinical trial conduct (e.g., feasibility, on-time recruitment, appropriate conduct and analysis, and dissemination of results) and other aspects of patient-oriented clinical trials research.

Abbreviations used in Core A

EAC = External Advisory Committee	UC BRAID = Biomedical, Research, Acceleration, Innovation and Development
SAC = Strategic Advisory Council	
IAB = Internal Advisory Board	CAB = Community Advisory Board
LHS = Learning Health System	BSC = Balanced Score Card
SFBay-RIN = San Francisco Bay Research Infrastructure Network	LSS = Lean Six Signa
CTR-IN = Clinical Translational Science Infrastructure Network	CTO = Clinical Trial Operations
INBRE = IDeA Network of Biomedical Research Excellence	

CORE A. ADMINISTRATION: RESEARCH STRATEGY

The University of California, San Francisco (UCSF) CTSA Hub, called the Clinical and Translational Science Institute (CTSI), was established in 2006 with the goal of transforming clinical and translational research across the UCSF enterprise to improve the health of the communities served by the Institution. In the last 14 years, CTSI has provided a resource-rich home for the over 3,300 faculty, staff, and trainees at UCSF and supported clinical and translational research across UCSF's remarkable breadth (mechanism-based bench research to population-based dissemination research) and depth ($650 million in NIH funding in 2018). Through unwavering institutional support and partnership (see **Letters of Support from executive leadership in Overall section**), the Administrative Core has positioned CTSI at the center of UCSF's clinical and translational science community, integrated CTSI's and UCSF's institutional leadership roles, and leveraged the substantial and diverse resources at UCSF committed to developing and disseminating advances in prevention, diagnosis, and treatment of human diseases (**Table A1**). The Administrative Core's successes have positioned CTSI to continue the rapid transformation of our local and national communities into high-performance clinical and translational science research networks.

Table A1. Selected accomplishments of the Administrative Core in the Current Cycle

Identified need	Implemented change and outcome
Creation of a centralized home for clinical and translational science research at UCSF	The Core worked with institutional leadership to establish the UCSF Office of Research as the institutional home for clinical and translational science research (https://research.ucsf.edu/), under the Executive Vice Chancellor and Provost of UCSF. This office is led by the Vice Chancellor of Research, Dr. Lindsey Criswell, a Multiple Principal Investigator (MPI) for CTSI.
Integration of CTSI and UCSF clinical and translational science leadership	Core Director, CTSI Director, and CTSA MPI (Dr. Collard) was appointed the Associate Vice Chancellor of Clinical Research, the highest-ranking institutional official for clinical and translational science. Executive leadership from both the University (Dr. Criswell) and School of Medicine (SOM) (Dr. Kirsten Bibbins-Domingo) were incorporated into CTSI's MPI structure.
Improved awareness of clinical and translational science researchers, research activities, and resources at UCSF	The Core expanded UCSF Profiles (https://profiles.ucsf.edu/search/), the main institutional resource for research collaboration and networking, to serve the entire 5-campus University of California CTSA network. The Core also developed a centralized research newsletter, Research Resources (https://research.ucsf.edu/research-resource), and an integrated web presence (https://ctsi.ucsf.edu/) that provides UCSF researchers and other stakeholders with easy navigation of, and access to, CTSI resources.
Infrastructure innovation to support access to and enabling of participation in clinical trials	The Core created a clinical trial search platform called Trial Finder (https://clinicaltrials.ucsf.edu/) that leverages ClinicalTrials.gov to allow patients and researchers to easily identify clinical trials in specific geographic areas/for specific medical conditions across all five University of California CTSA sites, in multiple languages, with links to directly contact investigators for information.
Harnessing UCSF expertise and resources to disseminate advances in clinical and translational science into practice and policy	The Core facilitated partnerships among all CTSI Core activities and institutional partners (e.g., Institute for Health Policy Studies, Center for Vulnerable Populations) to operationalize collaborative plans to translate research into practice and policy (e.g., San Francisco's soda tax). This work was a springboard for the proposed Optional Core entirely focused on centralizing UCSF's capacity to translate evidence into public health impact/action (**Core H**).

The renewal period Aims of the Administrative Core will continue the successful management of CTSI by:

- providing administrative leadership for CTSI (e.g., operations, annual planning, budgeting)
- strengthening UCSF's institutional governance of clinical and translational science research
- further incorporating UCSF's broad community of stakeholders
- further integrating comprehensive evaluation and quality improvement processes
- leveraging data standards and emerging technologies to facilitate and ensure high-quality clinical and translational science research across UCSF and the CTSA network

The Administrative Core is committed to collaboration with partners, affiliates, collaborators, and other CTSA Program Hubs, and to the expansion of clinical and translational research efforts to include special populations. Metrics will be carefully collected and used to drive innovation in quality improvement across all CTSI activities. As a key example, CTSI will prioritize engagement with the CTSA Program-wide Common Metrics program. The Administrative Core will work closely with its Strategic Advisory Council (SAC, **Aim A1.1**) and External Advisory Committee (EAC, **Aim A2.1**) to identify opportunities for improvement and actions to mitigate problems. The Administrative Core is focused on identifying best practices in translational research and workforce education (developed locally or at other institutions) and systematically evaluating the impact of these best practices at UCSF. Looking forward to expected growth in emerging methodologies, such as collection of real-world evidence and decentralized trials, the Administrative Core will work across all CTSI Cores to implement an overarching study lifecycle approach to ensuring efficient and high-quality research through alignment of technical and business systems.

APPROACH

Section A1: Organization, Governance, Collaboration, and Communication

Aim A1.1. Provide administrative oversight and coordination of CTSI Cores and functions to support clinical and translational science research.

CTSI organization and governance. CTSI is led by the U54 MPI team of Harold Collard, MD (Associate Vice Chancellor of Clinical Research, Contact PI), Kirsten Bibbins-Domingo, PhD, MD, MAS (Vice Dean for Population Health and Health Equity, School of Medicine), and Lindsey Criswell, MD (Vice Chancellor of Research).

- **Harold Collard, MD (contact PI):** Dr. Collard is Professor of Medicine in the Division of Pulmonary and Critical Care Medicine, Associate Vice Chancellor of Clinical Research for UCSF, and the Director of the UCSF CTSI. Over the last 15 years, Dr. Collard's group has produced seminal articles on the epidemiology, natural history, and management of interstitial lung diseases. Dr. Collard is an internationally recognized clinical researcher and clinical trialist and has extensive experience designing and leading both NIH-funded and industry-sponsored clinical trials. Dr. Collard has trained over a dozen clinical and translational research fellows (he is a recipient of a K24 award in patient-oriented research) who are now leading academic research programs around the world.
- **Kirsten Bibbins-Domingo, PhD, MD, MAS**: Dr. Bibbins-Domingo is Professor and Chair of the Department of Epidemiology and Biostatistics, Professor of Medicine, and the Vice Dean for Population Health and Health Equity in the UCSF School of Medicine. She is a general internist and cardiovascular epidemiologist who leads an innovative clinical research program using pragmatic trials, observational cohort studies, and simulation modeling to design and evaluate interventions aimed at cardiovascular disease prevention in diverse US populations. She is a member of the American Society for Clinical Investigation, the Association of American Physicians, and the National Academy of Medicine and has extensive experience leading NIH-funded collaborative center grants.
- **Lindsey Criswell, MD, MPH**: Dr. Criswell is Professor of Medicine and Orofacial Sciences, Chief, Division of Rheumatology, and Vice Chancellor of Research for UCSF. She has devoted her career to defining the genetic and environmental contributions to a number of systemic autoimmune diseases, including systemic lupus erythematosus and rheumatoid arthritis, and is Program Director for the NIH/NIAMS P30-funded PREMIER (Precision Medicine in Rheumatology) Center. As Vice Chancellor of Research, Dr. Criswell is responsible for directing UCSF's effort to advance innovative, collaborative, and interdisciplinary biomedical research across the University's professional schools and graduate programs.

Drs. Collard, Bibbins-Domingo, and Criswell share responsibility for overall CTSI management and direction, with each PI having responsibilities and oversight for key CTSI functional areas as described in the MPI Leadership Plan. CTSI is organizationally situated within and fully integrated into UCSF's Office of Research (**Figure A1**). The Office of Research provides enterprise-wide governance to UCSF's clinical and translational science research community and is led by the Vice Chancellor of Research, who reports directly to the Executive Vice Chancellor and Provost (EVCP), UCSF's top academic executive. This organizational positioning provides CTSI with extensive partnership across UCSF's institutional leadership.

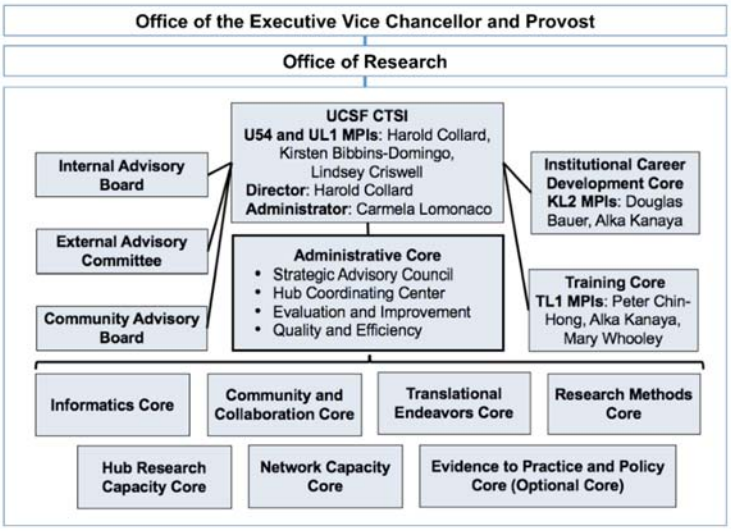


Figure A1. CTSI Organizational Chart

The Administrative Core provides operational oversight and support to CTSI's Core leadership teams and is responsible for managing overall progress toward CTSI's strategic goals. Dr. Collard and CTSI's Chief Administrative Officer (CAO), Carmela Lomonaco, PhD lead monthly faculty and staff meetings where work in progress is reviewed and multidisciplinary input is provided from across the institute. The Core oversees staff development and liaises closely with human resources to ensure that appropriate policies and procedures are followed. It holds weekly senior staff meetings where operations are reviewed and management strategies are shared. Annual planning, budgeting, and the annual progress report are managed by the Core, with quarterly status reports provided to all Core leads and managers. The Core is responsible for coordinating and administering ancillary and supplementary grant

applications for CTSI and communicating closely with the CTSA network to ensure bidirectional communication and dissemination of accomplishments and opportunities.

CTSI leadership team collaboration and communication plan. The KL2 and TL1 MPIs Douglas Bauer, MD (KL2 Contact PI), Alka Kanaya, MD (TL1 contact PI), Peter Chin-Hong, MD and Mary Whooley, MD and Dr. Lomonaco, join Drs. Collard, Bibbins-Domingo, and Criswell to form the CTSI leadership team. Dr. Collard serves as the point of contact for CTSI, responsible for communication and dissemination of CTSA-related information to the CTSI and the larger UCSF community. Drs. Collard, Bibbins-Domingo, Criswell, Bauer, Kanaya, Chin-Hong, Whooley, and Lomonaco meet monthly to review progress toward CTSI's Aims. A key focus of these meetings is attending to ways that educational programs in clinical and translational science at UCSF can most closely integrate with the broader activities of CTSI's Cores. A particular focus is placed on supporting the development of a multidisciplinary and diverse translational science workforce (**Overall theme: Workforce heterogeneity**). Consensus-based decision making is shared by the leadership team. In the unlikely event that a conflict arises that cannot be resolved by consensus, the matter will be referred to CTSI's Internal Advisory Board (IAB) (**Aim A1.2**). All members of CTSI's leadership team agree that determinations of the IAB will be final.

CTSI succession plan for critical leadership positions. CTSI continuously develops leaders among its faculty and staff through career planning, mentoring, and performance management. In the event that one or more of the MPIs for the U54/UL1 award step down, UCSF is committed to performing extensive national searches to identify the most qualified candidates, following established institutional protocols. This would occur in consultation with UCSF's Office of Research executive leadership and National Center for Advancing Translational Sciences (NCATS). In the event that one or more of the MPIs for the KL2 or TL1 awards or CTSI's Chief Administrative Officer step down, the remaining leadership team will work with the IAB, UCSF's other executive leadership, and NCATS to identify a replacement. In annual planning exercises, CTSI Core Directors are encouraged to identify and include potential successors. CTSI develops staff leaders through formal professional development plans and careful attention to performance evaluation and career planning.

Administrative Core Leadership and the Strategic Advisory Council (SAC). Dr. Collard directs the Administrative Core leadership team, which includes the UL1 MPIs, Dr. Lomonaco, and the newly-developed Strategic Advisory Council (SAC, **Table A2**; see **Letter of Support from SAC Chair** in Core A). The SAC is a major initiative of the renewal and consists of senior clinical and translational science research faculty from across UCSF's four professional schools (Dentistry, Medicine, Nursing, and Pharmacy). SAC members each bring institutional leadership experience, perspective, and subject matter expertise that align with the CTSA network's core themes of methods/processes, collaboration/engagement, informatics, integration across the lifespan, workforce development, integration of health care and research, and workforce heterogeneity. Importantly, the SAC complements and informs the IAB, which is charged with providing institutional stewardship of CTSI. SAC members were centrally involved in the development of this renewal proposal and will meet quarterly during the renewal period to review progress on milestones, assist with addressing unexpected institutional challenges or barriers, and provide general strategic and operational advice to CTSI with a focus on its mission to serve the larger CTSA community.

Table A2. Administrative Core Leadership

Name	Core Role and Qualifications
Harold Collard, MD	**Core A Director:** Dr. Collard is a UCSF Professor, Associate Vice Chancellor of Clinical Research, and the Director of the CTSI. Dr. Collard serves as the contact MPI for the U54 and UL1 awards.
Kirsten Bibbins-Domingo, PhD, MD, MAS	Organization and Governance co-lead: Dr. Bibbins-Domingo is a UCSF Professor, Chair of the Department of Epidemiology and Biostatistics and Medicine, Vice Dean for Population Health and Health Equity, School of Medicine and MPI of the U54 and UL1 awards.
Lindsey Criswell, MD, MPH	Organization and Governance co-lead: Dr. Criswell is a UCSF Professor, Chief of the Division of Rheumatology, Vice Chancellor of Research, and MPI of the U54 and UL1 awards.
Carmela Lomonaco, PhD	Evaluation and Improvement lead: Dr. Lomonaco is CTSI's Chief Administrative Officer. Dr. Lomonaco has extensive experience with large program evaluation including trans-NIH initiatives supported by the NIH Office of the Director and strategic planning and assessment for the National Cancer Institute.
Michael Potter, MD	CTSI Research Network lead: Dr. Potter is a UCSF Professor and the Director of UCSF's SF Bay-Clinical Research Network, a practice-based research network in the greater San Francisco Bay Area.
Payam Nahid, MD, MPH	Quality and Efficiency co-lead: Dr. Nahid is a UCSF Professor and the Associate Director of Clinical Trial Operations in UCSF's Office of Research. Dr. Nahid is an experienced clinical trialist and is also the Director of CTSI's Participant and Clinical Interactions Core
Winona Ward, MRA	Quality and Efficiency co-lead: Ms. Ward is the Assistant Vice Chancellor of Research. She is the top administrator at UCSF responsible for clinical trial quality and efficiency.

Strategic Advisory Council (SAC) Members	
Claire Brindis, DrPH	Chair, SAC: Dr. Brindis is a UCSF Professor in the School of Medicine. Dr. Brindis is the Director of UCSF's Phillip R. Lee Institute for Health Policy Studies.
Stuart Gansky, MS, DrPH	SAC member: Dr. Gansky is a UCSF Professor, School of Dentistry and Chair, Oral Epidemiology.
Kathy Giacomini, PhD	SAC member: Dr. Giacomini is a UCSF Professor in the School of Pharmacy. Dr. Giacomini is the Director of UCSF's FDA Center of Excellence in Regulatory Science and Innovation.
Ida Sim, MD, PhD	SAC member and Quality and Efficiency co-lead: Dr. Sim is a UCSF Professor in the School of Medicine. Dr. Sim is the Director of Digital Health for the Division of General Internal Medicine and the co-founder of Open mHealth, a non-profit focused on mobile health data integration.
Roberta Keller, MD	SAC member: Dr. Keller is a UCSF Professor in the School of Medicine. Dr. Keller is the Vice Chair of Research for the Department of Pediatrics.
Susan Chapman, RN, PhD	SAC member: Dr. Chapman is a UCSF Professor in the School of Nursing. Dr. Chapman is the Co-Director of the Master's and Doctoral programs in Health Policy.
Ralph Gonzales, MD, MSPH	SAC member: Dr. Gonzales is a UCSF Professor in the School of Medicine and the Associate Dean for Clinical Innovation, School of Medicine, and Chief Innovation officer for UCSF Health.
Urmimala Sarkar, MD, MPH	SAC member: Dr. Sarkar is a UCSF Professor in the School of Medicine. Dr. Sarkar is the Associate Director of the UCSF Center for Vulnerable Populations.

Administrative Core engagement with CTSI Cores and NCATS. The Administrative Core will lead monthly internal CTSI operational meetings with the Core Directors and administrative staff to maintain transdisciplinary interaction and integration of CTSI activities. Across all CTSI activities, the Administrative Core will prioritize engagement with NCATS and the national CTSA Program activities (**Core G Network Capacity; Table G5** lists current CTSI NCATS engagement). This includes MPI, selected faculty, and staff participation in the yearly CTSA Program meetings, Pod calls, and regular participation in telephone and email communication with UCSF's CTSA Program officer and other NCATS's leadership.

Aim A1.2. Enhance collaboration and communication between CTSI and institutional leadership.

CTSI manages competing institutional perspectives and priorities regarding resource allocation through collaborative engagement and communication with stakeholders at UCSF across multiple venues. It has successfully melded these various communities and cultures by the following activities:

Internal Advisory Board. CTSI maintains an IAB with membership from the four health professions schools, the Chancellor's office, and UCSF's two long-standing affiliate institutions (**Table A3**). The IAB's annual meeting has proven an effective vehicle for obtaining feedback on CTSI activities, and establishing collaborative engagement and communication to operationalize UCSF's institutional priorities for clinical and translational research support. In the renewal, the IAB will be expanded to include a number of additional core institutional stakeholders, including the Academic Senate, the Phillip R. Lee Institute for Health Policy Studies, the UCSF Academy of Medical Educators, the UCSF Helen Diller Family Comprehensive Cancer Center, and UCSF Health. CTSI will also add six members from the clinical and translational science community at UCSF: two faculty, two staff, and two trainees. These faculty, staff, and trainee members will serve two-year terms and be selected to represent the broad UCSF community.

Table A3. Internal Advisory Board membership.

Current IAB members		Additional proposed IAB members	
Name	**Title/stakeholder group ***	**Name**	**Title/stakeholder group ***
Dan Lowenstein, MD	Exec. Vice Chancellor, Provost	Sharmila Majumdar, PhD	Chair, Academic Senate
Talmadge King, MD	Dean, School of Medicine	Andrew Bindman, MD	Institute for Health Policy Studies
Catherine Gillis, PhD, RN	Dean, School of Nursing	Ann Poncelet, MD	Academy of Medical Educators
Joe Guglielmo, PharmD	Dean, School of Pharmacy	Eric Small, MD	Cancer Center
Michael Reddy, DMD, DMSc	Dean, School of Dentistry	Joshua Adler, MD	EVP Physician Svc, UCSF Health
David Morgan, PhD	Vice Dean for Research, SOM	TBD	Clinical/translational rsch faculty
Julene Johnson, PhD	Vice Dean for Research, SON	TBD	Clinical/translational rsch faculty
Andrej Sali, PhD	Vice Dean for Research, SOP	TBD	Clinical/translational rsch staff
Thomas Lang, PhD	Vice Dean for Research, SOD	TBD	Clinical/translational rsch staff
Sue Carlisle, MD, PhD	Vice Dean, ZSFG	TBD	Clinical/translational rsch trainee
Carl Grunfeld, MD, PhD	Assoc COS, Research, SFVA	TBD	Clinical/translational rsch trainee

* SOM = School of Medicine; SON = School of Nursing; SOP = School of Pharmacy; SOD = School of Dentistry; ZSFG = Zuckerberg San Francisco General; SFVA = San Francisco Veterans Administration

Representation on institutional leadership committees. CTSI leadership (Dr. Collard) is represented on multiple UCSF committees with oversight of clinical and translational research activities and support services and related areas. These include the following:

- School of Medicine Leadership Council: The SOM Department Chairs and organized research unit directors meet monthly with the Dean and other SOM leadership to discuss priorities and initiatives

- Research Leadership Committee: The Office of Research convenes the research leadership from the four professional schools, the health system, and the Chancellor's office for quarterly meetings
- Precision Medicine Platform Committee: This institution-wide committee brings together leadership from the science and policy office, population health, Cancer Center, digital health and other key constituencies to provide governance and oversight for UCSF's research community
- IT Governance Steering Committee: IT Governance manages information technology roadmap funds for UCSF, directing institutional investments in research technology
- NCIRE Board of Directors: The Northern California Institute for Research and Education is responsible for oversight and administration of non-VA research grants to SVFA faculty

UCSF Health/CTSI Learning Health System (LHS) Leadership Group. An important renewal initiative is expanding CTSI's working partnership with UCSF Health (see **Aim A1.3**). UCSF Health has committed to advancing, applying, and disseminating knowledge as a core “True North” pillar and strategic priority. UCSF Health has been working closely with CTSI to support development of EHR-linked data assets (**Core B Informatics; Aim B1**), novel digital interventions (**Aim B2.2**), and a series of embedded randomized controlled trials (**Aim B3.4, Table B3**) that demonstrate how research methods and innovation can be leveraged to meet UCSF Health goals. To capitalize on this developing opportunity and formalize our working relationship, CTSI and UCSF Health have created the LHS Leadership Group (**Table A4**), which will meet quarterly to achieve the following three objectives: work with stakeholders (patients, providers, researchers) to support priority areas for LHS investment at UCSF; leverage existing informatics and administrative resources to develop an infrastructure for LHS activities at UCSF; promote the integration of LHS activities into institution-wide efforts to improve health care quality and value. Successful realization of the Leadership Group's objectives, supported by infrastructure investments from CTSI and UCSF Health, will catalyze LHS activities that improve health care quality and value at UCSF.

Table A4. Learning Health System Leadership Group

Name	***Title/Role***	***Learning Health System role***
Joshua Adler, MD	Executive VP, Physician Services, UCSF Health	UCSF Health executive leadership
Russ Cucina, MD, MS	Chief Health Information Officer, UCSF Health	UCSF Health informatics leadership
Ralph Gonzales, MD	Chief Innovation Officer, UCSF Health	UCSF LHS True North pillar lead
Harold Collard, MD	CTSI MPI, Associate VC of Clinical Research	CTSI executive leadership
Mark Pletcher, MD, MPH	Director, Informatics Core	CTSI LHS project lead
Andrew Auerbach, MD	Chair, Clinical Content Oversight, UCSF Health	EHR-enabled research lead
Catherine Lucey, MD	Executive VD, Education, School of Medicine	Trainee quality improvement program lead
Robert Wachter, MD	Chair, Department of Medicine	UCSF digital health strategy lead
Niraj Sehgal, MD, MPH	VP, Chief Quality Officer, UCSF Health	UCSF quality improvement lead
Catherine Lau, MD	Director, Quality and Safety, Div of Hosp Med	Hospitalist quality improvement lead

Synergies with other institutional partnerships with federal agencies. As a top recipient of research funds, UCSF has research and training initiatives funded by nearly every federal entity. CTSI partners extensively with these funded initiatives; a select few with substantial synergies with CTSI activities are described here (**Table A5**).

Table A5. CTSI synergies with federally funded institutional partners

Organization	***Focus of partner organization and synergies with CTSI***
Agency for Health Research Quality (AHRQ)	**Learning Health Systems (LHS) K12** funds a career development program to train junior investigators in patient-centered outcomes research within LHS (**Cores B, I**)
Centers for Disease Control (CDC)	**Prevention Research Center** (funded by CDC). UCSF is a member of a network of 25 PRCs in 24 states and focuses on collaborating with community, academic, and public health partners to design and implement HIV prevention research (**Core C**)
National Institutes of Health (NIH)	**SF BUILD** (funded initially by Common Fund Program’s Enhancing the Diversity of the NIH-Funded Workforce and managed by NIGMS) funds a partnership between UCSF and San Francisco State University to promote training and retention of URM STEM students (**Core F**)
	UCSF REACH (funded by NIAMS Back Pain Consortium (BACPAC) Research Program) leverages community engagement and patient enrollment strategies to develop evidence-based approaches for managing a spectrum of spinal disorders (**Cores C, G**)
	Electronic Medical Record Search Engine (EMERSE; subcontract through University of Michigan). UCSF will implement this open source software and apply to UCSF de-identified EMR clinical notes. UCSF will share learnings and feedback (technical, data-related, usage, documentation, etc.) with the Michigan team (**Core B**)
	Implementation Science for Pulmonary and Cardiac Research Training K12 (funded by NHLBI) trains junior faculty in the science of improving the delivery of interventions proven to improve heart and lung health (**Core I**)

Patient-Centered Outcomes Research Institute (PCORI)	The **Eureka Research Platform** was developed with support from Mobilizing Research – an infrastructure funded by a consortium of institutes (**Core B**)
	The **PCORnet Blood Pressure Control Laboratory** led by UCSF conducts pragmatic RCTs with mobile health (mHealth) and EHR data (**Core B**)
	Health eHeart Alliance and Eureka platform conduct mobile health (mHealth) based research and leverages clinical research recruitment support (**Core B**)
US Food and Drug Administration (FDA)	**UCSF-Stanford Center of Excellence in Regulatory Science and Innovation (CERSI)** promotes regulatory science in development of medical products (**Core D**)
	UCSF Center for Cellular Construction (Science and Technology Center) works with the CTSI Catalyst Program to develop innovative, potentially transformative research and education projects on cellular engineering (**Core D**)
	Bay Area NSF Innovation Corps Node provides educational programs to accelerate the commercialization of science and foster technology entrepreneurship (**Core D**)

Aim A1.3. Expand CTSI's research network to include regional health systems and networks to reach a broad and diverse translational science community.

CTSI operates across three core health systems in San Francisco: UCSF Health, Zuckerberg San Francisco General (ZSFG), and San Francisco Veterans Administration (SFVA) (see **Letters of Support from UCSF Health, ZSFG, and SFVA** in Overall section). All three health systems are supported by UCSF faculty, staff, and trainees.

- UCSF Health: UCSF Health's core facilities consists of the Hellen Diller Medical Center at Parnassus Heights, the Medical Center at Mission Bay, and the Medical Center at Mt. Zion. These three medical centers provide comprehensive medical care to the San Francisco Bay Area with a combined 900+ beds and extensive outpatient facilities. UCSF Health has formal collaborations with over 100 medical groups and clinics across the region, providing coordinated care for much of Northern California.
- ZSFG: ZSFG is the public hospital for the City and County of San Francisco. Serving over 1.5 million people, ZSFG is the region's only Level 1 trauma center, and the anchor of the San Francisco Health Network, which includes 45 community health clinics and a long-term rehabilitation center.
- SFVA: The SFVA provides comprehensive health care to the region's over 65,000 veterans. Its 112-bed hospital is part of the regional VA Medical Center system, connected to a 120-bed community living center and to six community-based outpatient clinics across Northern California.

In 2010, CTSI partnered with the other University of California CTSA-funded institutions (UC Davis, UC Irvine, UC Los Angeles, and UC San Diego) to form the University of California Biomedical, Research, Acceleration, Integration, and Development (UC BRAID) network. CTSI remains its administrative home. UC BRAID's mission is to improve health through collaboration, sharing resources, and infrastructure development (see **Letter of Support from UC BRAID** in Overall section). UC BRAID has implemented integrated search tools to identify collaborators and clinical research opportunities across the network, assisted in the development of a network-wide data warehouse of EHR-based data (UC Health Data Warehouse), overseen two network-wide drug development and innovation grants (funded by NHLBI and the University of California Office of the President), and established multiple network-wide working groups to develop and share best practices on topics such as clinical trial activation, participant recruitment, and single IRB implementation.

San Francisco Bay Research Infrastructure Network (SFBay-RIN). Missing from the CTSI's research network, however, have been regional health system partners that serve the greater San Francisco Bay Area and California community and regional network partners that serve predominantly community and rural populations in the western US. Another major initiative of this renewal is the expansion of CTSI's research network to include four California community-based health systems (forming the SF Bay Research Infrastructure Network, [SFBay-RIN]) and two Western-region NIGMS-funded Institutional Development Award (IDeA) networks focused on community and rural health (**Figure A2 below**).The overarching goal of the research network is to engage with regional/community-based health systems to catalyze clinical and translational team science research with an emphasis on rural health/health disparities.

The SFBay-RIN will include the existing CTSI-affiliated health systems of UC Health, ZSFG, and SFVA, and four new partner health systems: John Muir Health in the East Bay, Marin Health in the North Bay, UCSF Fresno in the California Central Valley, and Washington Hospital in the South Bay (**Table A6 below**; see **Letter of Support from SFBay-RIN Steering Committee** in Overall section). Each partner will contribute personnel, clinical data, and other resources to the SFBay-RIN and will participate fully in decision-making on network initiatives. In building this network, CTSI will leverage its extensive experience partnering with community-based primary care organizations, practices, and clinicians through the San Francisco Bay Collaborative Research Network

(https://consult.ucsf.edu/sfbaycrn). The SFBay-RIN will be led by the SFBay-CRN's Director, Dr. Michael Potter.

The SFBay-RIN Steering Committee will conduct a comprehensive needs assessment across the network and work with the other CTSI Cores to provide bidirectional sharing of relevant resources and services. Priority activities identified from preliminary discussions among members (with relevant renewal Aim highlighted) include the following:

- Representation on the CTSI EAC to promote team science (**Aims A2.1 and C2.2**)
- Increase access to and utility of EHR and EHR-linked data assets (**Aim B1**)
- Implement training curricula in practice-based health-system research (**Aim C1.2**)
- Provide training programs in translational science across learner spectrum (**Aim D1.1**)
- Provide consultation in biostatistics, epidemiology, study design (**Aims E1.1, E1.2**)
- Promote involvement of special populations into translational science research (**Aim F1.1**)
- Facilitate connecting investigators with Trial Innovation Network (TIN) trials and resources and provide clinical trial participation opportunities through innovative approaches to subject recruitment (**Aims G1.1, G1.3**)
- Engage and advise community-based health systems in patient-centered interactions (**Aim F2.1**) and activities to improve regional delivery of health care (**Aim C1.3**)

Figure A2. CTSI's partner organizations

IDeA Network partnership. Another initiative in this renewal is formalizing a collaboration between CTSI and two NIGMS-funded IDeA programs: the Mountain West Clinical and Translational Research Infrastructure Network (MW CTR-IN) and the Nevada IDeA Network of Biomedical Research Excellence (NV INBRE; **Table A6**; see **Letter of Support from IDeA Network** in Overall section). Both the Mountain West CTR-IN and Nevada INBRE have been supported by NIGMS since 2013 and provide infrastructure support to a broad community of partner health systems across the western United States. This partnership between CTSI and the regional IDeA programs will leverage two NIH-funded clinical and translational science communities to share best practices on research training and infrastructure support across a broad community of scientists. Initial activities will include:

- Bidirectional provision of input and guidance to leadership
- Identifying complementary areas of research and administrative expertise and options for reciprocity
- Improving interoperability of health system datasets across networks to facilitate health services research
- Sharing informatics resources to enable use of mobile health technology in rural health research
- Co-sponsoring outreach activities aimed at engaging rural and underserved populations in research
- Sharing of training and career development opportunities across networks to encourage workforce diversity
- Encouraging community-academic partnerships in clinical trial design and conduct through the TIN

Table A6. CTSI Research Network Partners.

Partner Organization	Research Director	Essential elements and unique strengths
UC BRAID		
UC Davis	Ted Wun, MD	Northern California UC CTSA Hub
UC Irvine	Dan Cooper, MD	Southern California UC CTSA Hub
UC Los Angeles	Steve Dubinett, MD	Southern California UC CTSA Hub
UC San Diego	Gary Firestein, MD	Southern California UC CTSA Hub
SFBay-RIN		
Zuckerberg San Francisco General	Sue Carlisle, MD, PhD	San Francisco County hospital with UCSF-affiliated training and research programs
San Francisco Veterans Affairs Medical Center	Carl Grunfeld, MD, PhD	Regional VA Medical Center with UCSF-affiliated training and research programs
UCSF Fresno	Michael Peterson, MD	Rural hospital in Central Valley affiliated with a large FQHC and UCSF residency training programs
John Muir Health	Parveen Sra, MPH	Community-based health system in East Bay (UCSF affiliate)
Marin Health	Robert Newbury, MD	Community-based health system in North Bay (UCSF affiliate)
Washington Hospital	Albert Brooks, MD	Community-based health system in South Bay (UCSF affiliate)
IDeA Network		

Mountain West CTR-IN Univ of Nevada, Las Vegas	Parvesh Kumar, MD	IDeA Network Hub for clinical and translational science infrastructure support in traditionally underfunded states
Nevada INBRE Univ of Nevada, Reno	Josh Baker, PhD	IDeA Network Hub for biomedical research infrastructure support in traditionally underfunded states

CTSI Research Network administration. CTSI will provide administrative oversight and coordination for CTSI's Research Network, facilitating quarterly and ad hoc meetings between UC BRAID, SFBay-RIN, and IDeA Network partners. The IDeA Network and UC BRAID have their own governance and administrative structures; SFBay-RIN governance and administration will be supported by the Administrative Core. The CTSI Research Network Partner leads will collaboratively determine Network initiatives. Partners will meet bi-monthly and be chaired by an annually rotating member. Decision making will be shared and appropriate governance documents and protocols will be developed.

Table A7. Organization, Governance, Collaboration, and Communication Milestones and Metrics

Aim A1.1. Provide administrative oversight and coordination of CTSI Cores and functions to support clinical and translational science research.	
Milestones	Metrics (#, %, rating)
SAC leadership structure	# of SAC members; # of strategic recommendations from SAC
Bidirectional feedback	# of attendees at PI meetings attendance on CTSA Pod calls # communications of CTSA Program information to UCSF faculty and staff
Reporting system	Annual reports submitted on time (y/n)
Aim A1.2. Enhance collaboration and communication between CTSI and institutional leadership.	
IAB expansion	# stakeholders added
Cohesion across LHS projects	# members/meetings LHS Research True North group # priority areas identified for LHS research; # QI projects
Aim A1.3. Expand CTSI's research network to include regional health systems and networks to reach a broad and diverse translational science community.	
Research infrastructure network for local partnerships	# of SFBay-RIN members; # partners involved in decision making Needs assessment completed (Y/N)
Partnerships with IDeA Network western regional partners	# best practices/opportunities shared # communities engaged

Section A2: Evaluation and Continuous Improvement

Aim A2.1. Strengthen CTSI's Community Advisory Board and expand CTSI's External Advisory Committee

The Administrative Core uses a variety of methods for evaluation and continuous quality improvement. These include formal performance management across all CTSI activities and active participation in CTSA's Common Metrics reporting and Turn-the-curve analyses (**Aim A2.2**). Fundamental to the evaluation process is in-person engagement with and input from stakeholder community members. There are multiple important constituencies in CTSI's "evaluation landscape" community; the focus of this Aim is to establish a CTSI-wide Community Advisory Board (CAB) and expand the EAC to fully reflect CTSI's diverse stakeholder community.

CTSI Community Advisory Board. CTSI has a strong institutional commitment to community partnership and has helped UCSF to establish the UCSF Center for Community Engagement (CCE). The CCE's purpose is to coordinate and facilitate community-academic-health/health care partnerships across UCSF mission areas. The CCE is guided by a highly engaged 24-member Governing Council representing a broad spectrum of intramural and extramural stakeholders. To leverage the capacity created by the CCE for substantive community stakeholder engagement and facilitate further integration of CTSI with UCSF's institutional efforts, the Administrative Core will partner with the CCE Council to develop a CTSI-wide clinical and translational science CAB (the CTSI CAB, see **Letter of Support from CAB members** in Overall section) and develop a governance document that ensures a strong community voice in the stewardship of CTSI. Provisional members are listed in **Table A8**.

Table A8. Proposed CTSI Community Advisory Board Members

Name	Title	Stakeholder group
Tomás Aragón, MD, DrPH	Health Officer, SF Department of Public Health	Local government
Victor Rubin, PhD	Senior Fellow, PolicyLink	Researchers
Melissa Jones, MPA	Executive Director, Bay Area Region Health Inequities Initiative	Community leader
Christina Shea, LMFT	Deputy Chief and Director of Clinical Services, Richmond Area Multi-Services	Community leader
Chuck Collins, JD	President and CEO, YMCA of San Francisco	Community leader
Ellie Rossiter	Initiative Officer, San Francisco Foundation	Foundations

TBD		Trainees
TBD		Patients and families
TBD		Private sector/entrepreneurship

Important initial roles for the CTSI CAB will include partnering with the CTSI Community and Collaboration Core leadership in its work to institutionalize the use of study-specific CABs by the clinical and translational research community (**Aim C1.1**), providing formal stakeholder review of the CTSI Pilot Translational and Clinical Studies grants program (**Aim D2.2**), working with CTSI's Special Populations and Health Equity in Research and Education (SPHERE) Steering Committee (perhaps through shared committee membership, **Aim F1.1**) and participating on CTSI's EAC (see below). CTSI believes the CAB will ensure that UCSF's clinical and translational science community remains a trustworthy partner in community-engaged research.

External Advisory Committee. The CTSI EAC meets annually to review progress toward CTSI's Aims and to

Table A9. Current EAC membership and changes responsive to recent EAC recommendations

Current EAC membership	**Affiliation**
Gordon Bernard, MD	CTSA PI, TIN PI, Vanderbilt University
Ebony Boulware, MD, MPH	CTSA PI, Duke University
Ron Sokol, MD	CTSA PI, University of Colorado
Rachel Hess, MD, MS	CTSA PI, University of Utah
Laura Weisel	CTSA Administrator (ret.), Harvard University
Recent EAC recommendation	**Changes made in response**
Integrate CTSI and UCSF research leadership and infrastructure	• Appointment of PI/CTSI Director as Associate Vice Chancellor of Clinical Research • Incorporation of additional leadership as multi-PIs (Vice Chancellor of Research and Vice Dean for Population Health and Health Equity, School of Medicine) • Organizational positioning of CTSI within the UCSF Office of Research
Integrate the diversity and uniqueness of the Bay Area	• Development of training and education pipeline with San Francisco State University focused on workforce heterogeneity and diversity (i.e., SF Building Infrastructure Leading to Diversity) • Expansion of successful "innovation accelerator" optional core (Catalyst) into a sustainable UCSF partnership with Bay Area biotechnology and entrepreneurs
Find ways to connect researchers with big data more effectively	• Collaboration with UCSF technology leadership to develop an EHR-enabled research service that provides investigators with data access and analytics • Creation of data.ucsf.edu/research as a one-stop site for research data resources
Emphasize CTSA core domains in CTSI's activities	• Establishment of a SAC consisting of core domain experts to provide CTSI administrative leadership with additional focus on domain integration
Leverage University of California system as a unique CTSI resource	• Recommitment to UC BRAID (a University of California system CTSA consortium) as a regional partner and accelerator for the national CTSA network • Investment in leveraging the UC Health Data Warehouse (a University of California system EHR-based data resource) for use by UCSF and the larger CTSA network

Expanded External Advisory Committee. A major initiative in this renewal application is the expansion of the EAC to include a more diverse community of stakeholders and perspectives. CTSI will accomplish this through two strategies: 1) incorporating two representatives from CTSI CAB; and 2) incorporating representatives from the new CTSI Research Network members: SFBay-RIN and the partner IDeA Networks (**Aim A1.3**). The revised EAC will retain the five members of the current EAC (representing the NCATS/CTSA network stakeholder group), totaling nine members.

External Advisory Committee Role and Responsibilities. Together with input from UCSF's institutional leadership (CTSI IAB, **Aim A1.2**), the EAC provides a forum for input from all of CTSI's stakeholder constituencies (**Figure A3).** The full EAC will meet annually in person for a full-day meeting, as well as ad hoc and/or in subgroups by webinar as requested by CTSI or EAC leadership. The EAC annual meeting will involve formal presentations by Core Directors and relevant partner organizations on progress toward Core Aims and direct engagement of the EAC with leadership. The metrics and related information from CTSI's evaluation tools (**Aim A2.2**) will be reported to the EAC for discussion and recommendations regarding strategic course correction

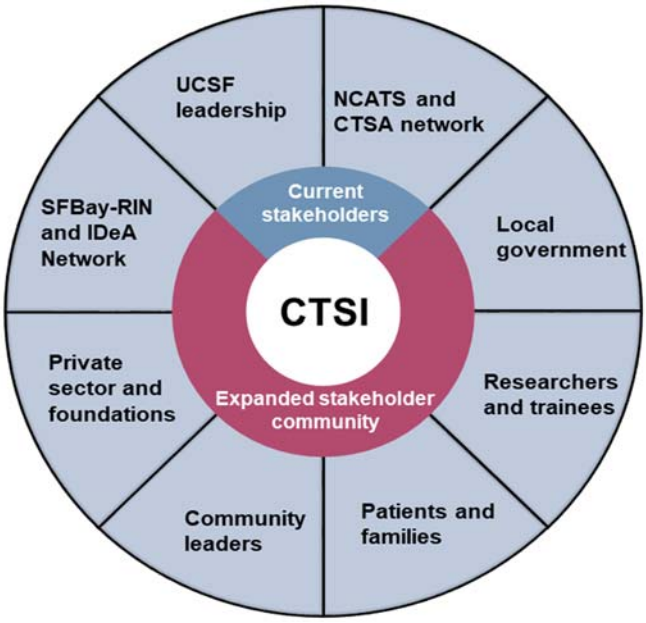


Figure A3. CTSI stakeholder community

or corrective action, should any be needed. Successful strategies identified will be highlighted for dissemination to the CTSA network.

Aim A2.2. Standardize CTSI's evaluation and process improvement activities.

The Administrative Core has an established evaluation and process improvement program consisting of active participation in Common Metrics, quarterly monitoring and assessments with Core Directors and staff leadership, and annual project reviews focused on aligning metrics with strategic goals. As part of the annual review, initiatives and metrics of each project are reviewed by CTSI leadership and discussed with the SAC (**Aim A1.1**), IAB (**Aim A1.2**), and EAC (**Aim A2.1**) to ensure CTSI is addressing priority issues. In this Aim, CTSI proposes to strengthen its evaluation and process improvement initiatives.

Continued commitment to Common Metrics. The Administrative Core will continue to enhance its evaluation and quality improvement framework through engagement in the Common Metrics program (**Aim G2.1**, **Table A10**). The Common Metrics process involves working closely with the CTSA Program Center for Leading Innovation & Collaboration (CLIC) and CTSI Cores to capture data related to the achievement of CTSA Program milestones annually, in order to demonstrate progress and forecast for the future. The results-based accountability Turn-the-curve thinking and action plan development for quality improvement involves starting with the desired outcomes and working backward to the steps needed to achieve it (**Aim G2.1**). CTSI has participated in the Common Metrics program since its inception in 2016, and Common Metrics are already well-integrated with the Administrative Core's existing evaluation process. CTSI has sought to advance the Common Metrics process through feasibility studies that have provided protocols for pooling and analyzing publications data.[1,2] Starting with the Common Metrics evaluation components, the Core continually refines its local metrics to address evaluation and process improvement of CTSI-specific and cross-CTSA collaborative initiatives and projects.

Table A10. Timeline for reporting of Common Metrics

Common Metrics step	*First quarter*	*Second quarter*	*Third quarter*	*Fourth quarter*
Required data collection			X	
Additional CTSI-specific data collection			X	
Turn-the-curve development				X
Common Metrics reporting	X			
Monitoring of Turn-the-curve plan	X	X	X	

Align CTSI evaluation and process improvement efforts with CTSA guiding principles. For the renewal, the Administrative Core proposes to refocus of its local evaluation analyses from the ten FOA-defined Cores to the seven proposed Aims of the Overall Section. These seven Aims focus on the five domains of activity that serve as organizing principles for CTSI (methods/processes, collaboration/engagement, informatics, integration across the lifespan, workforce development), as well as integration of health care and research and workforce heterogeneity (**Overall Section**). This strategic realignment will encourage collaboration among the different Cores and activities, define additional metrics for evaluation of CTSI performance across Cores, and guide process improvement efforts that better serve CTSI's overall goals. This will also align with the scope and focus of the SAC (**Aim A1.1**).

The Administrative Core is responsible for managing all evaluation activities and data. Evaluation activities utilize two established methodologies: Balanced Scorecard (BSC) and Lean Six Sigma (LSS). This two-pronged approach allows CTSI to maximize the appropriateness and impact of its evaluation metrics and streamline operational processes and establish efficiencies to best meet CTSI's strategic goals.

- *Balanced Scorecard.* The BSC is a strategic planning and management system that has been adapted to clinical and translational science and helps to align day-to-day activities of the organization with its vision and strategic goals.[3] The results of BSC analyses can allow organizations to align metrics with goals and prioritize internal processes to target process improvement strategies (see LSS below). Each CTSI Core has a BSC that aligns with the overall CTSI BSC.
- *Lean Six Sigma.* The LSS process improvement model combines two methods (Lean and Six Sigma) to achieve better internal operational efficiency for organizations; it has been applied successfully to clinical and translational science.[4,5] A3 is an LSS-based approach that provides a structured template for understanding problems related to process and identifying root causes; it has been used by CTSA Hubs and allows for benchmarking.[6] The A3 approach has been used previously by the Administrative Core to evaluate projects across the CTSI, including recent evaluations of activities in the Translational Endeavors, Research Methods, Hub Capacity, and Network Capacity Cores.[4-7] The overall value of LSS is to reduce operational inefficiencies, increase productivity, and improve quality. LSS projects can span days to months; projects are identified and prioritized with the BSC system and oversight provided by the Core.

The Administrative Core leadership has been committed to integrating evaluation and process improvement into the organizational culture of CTSI, and CTSI has experienced increased engagement at all levels of the organization. All CTSI staff are trained in the evaluation and process improvement methods described above, and CTSI promotes all staff members' involvement. It is expected that the direct integration of the mission and organizing domains of the CTSA Program into the evaluation process will further incentivize participation by CTSI faculty and staff.[3] The CTSI CAO, Dr. Lomonaco, is an experienced translational researcher and programmatic evaluator with extensive experience in federal, state, academic, and non-profit settings.

For all new projects proposed in this renewal, a baseline BSC will be performed to identify the most suited approach to process and evaluation. LSS will remain the default process improvement methodology for all activities, with utilization of different LSS roadmaps as appropriate for the product, project, or service.[8] Many of these methods are complementary and can be used in tandem. Direct input from investigator and trainee surveys and focus groups will also be incorporated.

Table A11. Evaluation and Continuous Improvement Milestones and Metrics

Aim A2.1. Strengthen CTSI's Community Advisory Board and expand CTSI's External Advisory Committee.	
Milestones	Metrics (#, %, rating)
Community Advisory Board constituted	First meeting of the CTSI CAB
Community stakeholders involved in strategic planning	#/% recommendations implemented # CTSI research CAB members
Aim A2.2. Standardize CTSI's evaluation and process improvement activities.	
Common Metrics participation and innovation	Annual reporting completed (y/n) # Turn-the-curve plan strategies implemented
Evaluation and CQI system	# balanced scorecards; #A3 reports; #LSS projects

Section A3: Quality and Efficiency

Aim A3.1. Implement organizational and technology-enabled solutions to ensure quality and efficiency of patient-oriented research lifecycle.

This Aim will leverage institutional investments and existing (e.g., RedCAP) and new technology and technology standards to maximize quality and efficiency for patient-oriented research (i.e., studies that directly interact with human subjects). Rapidly evolving mobile, networking, and cloud technologies are enabling virtual “decentralized” trials that promise lower costs and greater efficiency.[9] Additionally, industry, academia, and the FDA are increasingly interested in T4-5 translational research in which research questions and study execution are embedded in real-life rather than highly controlled experimental conditions.[10-12] This paradigm shift is introducing new complexity to patient-oriented research. Finally, the crisis of reproducibility is pushing the scientific community toward greater transparency, accountability, and data sharing to restore public trust in research quality and to accelerate findings through efficient data reuse.

Against this backdrop of simultaneous rapid changes to many components of the study lifecycle, an overarching end-to-end approach is needed. The Administrative Core aims to develop a standard set of business processes and systems that are fully aligned across the study lifecycle to increase efficiency and reduce cost of study initiation and execution, ensure compliance with regulatory and organizational standards, increase quality and informativeness of studies, and increase FAIR (findability, accessibility, interoperability, and reusability) data sharing practices and reuse to maximize scientific value.[13] In this Aim, the Administrative Core proposes to develop and socialize an operational roadmap, which will then be implemented with technology-based solutions and metrics-driven program management in alignment with the efforts of the Center for Data to Health (CD2H) (**Aim G2.2**).

Develop shared vision and priorities for re-engineering clinical research lifecycle support. The first step will be a landscape analysis followed by a structured group communication Delphi-like (e.g., iterative consensus-building) process that ultimately reaches a collective vision and priorities.[14,15] The Delphi study will be conducted with 20-25 representative stakeholder participants including researchers, clinical research coordinators, administrators and participants. In Round 1, participants will prioritize functional improvements to support patient-oriented research and will contribute further ideas to be incorporated into Round 2. In Rounds 2 and 3, participants will reappraise their ratings in view of the group consensus. The results of this process will be used to modify and adapt the Administrative Core's quality and efficiency milestones and metrics for patient-oriented research.

Clinical Trials Operations Program. In close partnership with the UCSF Office of Research, the Administrative Core will lead reorganization and coordination of existing activities related to clinical trial operations from design to dissemination. This Clinical Trials Operations (CTO) Program is a new initiative of the renewal that will allow UCSF clinical trialists to better identify and access CTSI and UCSF resources. It will be led by the Administrative

Core working closely with the PCI (**Core F**) and TIN Cores (**Core G**). Importantly, the program leverages strong institutional support and other CTSI initiatives to oversee the following activities and resources:

- Patient-oriented research design: Through the PCI Core's EQUiPT Program (**Aim F2.2**), the CTO Program will provide comprehensive design support for patent-oriented research ensuring community engagement, consultation in research design, scientific review, and space planning.
- Study initiation: The CTO Program will work with the Office of Research to develop a virtual dashboard allowing study investigators to monitor the progress of clinical trials throughout the activation pipeline. The dashboard will enable real-time visibility into the progress of trial start-up.
- Study execution: The CTO Program will create a clinical trial navigator system to decrease logistical barriers to performance of clinical trials, including studies performed as part of the TIN (**Aim G1.1**).
- Analysis: Through the BERD Core (**Aim E1.1**), the CTO Program will provide support for data management, cleaning, and analysis.
- Data sharing and dissemination: Through the Regulatory Knowledge and Support (RKS) Core's data sharing resource (**Aim E2.2**), the CTO Program will enable data sharing. Through early engagement of investigators with the Impacting Practice and Policy by Accelerating Translation (IMPACT) (**Core H**), the CTO Program will help integrate implementation and dissemination planning into all patient-oriented research projects.

Research technology innovation: Alignment of the technology systems supporting the various operations of the CTO Program will require interoperability of data and data systems. Standards-based interoperability approaches will ensure maximum flexibility and adaptability. Working off the shared vision from the Delphi study, CTSI will identify interoperability and functionality requirements in at least the following areas:

- Standardized collection of real-world data into RedCAP, OnCore, and other data collection systems: e.g., CTSI will leverage OnCore's current and future capabilities for ingesting EHR data in HL7 FHIR format, the *de facto* EHR data exchange standard. With NIH promoting FHIR for biomedical research,[16] it will also explore collection of other real-world data such as sensor[17] and patient-reported outcomes[18] data in FHIR format.
- Standardized study variables: The NIH Common Data Elements (CDE) Repository contains over 26,000 data elements that have been recommended or required by NIH and other organizations for research and for other purposes. Industry trials are increasingly using CDEs and standardized case report forms from the Clinical Data Interchange Standards Consortium (CDISC). For industry trials, FDA requires lab data to be coded in LOINC starting in 2020, and all dataset submissions must be in CDISC format. CTSI will support UCSF researchers to navigate and implement CDEs where required or appropriate.
- Data sharing and reuse: The work in **Aim E2.2** to support UCSF researchers in meeting data sharing requirements must dovetail with upstream technical and business processes.
- Lifecycle management: Protocol representation standards offer a potential approach to interoperating study management systems across the full lifecycle. CTSI will partner with CDISC to explore the use of CDISC 360 lifecycle tools[19] to support research management in academia(see **Letter of Support from CDISC** in Overall section).

Transforming toward comprehensive lifecycle support for patient-oriented research will be a multi-year process requiring buy-in from multiple stakeholders. Throughout this Aim's work, the Administrative Core will adapt implementation science strategies from the Expert Recommendations for Implementing Change (ERIC) project[20] to work iteratively with stakeholders. The implementation process will include activities to: 1) build toward organizational adoption; 2) stage, conduct, evaluate, and scale-up implementation projects; 3) facilitate and maintain adoption of technical and organizational change; and 4) ensure technical, organizational, and economic sustainability. Program evaluation will follow methodology from **Aim A2.2**.

Table A12. Quality and Efficiency Milestones and Metrics

Aim A3.1: Implement organizational and technology-enabled solutions to ensure quality and efficiency of patient-oriented research lifecycle.	
Milestones	*Metrics (#, %, rating)*
Shared vision and priorities	Landscape analysis (y/n)/Delphi (y/n) # stakeholders interviewed/surveyed Stakeholder ratings
Operational roadmap for systems solutions	# of pilots, # of operational metrics improved

CORE B. INFORMATICS: SPECIFIC AIMS

CTSI's Informatics Core supports all stages of clinical and translational science from knowledge discovery to community engagement to education. The Informatics Core is centrally involved across this renewal application in supporting omics and other biospecimen data management for precision medicine (**Aim G2.3**), community-based "ecological" data sets for population health (**Aim C1.3**), interoperability and harmonization among existing informatics platforms (**Aim G2.2**), and informatics support ensuring clinical trial quality (**Aim A3.1**) and enabling data security and sharing (**Aim E2.3**). A top priority for the clinical and translational science community is increasing the capacity of electronic health record (EHR) systems to enable health improvement and discovery. As currently configured, EHR systems represent a major barrier to achieving this.[1-6] CTSI's Informatics Core has been a leader in the CTSA network in EHR-based informatics-powered health improvement and discovery and proposes four aims that focus substantial effort on expanding training, resources, services, and network leadership in this area.

Aim B1. Increase access to and utility of EHR and EHR-linked data assets.

The Informatics Core will continue its development of EHR-based data assets with de-identification and maintenance of common data models; build a high-performance data warehouse infrastructure for EHR/EHR-linked data assets to support advanced data science and modeling; develop a streaming data analytics platform to support capture and real-time utilization of streaming data assets; support access to EHR data from our safety-net hospital and other regional partners; and provide expanded support services for researchers.

Aim B2. Enable next generation clinical decision support (CDS) and digital interventions.

The Informatics Core will develop a new “efferent arm” platform that will enable delivery of informatics-powered CDS through the EHR and patient-facing interventions using UCSF’s patient portal and a newly-enabled smartphone app ecosystem. Specifically, the Core will develop a new modular platform that supports development and hosting of digital intervention “apps” using existing standards (e.g., SMART [Self-Monitoring, Analysis and Reporting Technology], FHIR [Fast Healthcare Interoperability Resources], CDS Hooks). This platform will integrate with the EHR and with the emerging ecosystem of smartphones and connected/wearable devices to increase support for development of novel digital interventions, with design, budgeting, software development, and project management services for research projects requiring technical development.

Aim B3. Provide informatics support for research embedded within or enabled by health systems.

With informatics support, health systems can enable recruitment of study participants, collection of real-world data linked with patient-generated data, and conduct of efficient clinical trials and quasi-experimental studies entirely embedded within EHR systems and clinical workflows. Through these embedded Learning Health System research projects, health systems can improve and generate knowledge while delivering health care. In partnership with UCSF Health, the Informatics Core will leverage EHR and EHR-linked data assets for study participant recruitment; support integrated eConsent, online surveys, and mHealth data collection for research; develop a cloud-based adaptive randomization engine enabled for use by multisite clinical trials; and support health system-embedded clinical trials.

Aim B4. Develop and disseminate curricula in informatics and data science.

The informatics infrastructure described above will require a sophisticated workforce of users and future innovators. In collaboration with Cores D (Translational Workforce Development) and I (Institutional Career Development), the Informatics Core will support new workshops, courses, and degree programs in informatics for trainees, staff, and faculty learners.

Abbreviations used in Core B

EHR = Electronic Health Record	ZSFG = Zuckerberg San Francisco General
CDS = clinical decision support	ACT = Accrual to Clinical Trials
SMART = Self-Monitoring, Analysis and Reporting Technology	AWS = Amazon Web Services
FHIR = Fast Healthcare Interoperability Resources	SHARP = SMART Health Apps Rapid Platform
BCHSI = Bakar Computational Health Sciences Institute	UC BRAID = Biomedical, Research, Acceleration, Innovation and Development
SOM Tech = School of Medicine Technology Team	
OMOP = Observational Medical Outcomes Partnership	SFBay-RIN = San Francisco Bay Research Infrastructure Network
LHS = Learning Health System	NLP = Natural Language Processing
CDW = Clinical Data Warehouse	DSU = Digital Services Unit
PHI = Protected Health Information	API = Application Programming Interface
CD2H = Clinical Data to Health	

CORE B. INFORMATICS: RESEARCH STRATEGY

CTSI's Informatics Core develops innovative informatics infrastructure (including data assets, tools, services, curriculum, and governance) to support all stages of clinical and translational research. The Informatics Core has established close working relationships with all relevant institutional partners including UCSF IT, the Bakar Computational Health Sciences Institute (BCHSI), the School of Medicine Technology Team (SOM Tech), the Center for Digital Health Innovation (CDHI), the Center for Clinical Informatics and Improvement Research, and a new UCSF Digital Collaborative that supports and coordinates digital health/technology work at UCSF. In the current grant cycle, the Informatics Core focused on foundational work in developing and demonstrating EHR and EHR-linked data assets, data extraction and support services, EHR modifications for delivery of experimental interventions and EHR-embedded clinical trials, a new digital mobile health research platform, and efficient systems for participant recruitment (**Table B1**).

Table B1. Selected accomplishments of the Informatics Core

Identified need	Implemented change and outcome
Access to EHR data, additional linked data assets, tools, infrastructure and support services	Consolidated data extraction services (50% increase in volume and 70% reduction in time to data delivery for 200+ projects in 2019 alone); upgraded secure portal for protected health information data delivery and analysis (3,520 users hosted); de-identified EHR data assets now available via self-service access (no IRB required); high performance compute infrastructure (AWS, Apache Spark) for EHR data, images, and free text; installed enterprise Tableau server and homegrown R Shiny Observational Medical Outcomes Partnership (OMOP) tool for EHR data visualization; installed/implemented EMERSE (University of Michigan software to search EHR notes and free text)
Modify Epic-based EHR system for research, and provide other support for embedded RCTs	Launched a new Digital Services Unit (DSU) that supports intake, solutioning, budgeting, development, and project management for research projects requiring EHR system modification (66 projects served); supported development of 3 SMART on FHIR apps, 4 uses of Epic's Cognitive Computing Platform, and a platform for delivery of machine-learned decision support and enhanced images to the point of care (used by 3 clinical departments); co-developed CommonHealth, a new Android app equivalent to Apple Health
Informatics support for patient recruitment and digital engagement	Developed informatics infrastructure to support EHR-based recruitment of research participants (110,000 patients invited for 46 studies); launched 7 embedded randomized clinical trials and a Learning Health System (LHS) Oversight Committee to act as a standing DSMB; launched a direct-to-participant digital research platform enabling mHealth data collection via digital device/API-based data collection (20+ studies) and enabled EHR/mobile health-linked data collection; produced community-engaged design toolkit to facilitate digital engagement of diverse populations

APPROACH

Aim B.1. Increase access to and utility of EHR and EHR-linked data assets.

The Informatics Core (see **Table B2** for Core leadership) in close partnership with UCSF IT develops and hosts an extensive series of data assets derived from our Epic-based EHR system (**Figure B1 below**) and provides support services that help clinical and translational investigators access and use EHR data. The Core is strongly committed to evaluation and participation in NCATS's Common Metrics.

Table B2. Informatics Core Leadership

Name	Core Role and Qualifications
Mark Pletcher, MD	**Informatics Core Director:** Dr. Pletcher is a UCSF Professor and Chair of UCSF's IT Governance Research Technology Committee.
Ida Sim, MD, PhD	Informatics Lead: Dr. Sim is a UCSF Professor and Director, Digital Health for the Division of General Internal Medicine. She has served on multiple advisory committees of the National Research Council and National Academy of Medicine.
Atul Butte, MD, PhD	Data Science Lead: Dr. Butte is a UCSF Professor and Director, Bakar Computational Health Science Institute. He is the Chief Data Scientist for the University of California Health System and a member of the National Academy of Medicine.
Vanessa Jacoby, MD	Recruitment Lead: Dr. Jacoby is a UCSF Associate Professor. Dr. Jacoby is the director of CTSI's Participant Recruitment Program.
Ralph Gonzales, MD	Learning Health System Lead: Dr. Gonzales is a UCSF Professor, the Associate Dean for Clinical Innovation, School of Medicine, and the Chief Innovation Officer for UCSF Health.
Leslie Yuan	Information Technology Co-Lead: Ms. Yuan is CTSI's Chief Information Officer.
Rick Larsen	Information Technology Co-Lead: Mr. Larsen is the Director of Research Informatics, UCSF Health.
Alka Kanaya, MD	Training Lead: Dr, Kanaya is a UCSF Professor and a member of the MPI team for CTSI's KL2 and TL1 programs. She directs CTSI's Clinical and Translational Science Training program.

Expand development of data assets, with de-identification and maintenance of common data models. The Informatics Core's EHR-linked data assets include Epic data products (Clarity and Caboodle, depicted in black), common data models (blue), de-identified data assets (green), and a pilot version of a next generation cloud-based data warehouse (**Figure B1**). The Clinical Data Warehouse (Caboodle/CDW) includes data from external systems, including lab values and diagnoses from our legacy proto-EHR system launched in the 1980s, death dates from the California Death Index, and geocoded patient addresses enabling linkage with geospatial datasets (**Aim C1.3**).

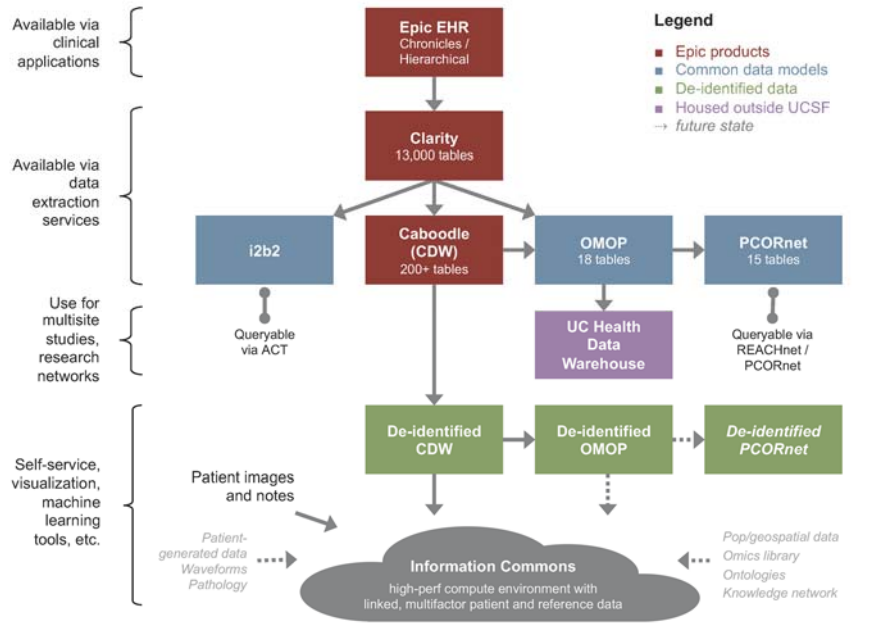


Figure B1. Informatics Core EHR-based data assets

The i2b2/SHRINE installation supports ACT; the OMOP database feeds into a UC Health Data Warehouse (combining with data from the other four University of California medical centers); and the PCORnet datamart is searchable via REACHnet, a PCORnet clinical research network that also enables secure linkage (via Datavant) to claims data. De-identified versions of CDW and OMOP, recently certified, enable CTSI researchers to have self-service access to EHR data without an honest broker (for data extraction) or IRB approval. For researchers who need assistance or need PHI, the Core will continue to work with investigators to define detailed specifications for required data elements and then honest broker data analysts complete the data extraction. Data extraction files containing PHI are delivered to investigators within a secure “MyResearch” environment. The Core hosts data visualization tools including a new enterprise Tableau server enabling use with PHI-laden EHR data and a home-grown R Shiny tool (Patient ExploreR) that allows search, drill down, and time-bound visualization of patient records; the open-source OMOP version is available.[7]

Build a high-performance data warehouse infrastructure for EHR/EHR-linked data assets, integrated with a knowledge network and population data, to support advanced data science and modeling. As EHR and EHR-linked data assets continue to expand in both volume and type/source, their value multiplies for data science and machine learning. However, ingesting, linking, de-identifying, and analyzing the data becomes increasingly difficult with traditional data warehouse infrastructure. Following designs envisioned in the 2011 National Academy report on Precision Medicine,[8] CTSI and BCHSI (led by Dr. Butte) have been building a next generation Precision Medicine platform called the "Information Commons" that supports high-performance compute-enabled machine learning/artificial intelligence using EHR/EHR-linked data assets with an underlying knowledge network (**Figure B1**). The pilot version is hosted by Amazon Web Services (AWS) and built on Apache Spark. Over the next five years, the Core will undertake a systematic evaluation of the three major cloud platform vendors (Amazon, Google, and Microsoft), informed by and in collaboration with CD2H's Tools and Cloud Infrastructure community. We will assess functionality, usability, security, and performance. Once a platform is chosen, the Informatics Core will set up EHR and EHR-linked data inputs and configure the platform to enable high-performance querying, model-fitting, and advanced machine-learning/artificial intelligence. In parallel, the Core will start loading novel data assets (e.g., clinical notes, radiology and pathology images, biospecimen-derived omics data (**Aim G2.3**), data from wearables and consumer smartphone apps, and developing regular automated data refresh mechanisms. Data warehouse concepts/ontologies will be linked to an emerging precision medicine knowledge network[8-10] and to relevant population health data (in collaboration with our Population Health Data Initiative, **Aim C1.3**). These assets will accumulate over time, increasing in size and value with the integration of additional data sources.

Develop a Streaming Data Analytics Platform to support capture and real-time utilization of high-resolution streaming data assets. The Informatics Core's current EHR-based data assets are limited by latency (Clarity is

updated once daily), transformation (some data sources, e.g., HL7 messages, are transformed with some information loss into structured data elements) and low sampling frequency (waveform data is output once a minute, so the microstructure is lost). The Core will develop a Streaming Data Analytics Platform to capture HL7 messages, waveform data from bedside monitors, and patient-generated data from sensors/apps with minimal transformation. This will capture data with richer information content for machine learning. It will also make these data available for real-time rendering of machine-learned decision support to enable digital interventions (**Aim B2**). We will also explore the HL7v2 REST interface and FHIR transformation features now available in cloud platforms, which could add value for data science[11] and for integration with the SMART Health Apps Rapid Platform (SHARP, **Aim B2**).

Support access to EHR data from our safety-net hospital and other CTSI/regional partners. CTSI has partnerships with many local and regional health systems and networks (**Aim A1.3**) that would benefit from informatics support. The CTSI-affiliated local safety net hospital Zuckerberg San Francisco General (ZSFG) has a newly installed Epic-based EHR system. The Informatics Core, in collaboration with ZSFG's health system leadership, will support development of ZSFG's EHR-based research data assets, including de-identification of their CDW and support for OMOP to enable cross-institutional querying. We will also work closely with the SFBay-RIN, IDeA Network partners, UC BRAID, and other regional partners (e.g., Sutter Health) to support a region-wide health information exchange that could facilitate both networked research projects and regional surveillance and population health interventions.

Provide support services for CTSI researchers. Researchers interested in using our expanding data assets and infrastructure need support services, including help with study design and data extraction, management, and analysis. This is especially true for our newer advanced resources, including the Information Commons (e.g., for natural language processing, imaging, and omics data analyses), the Streaming Data Analytics Platform (HL7 messages, FHIR, wave form data), and the UC Health Data Warehouse (cross-institutional OMOP), all of which require special expertise. The Informatics Core, in collaboration with BCHSI, will develop the required specialized consultation services to be hosted by CTSI's BERD Core (**Aim E1.1**). The Core will also work with RKS to develop regulatory guidance and resources for researchers regarding the use of EHR and other patient data sets (**Aim E2.2**). The Core will also support use of a newly purchased Github enterprise license for collaborative development and reuse of EHR data analysis code. This tool will be available to central IT analysts and to researchers, and should provide tangible benefits to a growing set of "communities of practice" user groups (e.g., for natural language processing (NLP) and Clarity) that CTSI has cultivated in recent years. The Core carefully tracks service provision and quality metrics, and will present regularly to researcher-stakeholders on a newly formed Data Sciences Faculty Council to ensure it is meeting the needs of clinical and translational researchers.

Aim B2. Enable next generation clinical decision support (CDS) and digital interventions.

The Informatics Core has supported a series of demonstration projects implementing digital interventions using our EHR system and recently launched a Digital Services Unit (DSU) that supports a broader set of projects requiring EHR system modifications. Through these efforts, the Core has learned about the pain points in the development process for informatics-powered digital interventions. To address these pain points and accelerate development of next generation CDS and digital interventions, the Core plans the following efforts.

Develop a new modular platform to support digital interventions. The SMART Health Apps Rapid Platform (SHARP) will support development and hosting of digital intervention "apps" for clinicians and patients using existing standards (SMART,[12] FHIR,[13-15] CDS Hooks[16,17]) that integrate with our EHR and an emerging ecosystem of smartphones and connected/wearable devices (**Figure B2 below**). SHARP will feature:

- Connections to EHR (Epic) APIs including FHIR and Interconnect enabling bidirectional data flow
- Cloud-based hosting of SMART, SMART on FHIR,[18] and CDS Hooks apps with an open source development environment that allows research teams to easily "fork and edit" (modify app code that exists in an accessible repository) to quickly launch new, derived apps for different purposes
- Automated software deployment managed in concert with governance mechanisms (streamlined "dev-ops") to minimize barriers to technical development and accelerate translation of idea to production
- Expanded use of the FHIR data standard, e.g., "SQL on FHIR,"[19] enabling use of data from Clarity and OMOP along with data elements pulled from the FHIR API
- A single "Client ID" from the perspective of the EHR (Epic's App Orchard) that will support multiple functional apps, reducing regulatory and financial barriers to innovation and dissemination

- Connection to the Streaming Data Analytics Platform (**Aim B1**) so SHARP apps can use real-time streaming data in decision support and can launch from an HL7 "push" event
- Connection with the emerging ecosystem of wearable devices and smartphone apps made possible by Apple Health and the Android CommonHealth app (co-developed by the Informatics Core and first-piloted at UCSF), which deliver FHIR-extracted data to consumers' smartphones and make it available to other smartphone apps to enable consumer-facing digital interventions

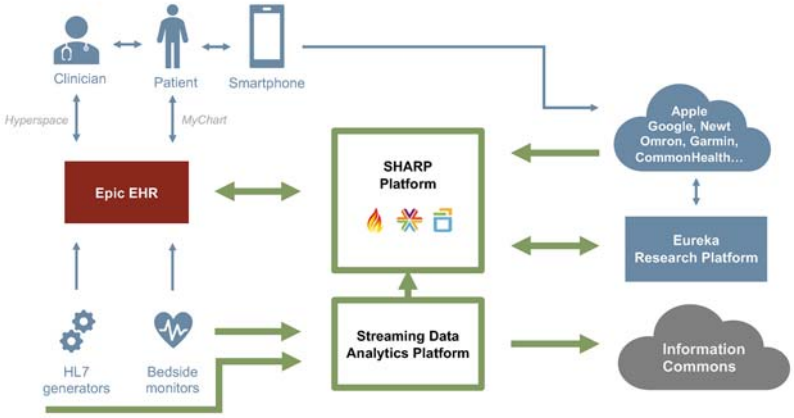


Figure B2. SMART Health Apps Rapid Platform (SHARP)

- Connection to Eureka and a proposed cloud-based randomization engine (**Aim B3**) to enable embedded, multisite, direct-to-participant RCTs
- A modular technical roadmap allowing the development of independent modules for particular use cases as they arise

To help develop and demonstrate the utility of SHARP, the Informatics Core will release a Call for Proposals, hosted on the CTSI Open Proposals platform,[20] to solicit ideas from clinicians for SMART on FHIR apps that the Core will then build out. The Core will work closely with CD2H to invite, encourage, and support use and open source co-development by CTSA partners, following the roadmap CTSI's technical group has used for co-developing Profiles and Clinical Trial Finder with CTSA partners (**Aim G2.2**).

Increase support for development of novel digital interventions. As mentioned, the Informatics Core recently launched the DSU that provides intake, design, budgeting, software development, and project management for research projects requiring technical development of new digital interventions using our EHR system. The DSU has quickly become heavily utilized by CTSI researchers; DSU has launched 17 projects into our production EHR environment, including three live SMART on FHIR apps, and four uses of Epic's Cognitive Computing Platform for real-time predictive analytics-enabled decision support systems. In the renewal, the Informatics Core proposes to build the DSU into a sustainable service governed jointly by UCSF Health and CTSI, supported by the SOM Tech team, and used by UCSF's Digital Collaborative as the sanctioned approach for implementing digital interventions (see **Letter of Support from UCSF Digital Collaborative** in Overall section).

Aim B3. Provide informatics support for research embedded within or enabled by our health systems.

Health systems engage patient populations, collect EHR data, and wield important technology (EHR systems) that can enable research, discovery, and innovation to impact health. UCSF Health, our health system, is committed to supporting CTSI research, and vice-versa, in a self-reinforcing Learning Health System (see **Letter of Support from UCSF Health** in Overall section). The Informatics Core will provide support for these efforts, from participant recruitment, eConsent, randomization, and collection of patient-reported outcomes and mHealth data, to conduct of randomized clinical trials that are fully embedded within our health system.

Leverage EHR and EHR-linked data assets for study participant recruitment. The Informatics Core has provided a participant recruitment service that helps researchers develop an EHR data query to find eligible patients (e.g., based on diagnoses, medications, etc.) and then serves as an honest broker to mail patients study-specific recruitment materials. In the current grant cycle, 46 studies have used this service to send >110,000 letters to UCSF Health patients about research participation opportunities. More recently, the Core (with close collaboration from UCSF Privacy, Compliance, IRB, and Patient and Family Advisory Groups) increased EHR recruitment capacity by developing a dynamic search program that identifies newly eligible patients on a daily basis using new diagnosis codes, laboratory or imaging results and supports recruitment messages sent daily through our EHR MyChart patient portal. The Core pilot tested this workflow in 12 studies and found that 40% of enrolled participants were engaged in the study through the MyChart recruitment message. Study teams report high satisfaction with the program because it is easy to use and has high yield for participant enrollment. Careful attention was paid to preventing over-contacting of potential participants by limiting MyChart recruitment

messages to 2/patient/week. In addition to providing ongoing support for these services, the Core will expand its capacity to find study eligible patients through real-time EHR searches by developing new services to identify: 1) newly admitted inpatients, 2) patients in the Emergency Department, and 3) patients with upcoming appointments in outpatient clinics. Recruitment alerts triggered by these EHR searches will be sent to study teams via email or page/SMS with adequate safeguards to protect against alert fatigue. These services will also be available for TIN clinical trials (**Aim G1.2**), and the Core will work with CD2H to disseminate EHR-based recruitment tools across the CTSA network.

Support integrated eConsent, online surveys, and mHealth data collection for research. The Informatics Core's mobile health research platform (Eureka) supports eConsent and integrated data collection from a wide variety of consumer wearable devices and apps.[21-26] Eureka is connected to UCSF's FHIR API ("Eureka on FHIR") so that the platform can directly collect EHR data from consenting UCSF patients. The Core plans to further integrate the Eureka platform with SHARP (**Aim B2**) to support direct-to-participant trials of SHARP interventions and SMART on FHIR launch from a patient portal context so partner institutions can easily use EHR-linked data collection. This will provide the CTSA Consortium with a tool that supports collection of linked EHR, mHealth, and patient-reported outcomes data for direct-to-participant multisite trials.

Develop a cloud-based adaptive randomization engine enabled for use by multisite randomized clinical trials. The Informatics Core has successfully implemented stratified blocked randomization for patients, encounters, providers, and other randomization units within an Epic-based EHR system. The Core plans to build in adaptive randomization algorithms that require a feedback loop (via FHIR calls) and enable multisite embedded randomized clinical trials by generalizing randomization procedures and hosting them (with CD2H) in a cloud platform available to the CTSA network.

Support health system-embedded randomized clinical trials. The Informatics Core, in collaboration with UCSF Health leadership and IT, has supported a series of methodology pilots designed to develop and demonstrate capacity for conducting randomized clinical trials that are fully embedded in our health system (**Table B3**). These studies use our EHR (Epic) system for enrollment, randomization, intervention delivery, and data collection, and they are seamlessly embedded within clinician workflow. These "LHS Demonstration Projects" have all required technical and methodologic innovation.[32]

Table B3. Health system-enabled RCTs and technical innovations required

Trial focus	Technical innovation
COPD admission orders	Adaptive admissions order set triggered by a logistic function using ED data
Newborn feeding supplementation	Weight loss nomogram delivered to clinical workflow through SMART on FHIR
Unnecessary vital sign checks	Sidebar alert/ordering using Epic Cognitive Computing Platform (logistic function)
Hypoglycemia alerts to clinicians	Delivery of alerts to clinicians via customized "careweb" pager system
Unnecessary telemetry	Alert delivered to clinicians when recommended telemetry duration exceeded
Ultrasound for nephrolithiasis	Alert triggered by CT scan order that provides safety criteria for ultrasound use
Hypertension management	FHIR integration with mobile health data delivered via in-basket message

In partnership with the LHS Leadership Group (**Aim A1.2**), the Informatics Core will build on this foundation in the following ways:

- Strengthening our partnership with UCSF Health through collaboratively demonstrating the value of A/B testing and randomized quality improvement in helping to achieve True North goals
- Scaling up design and analysis services, including implementation of an automated reporting system that supports on-demand generation of analysis tables and an envisioned "Bayesian analysis dashboard" for interim monitoring of EHR-embedded trials, with a dedicated consultation service (**Aim E1.2**)
- Strengthening governance models, building on our existing LHS Oversight Committee, which acts as a standing Data and Safety Monitoring Board for embedded randomized clinical trials and early termination/implementation decisions
- Supporting EHR-embedded RCTs utilizing apps developed and hosted on SHARP (**Aim B2**)
- Exploring EHR-embedded trials at ZSFG and other CTSI network partners. As best practices for integrating health system and research priorities develop, CTSI will learn from successful institutions (e.g. NYU,[27] Vanderbilt,[28] Duke[29,30]) and further contribute to the CTSA consortium

Aim B4. Develop and disseminate curricula in informatics and data science.

As described in Core I (**Aim I2**), CTSI supports extensive clinical research training and career development programs in partnership with the Department of Epidemiology and Biostatistics. These programs include an established track in implementation science and a new track in data science, and a variety of courses relevant

to but not focused on informatics.[31] In collaboration with Core D, Core I, and the Department of Epidemiology and Biostatistics, the Informatics Core has recently helped launch development of a Master's program in data science; this will be expanded in the current cycle to include a partner program in clinical informatics and extensive new course development (**Table B4**).

Table B4. Course list (partial) for curricula in data science and clinical research informatics

Curriculum in data science	Curriculum in clinical informatics
Introduction to Data Science (BIOSTAT 202)	Introduction to Clinical Informatics (Proposed)
Introduction to Computing in R (BIOSTAT 213)	Working with Electronic Health Record Data (Proposed)
Advanced R/Data Wrangling (Planned Winter, 2020)	Leadership in Informatics Systems (Proposed)
Machine Learning I (BIOSTAT 216)	Human-centered Design (EPI 243)
Machine Learning II (Planned Winter, 2020)	Health Systems and Health Policy (Proposed)
Stochastic Simulation (Proposed)	Consumer Technology and Digital Health (Proposed)
Data Visualization Methods (Proposed)	Cloud Platforms for Data Storage and Analytics (Proposed)

CTSI will directly co-develop two new informatics courses – Introduction to Clinical Informatics and Working with EHR Data – that CTSI leadership sees as critical deficiencies. The Informatics Core will co-develop these courses and other curricula across the spectrum of our workforce, from students and staff researchers and data managers to faculty and frontline clinicians engaged in quality improvement, to ensure that the workforce of the future contains well-trained informatics leaders.

Table B5. Informatics Core Milestones and Metrics

Aim B1. Increase access to and utility of EHR and EHR-linked data assets.	
Milestones	*Metrics (#, %, rating)*
Accessible data assets	COMMON METRICS % patients with age/DOB value; % patients with administrative sex value % of patients with LOINC ID value; % of patients with RxNorm ID value % of patients with ICD 9/10 or SNOMED or CPT Procedure value % of patients with free text data Presence of Observations or Absence of Observations Terabytes (TB) accessible EHR/-linked data: Total/de-id/OMOP/in high performance compute
High-performance data warehouse with images, notes, omics, pathology, waveform data, and underlying knowledge network	# new data types; # knowledge network nodes + connections/databases # publications supported
Streaming data analytics platform with HL7 messages and waveform data captured and available in real time	# HL7 messages stored # bedside monitors streaming into platform # analytics produced and available in real time
EHR data access and interoperability for ZSFG and other regional partners	# ZFSG EHR data users/projects/extractions # health systems with CDW/de-identified/OMOP # networked regional projects using EHR data
Support services for EHR data use	# users/projects/extractions Time to extraction, user satisfaction # Github repositories and registered active users
Aim B2. Enable next generation clinical decision support (CDS) and digital interventions.	
SHARP Platform implementation, apps supported, features enabled, developers using the platform, clinicians and patients using the apps	# apps supported by platform, total/clinician/patient # using SMART/FHIR/CDS Hooks; Streaming Data Analytics Platform; using CommonHealth or wearable data; with multisite implementation # developers contributing code # tracked app views/downloads by clinicians/patients
Digital Services Unit support services	# project intakes/letters of support/funded/launched
Aim B3. Provide informatics support for research embedded within or enabled by our health system.	
Study participant recruitment via EHR methods	# projects supported/invitations/team alerts delivered/patients recruited
Eureka Research Platform support for eConsent, online surveys, mHealth data collection, EHR integration	# eConsents/surveys/mHealth observations collected # Institutions enabling Eureka on FHIR # EHR encounters imported via FHIR
Cloud-based randomization engine	# multisite RCTs enabled # adaptive randomization algorithms activated
Support for health system-embedded RCTs	# embedded RCTs launched/in-progress/completed # randomization events # RCT-evaluated interventions implemented
Aim B4. Develop and disseminate curricula in informatics and data science.	
Informatics/data science curriculum	# new courses, # students enrolled

CORE C. COMMUNITY AND COLLABORATION: SPECIFIC AIMS

Community Engagement (CE) and Collaborative Team Science (CTS) are the foundational themes upon which CTSI has built this renewal. Inclusiveness and partnership represent the building blocks of transformative, impactful science, and this principle informs all of the **Community and Collaboration Core's** Aims and research methods. In Core C, the CE and CTS units have proposed an integrated and innovative program for promoting broadly engaged team science and for providing UCSF and its stakeholder partners with the training, resources, and tools necessary for success. Bidirectional dissemination of successes with the CTSA network will be emphasized.

Section C1: Community Engagement (CE)

Aim C1.1. Promote community engagement and partnership with community advisory boards in all Hub-based research activities.

The CE Core partners with patients, clinicians, and community members through organized systems to increase stakeholder-engaged research. The CE Core will work to implement standardized, institution-wide community engagement through partnership with community advisory boards (CABs). This will include developing standard contractual agreements and operating guidelines for CAB members; digital tools to facilitate CAB recruitment; CAB "best practice" tool kits; training of CAB members and researchers; and consultation on methods to evaluate CAB engagement processes and outcomes.

Aim C1.2. Develop a pipeline of community-based leaders with practice-based research skills and successful academic-community research collaborations.

The CE Core will build on its extensive Community-based Participatory Research (CBPR) experience to develop a training program designed to assist UCSF's network of community-based residency programs in developing the next generation of practice-based researchers called Training In Practice-based Research (TIPR).

Aim C1.3. Integrate socioeconomic, environmental, and regulatory datasets with EHR-based patient-level data to enhance population health research.

In collaboration with the Informatics Core (**Core B**), the CE Core will enable researcher access to and use of ecologic datasets (datasets that include social (e.g., racial segregation), environmental (e.g., green spaces), and policy (e.g., soda taxes) variables to promote application of multilevel methods to community-engaged population health research.

Section C2: Collaboration and Multidisciplinary Team Science (CTS)

Aim C2.1. Enhance resources to support broadly engaged team science.

The CTS Core will promote multidisciplinary scientific and community-based team science through a variety of methods: team science-focused supplements to CTSI pilot grant awardees; enhanced recognition of team science in the academic review, promotion, and tenure process; and partnering with the RKS Core (**Core E**) to provide regulatory guidance and resources around barriers to broadly engaged team science.

Aim C2.2. Promote broadly engaged team science by developing non-traditional investigators.

The CTS Core will collaborate with the CE and Translational Workforce Development (TWD) Cores to develop research capacity and skills among community members. This innovative program will develop "non-traditional" investigators among non-medical community members and non-clinician health care workers with the ability to effectively collaborate as team science partners in clinical and translational research. These efforts will be evaluated and successes will be disseminated across the CTSA network.

Abbreviations used in Core C

CE = Community Engagement	CBPR = Community-based Participatory Research
CTS = Collaboration and Multidisciplinary Team Science	PBRN = Practice-based Research Network
CAB = Community Advisory Board	SFHIP = San Francisco Health Improvement Program
TWD = Translational Workforce Development	SFBayRIN = San Francisco Bay Research Infrastructure Network
UC BRAID = Biomedical, Research, Acceleration, Innovation and Development	TIPR = Training in Practice-based Research
SFBayCRN = San Francisco Bay Collaborative Research Network	PHDI = Population Health Data Initiative
	BERD = Biostatistics, Epidemiology, and Study Design (Core E)
ASPIRE = Accelerating Systematic Stakeholder, Patient, and Institution Research Engagement	ISP = Integrating Special Populations

CORE C. COMMUNITY AND COLLABORATION: RESEARCH STRATEGY

Section C1: Community Engagement

Advancing a novel model of System-based Participatory Research[1] grounded in the disciplines of Community-based Participatory Research (CBPR) and Practice-based Research Networks (PBRN), the Community Engagement (CE) Core partners with patients, clinicians, and community members through organized systems to increase translational science efficiency and impact across all aspects of CTSI. The CE Core is closely connected to the UCSF Center for Community Engagement (CCE), a campus-wide program promoting partnerships across all university mission areas, UCSF Health and the UCSF Health Office of Population Health, the San Francisco Department of Public Health, and multiple community-based coalitions. The extensive array of the CE Core's stakeholder partners is shown in **Figure C1**.

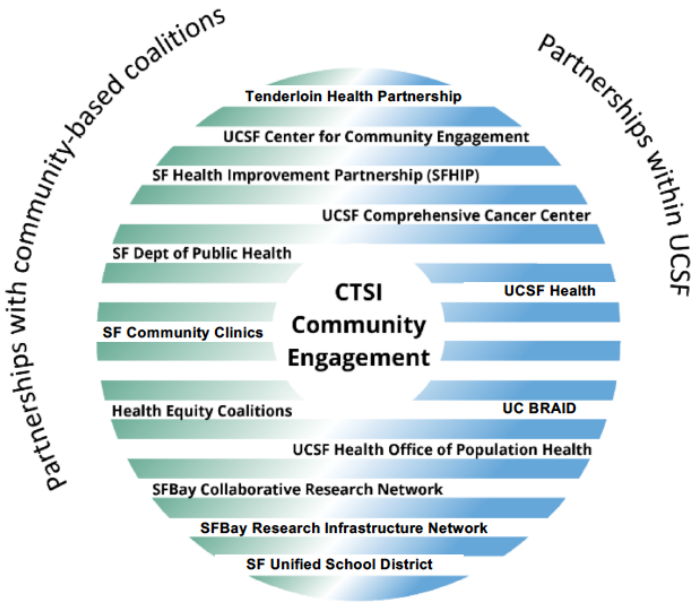


Figure C1. Selected CE Core partnerships

The CE Core has successfully constructed and progressively enhanced two key infrastructures for systems-based participatory research. The San Francisco Health Improvement Partnership (SFHIP)[2] is a vibrant citywide consortium that studies and implements sustainable community-based interventions involving San Francisco's public health department, school district, ethnic-focused community health equity coalitions, local hospitals, Board of Supervisors, and other stakeholder groups. The SFBay Collaborative Research Network (SFBayCRN) is a partnership with large medical groups and consortia of community health centers to study primary care innovations and develop processes for sharing electronic health record (EHR) data.[3] In addition to supporting these infrastructures, the CE Core conducts trainings, consultations, and community linkages. **Table C1** presents selected significant accomplishments from the current funding cycle.

Table C1. Selected Accomplishments of the CE Core

Identified need	Implemented change and outcome
Strengthen academic and community capacity to conduct stakeholder-engaged research	Successfully engaging diverse stakeholders including community members, civic organizations, and clinicians participating in the SFBayCRN PBRN; high profile engagement projects include NIH-funded All of Us Precision Medicine Initiative, UCSF Comprehensive Cancer Center San Francisco Cancer Initiative, and UCSF Benioff Children's Hospital NIHLBI sickle cell registry, in addition to multiple new extramurally funded research studies with UCSF-community partnerships.
Promote science-informed practice and policy strategies to prevent chronic disease and reduce inequities	Forged scientist-community SFHIP partnership to synthesize research on health effects of sugary beverages (SBs) and effective interventions to reduce consumption of SBs and improve public access to clean tap water; outcomes included enactment of SF soda tax, prohibition of SB sales by UCSF and most SF hospitals, and initiative by SF Public Utilities Commission to install tap water bottle refill stations in public parks and schools.
Advance innovative community-engaged translational methods and practices to local, regional, and national stakeholders	Presentations and trainings co-designed by stakeholder partners on systems-based participatory research at national meetings; co-authored "synergy" manuscript with 5 CTSA-funded CE programs on best practices in stakeholder engagement (currently in press at Journal of Clinical and Translational Science).
Engage regional community-based health organizations as partners in translational science using EHR data	Created a harmonized EHR dataset on 169,000 unique patients with hypertension from 3 SFBayCRN member health care organizations; published initial study on risk factors for poor blood pressure control[3]; contributed data to SF-wide EHR data sharing project including mapping of clusters of patients with hypertension.

One of the CE Core's high-impact efforts in the current cycle has been enabling translation of scientific evidence into policy. As one example, the CE Core made central contributions regarding the science and policy implications of sugary beverage consumption, culminating in the enactment of a soda tax in San Francisco and the elimination of sugary beverages from municipal government facilities, hospitals, health systems, and many universities (including UC-BRAID collaborating institutions).[2] Building on the success of the CE Core's evidence-to-impact efforts, CTSI is proposing a new optional Core in this renewal to further catalyze the University of California, San Francisco's capacity for this work (**Core H**).

APPROACH

Aim C1.1. Promote community engagement and partnership with community advisory boards in all Hub-based research activities.

The CE Core (see **Table C2** for leadership) proposes to sustain foundational activities as well as propose new Aims for the renewal. Sustained activities reflect years of investment and experience in nurturing trusting stakeholder partnerships, and include community engagement consultation (through collaboration with **Core E**) and training (through collaboration with **Core D**), the development and dissemination of resources (e.g., datasets and tool kits) locally and nationally, and supporting the SFHIP and SFBayCRN consortia (see **Letter of Support from San Francisco Joint Health Equity Coalition** in Overall section and **Letter of Support from SFHIP** in Core C). The CE Core will also work closely with the new optional IMPACT Core (**Core H**) to ensure integration of the principles and practices of community engagement.

Table C2. CE Core Leadership

Name	Core Role and Qualifications
Kevin Grumbach, MD	**CE Core Director:** Dr. Grumbach is a UCSF Professor and Chair, Department of Family and Community Medicine. He is a member of the National Academy of Medicine.
Michael Potter, MD	Training in Practice-based Research Lead: Dr. Potter is a UCSF Professor and the Director of UCSF's SF Bay-Clinical Research Network, a practice-based research network of community providers in the greater San Francisco Bay Area.
Tung Nguyen, MD	CAB co-Lead: Dr. Nguyen is a UCSF Professor, Director of the Asian American Research Center on Health and the ISP Core Director. Hs is the PI of the ASPIRE program.
Wylie Liu, MPH, MPA	CAB co-Lead: Ms. Liu is Executive Director, UCSF Center for Community Engagement.
Mark Pletcher, MD. MPH	Population Health Data Lead: Dr. Pletcher is a UCSF Professor, Chair of UCSF's IT Governance Research Technology Committee, and the Informatics Core Director.
Monique LeSarre, PsyD	Community Partner co-Lead: Dr. LeSarre is Executive Director, Rafiki Coalition and Administration Lead for African American Health Equity Council, and Co-Chair, UCSF Center for Community Engagement.
Laura Miller, MD	Community Partner co-Lead: Dr. Miller is the Chief Medical Officer, Alameda Community Health Center Network and a member of the SFBayCRN Steering Committee.

The CE Core has partnered closely with institutional stakeholders (e.g., the Center for Community Engagement) to lead a Patient-Centered Outcomes Research Institute (PCORI)-funded initiative called "Accelerating Systematic Stakeholder, Patient, and Institution Research Engagement (ASPIRE)" to systematically assess opportunities and barriers for involvement of community advisory boards (CABs) in UCSF translational science efforts. This assessment revealed the need for CTSI to formally integrate a CAB into its governance and to develop standardized and user-friendly institutional processes to facilitate formation and operation of study-specific CABs. The CE Core will work closely with the Administrative Core to address the first of these strategic priorities, establishing in the next cycle a CTSI Hub CAB to advise the Administrative core (**Aim A2.1**). In addition, the CE Core will work to implement standardized, institution-wide procedures and policies for research study-specific CABs, informed by the assessment conducted for the ASPIRE initiative and supported by efforts across CTSI (**Aim A2.1**, **Aim E.1.2, Aim F1.1**) This Aim will involve the following activities:

- Standardized contractual agreements and operating guidelines for CAB members. In consultation with community partners, the CE Core will develop guidelines for CAB member incentives and compensation that span a range of commitments. The Core will work with UCSF’s Supply Chain office to streamline and simplify this process, and provide concierge service to assist CAB members in completing required forms.
- Digital tools to facilitate CAB recruitment. The CE Core will collaborate with the Informatics Core to expand the scope of UCSF Profiles to include not only UCSF investigators, but also community research partners, highlighting networks of university-community research collaborators to facilitate linkages with community partners.
- CAB "best practice" tool kits. This cycle, the CE Core updated its set of popular manuals on community-engaged research (> 300 downloads annually). The Core will develop a companion set of web-based resources, including video tutorials, providing more pragmatic “how to” information on CAB formation and operation, and will disseminate this tool kit locally and across the CTSA network.
- Training for CAB members and researchers to build the capacity of all stakeholders. In coordination with **Core F**, the CE Core will offer formal CAB training workshops quarterly to researchers, trainees, and community members, with a best practice tool kit-based curriculum.
- Consultation on methods to evaluate CAB engagement processes and outcomes. The CE Core will compile a menu of evaluation tools, drawing from formative work conducted by the CTSA Collaboration/Engagement Domain Task Force, and provide consultation to research teams seeking to evaluate the success of their CABs and related engagement strategies.

- Educating the CTSI community on the value and importance of community engaged research and CABs. The CE Core will continue to build awareness of opportunities for stakeholder-engaged research by providing regular updates at monthly CTSI community meetings and inviting leaders of CTSI Cores to join monthly Core team meetings on a rotating basis to strengthen collaborative planning.

The result of the above efforts will be a more efficient and user-friendly process that lowers the “action potential” to establish and sustain project-specific CABs across Hub-based research activities. Major efforts will be made to disseminate these activities across the CTSA program network.

Aim C1.2. Develop a pipeline of community-based leaders with practice-based research skills and successful academic-community research collaborations.

The creation of the SFBay-RIN (**Aim A1.3**) has aligned community-based health system leaders from across Northern California to create an infrastructure for research collaboration, positioning the SFBayCRN in this CE Core Aim C1.2 to engage new community-based partners in regional collaborations. There has recently been substantial growth in community-based family medicine residency training programs affiliated with UCSF (currently 9 programs, > 300 residents), many of which are based at SFBay-RIN member health care organizations. The leaders of both the SFBay-RIN and UCSF's community-based residency programs desire greater research engagement, but their capacity to train their workforce in research methods is limited by lack of local expertise and resources.

In this Aim, the CE Core will build on its extensive CBPR experience to create a training program designed to assist community partners in developing the next generation of practice-based researchers. Working closely with the TWD Core (**Aim D1.1**) and the UCSF Department of Epidemiology and Biostatistics, the Core will develop a "Training in Practice-based Research " Program (TIPR).

The TIPR program will combine foundational skills development in study design and analysis with education in the practice of systems-based participatory research delivered online (**Figure C2**). Critically, TIPR will address several important logistic and academic barriers for practice-based trainees: travel to UCSF for training is impractical and expensive; traditional, in-person curricula are too time intensive for working learners; many clinical research courses are not tailored to practice-based training skills and needs. In addition to focusing training on methods and design specific to practice-based research environments, the program will emphasize essential skills in population health and community-based participatory research. It will emphasize special populations (e.g., rural patients, lower income, and other underserved populations) that are highly prevalent in these community-based settings. Notably, the TIPR program will employ a “train-the-trainer” model, identifying local, residency-based faculty to serve as research champions at each partner program and working with them to facilitate engagement of faculty and residents at their sites and to provide local mentoring (see **Letter of Support from UCSF Family and Community Medicine Education Alliance** in Core C).

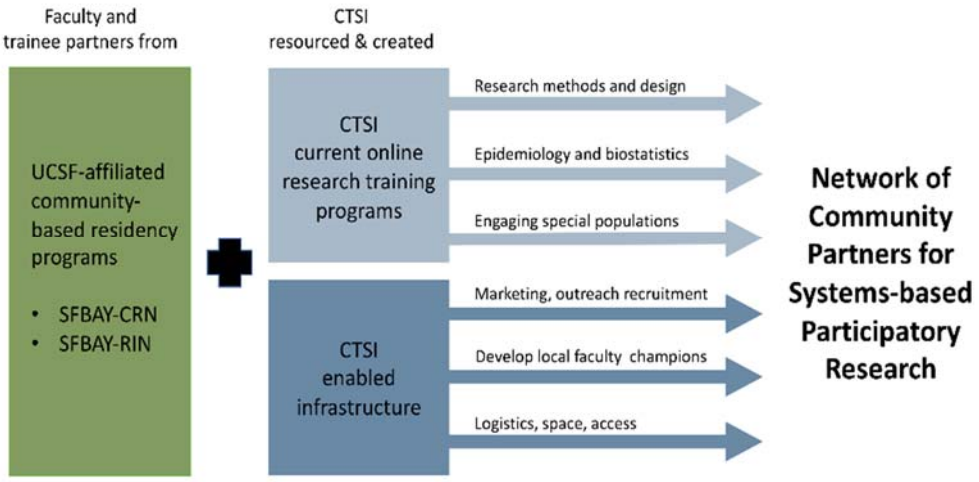


Figure C2. CTSI's Training in Practice-Based Research (TIPR) Program.

Aim C1.3. Integrate socioeconomic, environmental, and regulatory datasets with EHR-based patient-level data to enhance population health research.

The ability to combine large datasets with both patient and population-level variables opens the door to full integration of traditional clinical datasets (e.g., those contained in most EHRs) with "ecologic" datasets that include social (e.g., racial segregation), environmental (e.g., green spaces, air quality), and policy (e.g., soda taxes) variables. These ecological data provide the opportunity for hierarchically structured "multilevel" research (e.g., research to understand group effects and the impact of population level variables)[4,5] and are of particular

value for studying innovative population health interventions as implemented by learning health systems. In 2018, UCSF established the UCSF Population Health Data Initiative (PHDI) (https://pophealth.ucsf.edu/population-health-data-initiative), which leveraged CTSI's Informatics Core to geocode EHR data from UCSF Health and Zuckerberg San Francisco General and link this clinical data to several ecological datasets. The protocols used by PHDI have been made available to UCSF investigators through CTSI Informatics Core (**Core B**) and the BERD core (**Core E1**) and are now used for geocoded data for the UC-wide Common Data Warehouse. The CE Core now proposes to work in close collaboration with the Informatics Core to optimize use of ecological datasets for systems-based participatory research emphasizing population health. Specifically, this Aim will:

- Build capacity among UCSF and community health care partners for multilevel population health research. In collaboration with the SFBay-RIN (**Aim A1.3**), the CE Core will provide orientation and training to community-based health care organizations to incorporate geocoding methods into their own EHRs to promote multilevel learning health systems research in their organizations and collaborative population health research projects aggregating data across organizations.
- Facilitate community-based researcher access to and use of these data sets for research such as targeting of public health resources (e.g. soda tax, community programs addressing social isolation, referrals to community resources, community teaching for advanced care planning in neighborhoods with elders) based on geocoded information about patients. The PHDI currently includes very few resources to engage community-based researchers in the use of these datasets. The CE Core will collaborate with the Informatics and BERD cores to provide access to and consultation on methodology for multilevel research.
- Help develop and implement a community-informed ethical framework for research using population health and other electronic health data in partnership with the RKS Core (**Core E Aims 2.1 and 2.2**).
    - Scale learnings from UCSF Health to University of California (UC) Health systemwide and the broader CTSA network. The newly formed UC Health Systemwide Population Health Collaborative provides an opportunity to scale approaches tested at UCSF to this larger network of health systems. The CE Core will work to disseminate ecological dataset-based systems-based participatory research successes to the broader UC Health system through this systemwide collaborative, and to the CTSA network through Center for Data to Health (CD2H) and other network collaboratives.

Table C3. Community Engagement Core Milestones and Metrics

Aim C1.1: Promote community engagement and partnership with community advisory boards in all Hub-based research activities.	
Milestones	*Metrics (#, %, rating)*
UCSF governance and SOPs for research CABs	CAB member satisfaction survey # contracts with CAB members
Collaborative network with partners	# projects initiated via Profiles with at least one community partner # community partners added to Profiles
Culture of improvement	# clicks/downloads on online evaluation tool kit resources # consults/trainings/workshops/resources #/% organizations/individuals trained
Aim C1.2. Develop pipeline of community-based leaders with practice-based research skills and successful academic-community research collaborations.	
Five community-based faculty champions and four residents trained from each program	#/% of community partners with at least one local champion trainer #/% community-based faculty/resident trained in practice-based research methods
Community research engagement	# practice-based research projects at community partners # clicks/downloads on online CBPR course
Regional collaborations	# projects
Aim C1.3. Integrate socioeconomic, environmental, and regulatory datasets with EHR-based patient-level data to enhance population health research.	
Researcher access to ecological data	# new clicks/downloads on PHDI online tutorials “how tos” # data extractions
Multilevel population health research at UCSF Health	# projects/publications aimed at improving population health using multilevel health data
Community-led multilevel population health research	# organizations implementing geocoding of EHR data #projects/publications using geocoded data from community partner organizations

Section C2: Collaboration and Multidisciplinary Team Science

The Collaboration and Multidisciplinary Team Science (CTS) Core fosters multidisciplinary, multi-stakeholder research collaboration by providing training, resources, and support that promote team science. UCSF’s comprehensive health sciences campus, with top-ranked professional schools and graduate programs, and its strong relationships with community stakeholders positions it as a national leader in multidisciplinary, multi-

stakeholder team science. While research programs frequently bridge schools, divisions, and departments, institutional barriers to collaboration and the engagement of community stakeholders (e.g., community leaders, government officials and policy makers, technology companies, philanthropists) remain, limiting the full realization of UCSF's potential. Recent efforts have included team science education for K Scholars, facilitation of multidisciplinary grant partnerships, and efforts to lower barriers to recognition for team science in academic careers. **Table C4** presents selected accomplishments in these domains.

Table C4. Selected Accomplishments of the CTS Core

Identified need	Implemented change and outcome
Education in collaboration and team science	Led team science training via faculty workshops and integration of team science concepts into K training curricula. Created mechanisms to establish projects and teams that cross institutional silos of discipline, department, and Schools.
Funding to support multidisciplinary research collaborations	Established team science pilot award program. Supported 6 awards supporting 6 teams across 17 departments for a total of $450,000 which enabled the development of novel imaging techniques, therapeutics, diagnostics, technology assisted interventions, and forecasting models to improve patient health.
Recognition of collaboration/team science in the promotions process	Established wording in the UCSF Department of Medicine criteria for promotion to specifically recognize team science.

APPROACH

Aim C2.1. Enhance resources to support broadly engaged team science.

In this renewal, the CTS Core (see **Table C5** for leadership) will focus on enhancing existing CTSI team science resources and promoting the concept of "broadly engaged team science". As developed by the CTSA community, broadly engaged team science refers to the meaningful involvement of patients, caregivers, clinicians and other health care stakeholders in the research process. [7]

Table C5. CTS Core Leadership

Name	Core role and Qualifications
Daniel Dohan, PhD	**CTS Core Director:** Dr. Dohan is a UCSF Professor and the Deputy Director, UCSF Institute for Health Policy Studies. He is Co-Director the UCSF/UC Hastings Consortium. A sociologist, Dr. Dohan leads UCSF's study of the culture of medicine and the value of transdisciplinary science.
Kevin Grumbach, MD	Broadly engaged team science Co-Lead: Dr. Grumbach is a UCSF Professor and Chair, Department of Family and Community Medicine. He is a member of the National Academy of Medicine.
Elena Fuentes-Afflick, MD, MPH	Promotions Lead: Dr. Fuentes-Afflick is a UCSF Professor and Vice Dean, Academic Affairs, UCSF School of Medicine.
Jaime King, JD, PhD	Broadly engaged team science Co-Lead: Dr. King is a UC Hasting School of Law Professor and co-director UCSF/UC Hastings Consortium.
Sunita Mutha, MD	Broadly engaged team science Co-Lead: Dr. Mutha is a UCSF Professor and Director, UCSF Healthforce Center (https://healthforce.ucsf.edu, health care workforce development).

This Aim continues successful programs to support multidisciplinary scientific and community-based (broadly engaged) team science through the following efforts:

- Provide team science pilot awards and team science supplements to additional pilot grant awardees. To catalyze engagement in team science by clinical and translational researchers, the Pilot Translational and Clinical Studies (PTC) Core awards team science pilot awards (see **Aim D2.1**). The CTS Core will add to CTSI's efforts to support collaborative research by offering supplement awards of $5,000 to all successful CTSI Pilot Grant awardees specifically to incorporate multidisciplinary, multi-stakeholder engagement in the pilot's science. The administration of these supplements is described in the Pilot Translational and Clinical Studies Core (**Core D**). Team science supplement awardees will work directly with the CTS Core Director to develop a team science strategy for their research, and will leverage the resources of the CTSI.
- Expand and evaluate recognition for multidisciplinary team science in academic review, promotion, and tenure. The CTS Core will build on the Department of Medicine (DOM) criteria for promotions, which recognize collaboration and contributions to team science, to demonstrate their impact on team science researchers. In collaboration with the Office of Academic Affairs, the CTS Core will leverage CTSI's evaluation program (**Aim A2.2**) to directly evaluate the impact of these departmental promotion criteria on faculty in the Department. While these criteria are in place and approved, several divisions within DOM are not currently utilizing these criteria and other departments have not yet adopted. Low-utilizing departments and divisions will receive education and outreach regarding team science promotions criteria as part of the Department's pre-review process, and outcomes will be compared pre and post intervention. Interventions that demonstrate success will be disseminated across the CTSA network for further evaluation.
- Address regulatory and legal barriers to broadly engaged team science. Investigators pursuing clinical and translational research may encounter regulatory and legal issues that hamper collaboration (e.g., inter-

institutional data sharing agreements, scientific engagement with non-traditional stakeholders).[6] In close collaboration with the RKS Core (**Core E2**), the CTS Core will leverage the expertise of the UCSF/UC Hastings College of the Law Consortium on Law, Science, and Health Policy and the UCSF Healthforce Center to develop novel resources (e.g., workshops, web materials) that encourage and enable regulatory compliance with broadly-engaged multi-stakeholder team science (See **Letter of Support from UC Hastings** in Core C).

Aim C2.2. Promote broadly engaged team science by developing non-traditional investigators.

Boundary-spanning transdisciplinary science must empower research collaborators from non-traditional research settings as full members of the scientific team. In this Aim, the CTS Core will collaborate closely with the CE Core's TIPR program (**Aim C1.2**, which is focused on clinicians) to enhance research capacity and skills among a broad range of stakeholders, in particular, non-medical community members and non-clinician health care workers.

- Non-medical community members: This CTS activity will focus on non-medical community members such as patients, community residents, and staff from community-based and faith-based organizations. Existing CTSI curricula will be adapted to develop an introductory course on clinical and translational research tailored to a community audience. The course will cover concepts including the rationale for conducting clinical research, protection of human study participants, principles of community-engaged research, and basic concepts of study design. The course will emphasize pragmatic approaches to research in community settings, including topics such as program evaluation which are often of particular interest to community stakeholders. The primary goal will be to enhance community members' abilities to collaborate more fully as team science partners with academic investigators.
- Non-clinician health care workers: This CTS activity will focus on non-clinician healthcare workers in the community to provide similar training and engagement through modifying the non-medical community member course to address and leverage the expanded medical knowledge base of these health care worker stakeholders. The coursework would emphasize health-system embedded research opportunities and perspectives, highlighting learning health system, implementation science, and population health.

In both the non-medical community member and non-clinician health care worker courses, participants will be asked to identify their learning priorities and goals, to ensure that the course is responsive to their needs. Both courses will be offered online, with each course segment “dosed” at a content level and duration appropriate for its audience, supplemented by an online learning community that includes synchronous webinar sessions. Course participants will receive a certificate upon successful completion of the course. Both courses will be piloted with members of the CTSI community. For the non-medical community member course, the CTS Core will leverage the CTSI CAB (**Aim A1.2**), and for the non-clinician health care worker course, the CTS Core will leverage the SFBayRIN members (**Aim A1.3**).

Across its portfolio of activities, the CTS Core will engage with recipients of its services (e.g., team science pilot awardees, KL2 and other trainees, stakeholders who complete team science curricula) to evaluate how CTS Core programs help advance broadly engaged team science clinical and translational research. This work will identify successes and develop a framework for identifying areas of additional team science support needs. These results will inform the value and utility of further disseminating the framework across the CTSA network.

Table C6. Collaboration and Multidisciplinary Team Science Core Milestones and Metrics

Aim C2.1. Enhance resources to support broadly engaged team science.	
Milestones	Metrics (#, %, rating)
Team science supplements awarded	# trained; # promotions based on team science criteria # other departments who adopt criteria
Effective recognition of team science in academic promotion	Inclusion of team science-specific criteria in all faculty promotion guidelines # of faculty for whom team science was an important criterion for promotion
Reduced regulatory barriers to team science	# attendees at regulatory team science workshops # of uses of Core web materials and consultative services to address intercampus/collaborative regulatory barriers
Aim C2.2. Promote broadly engaged team science by developing non-traditional investigators.	
Non-traditional investigators trained	# of community stakeholders (community leaders, policy makers) trained # non-clinician health care workers (nurses, therapists, social workers) trained
Stakeholder engaged team science	# of non-traditional stakeholders engaged in team science projects
Framework for team science	# team science investigators interviewed; gaps in team science resources identified
Dissemination of broadly engaged team science successes	Formation of a cross-UC Health "team science" working group Development of a shared team science program across all five University of California CTSA-funded campuses

CORE D. TRANSLATIONAL ENDEAVORS: SPECIFIC AIMS

CTSI aims to develop a highly qualified, diverse clinical and translational workforce and solicit, review, select, and fund pilot research projects that are aligned with the aims of CTSI and the NCATS CTSA program. CTSI's Translational Endeavors core has a particular focus on enhancing research opportunities for junior investigators and for underrepresented minority (URM) learners. Below we describe Specific Aims in the Translational Workforce Development (TWD) and Pilot Translational and Clinical Studies (PTC) Cores.

Section D1: Translational Workforce Development (TWD)

Aim D1.1. Provide translational science training programs across the spectrum of learners.

This aim describes CTSI's comprehensive approach to development of a multidisciplinary clinical and translational workforce across the spectrum of learners. The TWD Core supports eight distinct programs organized by and tailored to the level of learner, with emphasis placed on workforce diversity, collaboration, and career development. These efforts are integrated with the Career Development (**Core I**) and Training (**Core J**) components of this application. The TWD Core proposes to support the following programs:

- Pre-health undergraduate program (PUP)
- Clinical Research Coordinator training program
- Predoctoral yearlong inquiry program (YIP) (TL1)
- Postdoctoral clinical research informatics program (CRISP) (TL1)
- Resident research training program (RRTP)
- Fellows advanced skills training in clinical research (FAST CaR)
- K-Grant writer's workshop
- K Scholars program (including the KL2)

The TWD Core provides leadership and ensures integration of all of the TWD activities, including those programs that are specifically funded by the KL2 and TL1. This model allows for efficiency and synergy and enables the development of a clear roadmap for translational research training, as well as multiple “on-ramps” for training targeted for specific learners. The TWD core also actively works to disseminate all of its successful programs to local partner organizations and other CTSA hubs.

Aim D1.2. Enhance opportunities in translational science for underrepresented in medicine trainees.

Through partnerships with UCSF and local community campuses and organizations, the TWD Core will actively support and retain URM students in STEM through participation in TWD's training programs and identify resources to promote careers in clinical and translational research for URM trainees and early career faculty. Efforts supported by this aim include development of peer-to-peer support groups, sponsorship of URM trainees and junior faculty by faculty and staff, and organization of interest groups for URM trainees.

Section D2: Pilot Translational and Clinical Studies (PTC)

Aim D2.1. Provide pilot grant funding to investigators in support of innovative and novel research.

This aim describes CTSI's PTC Pilot grant program, which will provide funding of limited duration (up to one year) and budget (up to $40,000) to the UCSF clinical and translational research community. In collaboration with several other CTSI Cores, the PTC Core will provide pilot grant supplements of $5,000 for research focused on CTSI and CTSA network priority areas.

Aim D2.2. Expand the pilot translational and clinical studies application process to include stakeholder review and promote community-engaged research.

In this aim, a formal stakeholder review process is developed to provide broad-based feedback from CTSI's Community Advisory Board (CAB) and promote community-engaged research. This stakeholder review will be integrated with an NIH-style scientific review to provide comprehensive input. This aim describes the PTC Core’s full participation in NCATS’ Common Metrics.

Abbreviations used in Core D

TWD = Translational Workforce Development	RRTP = Resident Research Training Program
PTC = Pilot Translational and Clinical Studies	FAST CaR = Fellows Advanced Skills Training Clinical Research
URM = Underrepresented Minority	CAB = Community Advisory Board
PUP = Pre-health Undergraduate Program	CRC = Clinical Research Coordinator
YIP = Predoctoral Yearlong Inquiry Program	SF BUILD = Building Infrastructure Leading to Diversity
CRISP = Post-doctoral Clinical Research Informatics Program	RAP = Resource Allocation Program

CORE D. TRANSLATIONAL ENDEAVORS: RESEARCH STRATEGY

Section D1: Translational Workforce Development

Workforce development in translational science requires a combination of rigorous training in methods and processes, working with communities, and trainee level-specific mentoring and career development. The Translational Workforce Development (TWD) Core serves as UCSF's home for innovation in clinical and translational science workforce development, providing didactic, networking, and mentorship services to the full spectrum of learners. Traditional topics such as biostatistics, epidemiology, and research design are combined with more novel topics including the use of electronic health record data and other big data sources. Additionally, trainees are oriented to the importance of community engagement, health disparities, and research in special populations. **Table D1** presents selected accomplishments from the current funding cycle.

Table D1. Selected Accomplishments of the TWD Core in the Current Funding Period

Identified Need	Implemented Change and Outcome
Training in clinical research	Expanded offerings to a total of 40 courses, and 4 educational programs: a summer Clinical Research Workshop; a 1-year Advanced Training in Clinical Research Certificate Program; a 1-year Implementation Science Certificate Program; and a 2-year Master's Degree in Clinical Research. The Department of Epidemiology and Biostatistics (DEB) and tuition now support these courses and programs.
Mentor training in clinical and translational research	This program includes in-person and online components and trains early, mid-career, and senior faculty in effective mentoring strategies and is now supported by institutional resources.
Online education for broader access to courses and programs	This program has created 6 new online courses and 2 programs: Mentoring Training and Implementation Sciences. These online programs are used by UCSF, US, and international institutions, and are supported by the DEB and institutional resources.
Undergraduate training in clinical research to promote health careers	The Pre-health Undergraduate Program (PUP) has recruited URM students for a summer didactic training and mentorship program. Over the past 3 years, of 47 undergraduates (18 institutions), 83% are URM. 16 (57%) have received subsequent research funding to date.
Clinical research coordinator training and career development	Developed the Clinical Research Coordinator (CRC) training program that features foundational courses on research operations and Good Clinical Practice. Courses receive high ratings from participants for their direct application of knowledge gained to the job (mean = 6.3/7) and improved productivity (mean = 6.2/7).
Increase capacity for K-Grant writing assistance	The K-Grant Writer's workshop program supported 43 clinical and translational science-based K applicants across UCSF in the current funding period; 27 (63%) of these applicants were women and 7 (16%) were URM.
Strategies for increasing workforce diversity in trainees and junior faculty	Actively promoted, recruited, and mentored URM trainees at all levels. TWD programs currently enroll from 12%-27% URM trainees.

APPROACH

Aim D1.1. Provide translational science workforce development across the spectrum of learners.

The TWD Core (see **Table D2** for Core leadership) coordinates and supports CTSI's workforce development programs providing a comprehensive and coordinated training environment. An emphasis is placed on mixed didactic and experiential learning, collaboration, peer learning, mentorship, and career development.

Table D2. TWD Core Leadership.

Name	Core Role and Qualifications
Kirsten Bibbins-Domingo, MD, PhD, MAS	**TWD Core Director:** Dr. Bibbins-Domingo is a UCSF Professor, Chair of the Department of Epidemiology and Biostatistics, Vice Dean for Population Health and Health Equity, School of Medicine and MPI of CTSI's U54 and UL1 awards. Dr. Bibbins-Domingo has extensive experience with workforce development and previously served as MPI for CTSI's TL1 and KL2 awards.
Alka Kanaya, MD	Clinical and Translational Science Training Lead: Dr. Kanaya is a UCSF Professor and a member of the MPI team for CTSI's KL2 and TL1 programs.
Kala Mehta, DSc	PUP Lead: Dr. Mehta is a UCSF Associate Professor. She is a core faculty member of SF BUILD, a pipeline program to promote diversity in science.
Alison Huang, MD	Resident Research Training Program (RRTP) Lead: Dr. Huang is a UCSF Associate Professor.
Urmimala Sarkar, MD	Fellows Advanced Skills Training Clinical Research (FAST CaR) Lead: Dr. Sarkar is a UCSF Professor. She is the Director of UCSF's Primary Care Research Program and a co-PI on UCSF's learning health system K12 program.
Naomi Bardach, MD	K-Grant Writer's Workshop Lead: Dr. Bardach is a UCSF Associate Professor.
Lisa Schoonerman	CRC Training Lead: Ms. Schoonerman is a senior manager for CTSI overseeing training and educational resources.

The TWD Core oversees all 12 programs shown in **Figure D1**; seven are developed and run in collaboration with other cores (i.e., **Cores B, C, F, H, I, and J**). Descriptions of these seven programs are located in the collaborating core. The five programs housed in Core D are described in detail.

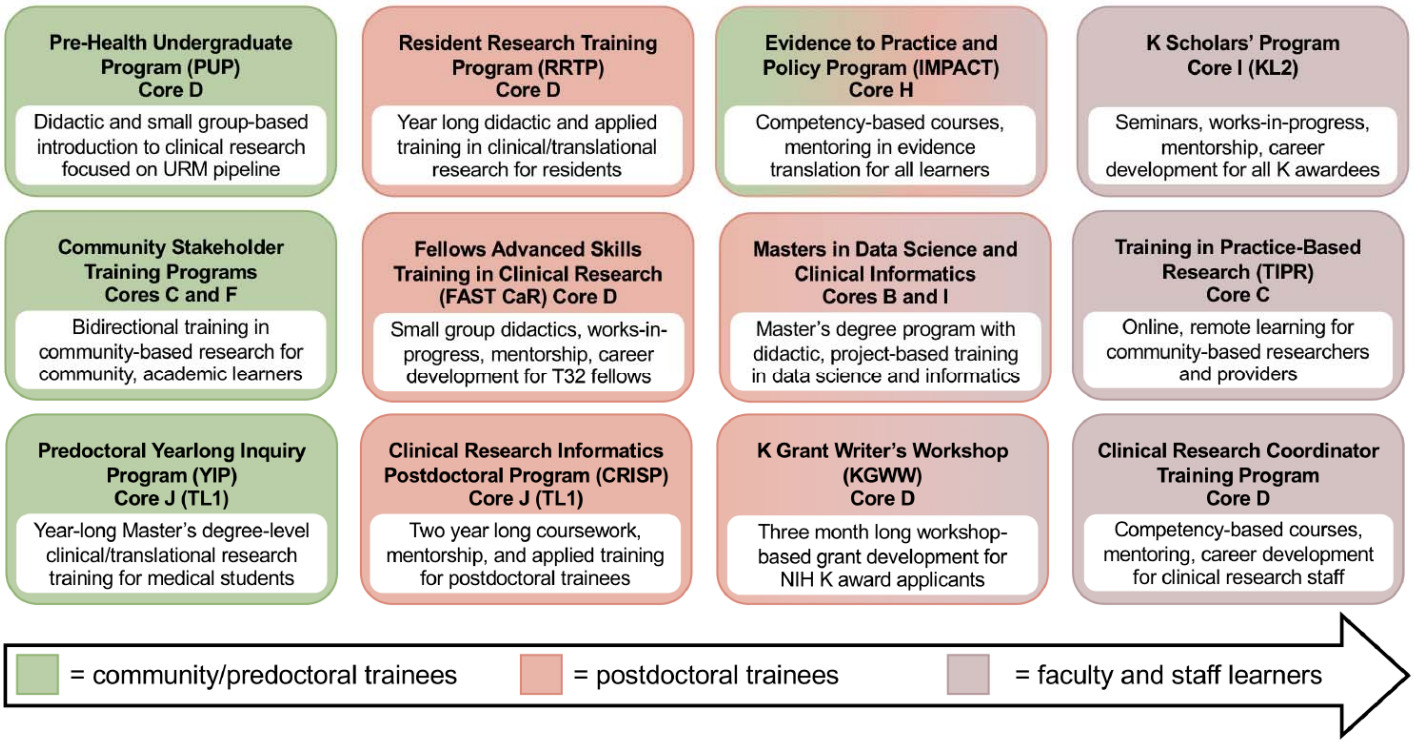


Figure D1. CTSI's Workforce Development programs.

Pre-health Undergraduate Program (PUP). This program serves primarily URM undergraduates who receive didactic clinical research methods training, small group didactic exposure to different types of clinical and translational research by faculty, and near-peer mentoring by medical students in the YIP program (see below). Students are mentored by faculty at their institution on a research project. In the renewal, TWD will expand this program to serve 20 URM undergraduate students each summer and provide broader exposure to community-based participatory research, qualitative methods, and clinical informatics.

Resident Research Training Program (RRTP). The RRTP provides support for research training to residents across the CTSI community. The program includes a foundational research methods course, guidance on research protocol development for a mentored research project, assistance with scientific writing, and opportunities for research funding and travel grants. The program also provides a foundational workshop in statistical methods and STATA software. In this renewal, TWD will expand access to RRTP to SFBay-RIN community residency programs (**Aim A1.3**). To facilitate and tailor the latter, the program will modify an online didactic curriculum for research methods and develop a health system-based research curriculum.

Fellows Advanced Skills Training in Clinical Research (FAST CaR) program. This new initiative for the TWD Core will provide CTSI with a workforce development community for fellows in T32 fellowship training programs who are interested in pursuing careers in clinical and translational science. The goals of FAST CaR are to ensure fellows have foundational skill in scientific writing, evidence presentation, research dissemination, and professional networking, and to enhance fellows' readiness to compete for research faculty positions. The program is structured around small groups of 8-10 fellows from similar clinical specialties (e.g., primary care and family medicine; nephrology, gastroenterology, and hepatology; oncology and radiation oncology; and surgery and anesthesia), with group sessions led by a faculty facilitator. These small groups provide twice-monthly "works-in-progress" feedback of ongoing research and peer-to-peer mentoring. Quarterly large group seminars focus on career development. A pilot cohort started in November 2019 demonstrated considerable interest, with 35 participants of whom 43% are women. FAST CaR will expand on this pilot to accommodate clinical research fellows from all T32 programs at UCSF.

K-Grant Writer's Workshop. Each workshop is led by a senior faculty researcher and up to four grant writers (depending on the cohort size) and is timed to coordinate submission with the next NIH application cycle.

Workshops are held twice monthly over a 3-month period to discuss and draft the four most challenging sections of the K-Grant: Specific Aims, Significance, Innovation, and the Career Development and Mentoring Plan. In the renewal, the K-Grant Writer's Workshop will improve dissemination and access to its materials through the development of video lectures and resources for K-Grant writers across UCSF, which will be shared within CTSI and the greater CTSA network. The program will also expand development of its library of successful grants, annotated in the four main sections to highlight the key components of a successful application. The annotated grants will cover a range of content and methodological areas, reflecting a diverse group of successful applicants.

Clinical Research Coordinator (CRC) Training Program. The CRC training program provides competency-based courses, including Good Clinical Practice, and activities to increase engagement and foster career development for clinical research staff. The program hosts an annual recognition event for CRCs and convenes interdepartmental collaborative workgroups to discuss and disseminate relevant process changes to the CRC community. In the renewal, the CRC training program will continue to develop resources based on CRC and other stakeholders' needs assessments, partner with institutional stakeholders to identify and address common mistakes and inefficiencies in research administration and conduct, and expand its mentoring program for CRCs.

Workforce development programs in collaboration with other cores include:

- Community stakeholder training programs: CTSI's two new initiatives provide training in community-engaged research, with academic partners and community members training each other in clinical research methods and community engagement (**Aim F1.2**), and develop community members as full partners in research through community member-focused research training (**Aim C2.2**).
- Predoctoral Yearlong Inquiry Program (YIP): CTSI's yearlong pre-doctoral training program providing Master's level educational and mentored research opportunities to medical students (**Core J**).
- Clinical Research Informatics Program (CRISP): CTSI's new two-year post-doctoral training program in clinical informatics and data science with mentorship from faculty with applied clinical research informatics projects. (**Core J**).
- K Scholars program: CTSI's highly successful K Scholars Program providing a clinical and translational science community to the broad community of K-funded junior faculty from across UCSF, including those funded through the KL2. (**Core I**).
- Evidence to Practice and Policy (IMPACT) Training: CTSI's new initiative in translating evidence to practice and policy (IMPACT core) will provide competency-based didactic and experiential training for learners across the spectrum of clinical and translational science (**Aim H2**).
- Masters in Data Science and Clinical Informatics: CTSI will provide new workshops and courses in data science and clinical informatics and in collaboration with the Department of Epidemiology and Biostatistics will develop degree-granting Master's programs (**Aim B4** and **Core I**).
- Training in Practice-based Research Program (TIPR): CTSI's new program providing clinical research training to community-based residency program faculty and residents (**Aim C1.2**).

Aim D1.2. Enhance opportunities in translational science for underrepresented in medicine trainees.

Providing training and career development opportunities to women and people from racial, ethnic, and socioeconomic minority backgrounds has long been a central focus of CTSI and UCSF leadership. While significant strides have been made for women trainees, progress in recruiting and retaining URM scholars has been slower. Because of this, the TWD Core has decided to focus an entire Aim and substantial Core resources on improving opportunities in translational science for URM trainees.

Currently, only 12% of medical school graduates in California are people who qualify as traditionally URM.[1] Although 26% of UCSF's medical students are URM, this is true of only 15% of residents and fellows, and only 8% of faculty. To better serve the UCSF community and its diverse patient populations, the CTSI must enhance the training and career development opportunities in translational science for URM trainees. To do this, the TWD Core will partner with current UCSF-wide diversity initiatives, including the UCSF School of Medicine Differences Matter campaign, the Office of Diversity and Outreach programs, and the Research Action Group for Equity. These institutional efforts provide funding for recruitment of fellows and faculty from underrepresented backgrounds. TWD Core programs can provide mentorship and training to these new fellows and faculty. Several new strategies are proposed:

Retention of URM undergraduate students for clinical research careers. SF BUILD is a NIGMS-funded partnership between UCSF and San Francisco State University (SFSU). SFSU is part of the California State University system, the largest public system in the nation and a designated Hispanic-serving institution. SF BUILD is a part of the NIH's investment in strengthening the pipeline for URM student to graduate STEM

education. Over the past 5 years, SF BUILD has recognized the need to continue to support promising undergraduates after graduation to ensure they are retained in the biomedical workforce. SF BUILD and CTSI will partner in two important ways in this retention effort: (1) support for an SF BUILD alumni program for those graduating seniors who are bound for graduate school or one of the health professional schools, but who may take 1 or 2 years to work at UCSF while applying. This program encourages and supports diversity supplements to fund their ongoing research and provides mentorship and support for graduate school applications. (2) support for a new CRC recruitment program for URM students graduating from SFSU for whom CRC may be a temporary career on the path to graduate school or a more long-term career. Training modules for current CTSI CRC and CRC supervisors will also be developed to improve cultural competency, address hiring issues, and discuss implicit bias.

URM trainee mentorship and sponsorship. Each TWD Core program will develop peer-to-peer support groups for URM trainees to discuss issues facing clinical and translational trainees specific to their level of training, facilitated by URM faculty. We have piloted these with the HRSA funded Latinx Center of Excellence for URM junior faculty of all underrepresented backgrounds this year. We will also create opportunities for near-peer mentorship, combining groups of different levels of learners (medical students with residents, residents with fellows, and fellows with faculty) to develop better linkages among trainees through the training pipeline. We will also create opportunities for sponsorship of URM trainees and junior faculty in partnership with UCSF leadership and institutional programs. Sponsors act as advocates and are invested in the trainees' career development and success. All Core faculty and program managers will be required to take the UCSF Diversity, Equity, and Inclusion Champion Training (https://differencesmatter.ucsf.edu).

URM trainee community building. The TWD Core will organize interest groups for URM trainees aiming to become clinical and translational scientists, focused on peer and near-peer community across units on campus. Monthly professional development seminars will cover topics such as the mentor-mentee relationship, the practical specifics of applying for grants, developing scientific careers, and discussions of diversity issues that can affect the career advancement of URM trainees.

Table D3. Translational Workforce Development Core Milestones and Metrics

Aim D1.1. Provide translational science training programs across the spectrum of learners.	
Milestones	*Metrics (#, %, rating)*
Trainee engagement in clinical and translational science	COMMON METRICS # and % of TWD program graduates currently engaged in clinical and translational research # of grant writers in the K-Grant Writer's Workshop # obtaining career development grant funding # of publications
Women engagement in clinical and translational science	COMMON METRICS # and % of women of TWD graduates currently engaged in research
CRC mentorship	Median duration of employment # promotions of CRC within job series # mentor/mentee pairings/mentor workshops
Career pathway for physician-scientists	# pre-doctoral fellows supported by TL1 in YIP program # residents in RRTP with at least 1 publication # FAST CaR participants; # FAST CaR graduates retained in clinical research # trainees who obtain academic promotion
Aim D1.2. Enhance opportunities in translational science for underrepresented in medicine trainees.	
Representative CRC workforce	# SFSU recruitment events/students hired # and % URM CRCs
Increased support for URM	# PI-URM matches/peer-to-peer groups/meetings # URM sponsored; # URM interest groups
URM engaged in clinical and translational science	COMMON METRICS # and % of URM graduates of TWD programs currently engaged in research

Section D2: Pilot Translational and Clinical Studies

CTSI's Pilot Translational and Clinical Studies (PTC) Core provides pilot grant support to UCSF investigators, with an emphasis on UCSF, regional, and CTSA network priorities. Providing resources for innovative and novel pilot research in translational science addresses a critical unmet need and has demonstrated substantial return on investment (**Table D4**). In the current grant period, additional focus was placed on developing a pilot program to support discovery in the science of therapeutics and entrepreneurship that has resulted in the UCSF Catalyst program, a highly successful academic-industry collaborative.

CTSI's PTC Core has been innovative in developing an institutional home for intramural small grant review and administration (see **Letters of Support from UCSF Research Development Office, Academic Senate, and Office of Diversity and Outreach** in Overall section).[2] In a previous funding cycle, CTSI developed and successfully institutionalized the Resource Allocation Program (RAP), which provides a centralized application portal and comprehensive, NIH-style scientific review by standing committees of UCSF faculty. RAP now supports approximately two dozen different funding sources from across UCSF, including the PTC Core pilot awards, and its operational funding is supported by UCSF. All applicants to RAP get formal feedback on their applications with written reviews. The PTC Core is a leader among the UCSF intramural funding agencies in creating new small grant opportunities for specific constituencies (faculty caregivers, junior faculty, URM faculty, team science) and targeting funding toward priority areas such as the opioid epidemic. Lastly, the PTC Core has committed to innovation in process improvement through participation in the development and use of the CTSA network-wide Common Metrics.

Table D4. Selected Accomplishments of the PTC Core in the Current Funding Period

Identified Need	Implemented Change and Outcome
Pilot funding for innovative, novel research in translational/clinical studies	Provided 43 awards totaling $1,895,000; 29 (67%) funded research in special populations; 38 (90%) obtained subsequent funding of ~$24,788,490 (**Figure D1**).
Opportunities for funding for junior faculty, faculty with family caregiver responsibilities, and URM faculty	Established specific intramural RFAs for these three constituencies. Overall, 20% of PTC award recipients have been URM, 40 were junior faculty (74%), and 4 were faculty with caregiver responsibilities (8%).
Pilot funding and resources for the discovery and development of promising drugs, devices, and other therapeutics	Developed the UCSF Catalyst program as a translational accelerator fostering academic-industry collaboration and education in entrepreneurship. Provided 73 awards totaling $3,211,494 million, resulting in 25 patents and 22 new companies.

APPROACH

Aim D2.1. Provide pilot grant funding to investigators in support of innovative and novel research.

The PTC Core (see **Table D5** for leadership) will continue to publish requests for applications (RFAs) for 1-year pilot funding (up to $40,000 per PTC Pilot award) in support of innovative and novel translational and clinical studies by UCSF investigators meeting award criteria. The Core anticipates funding 8-10 PTC Pilot awards each year. All Pilots will be supported with CTSI Program funds and will comply with relevant federal regulations and NIH policies, including the requirement for prior approval. The following PTC Core RFAs will be offered:

- Team Science PTC Pilot: for multidisciplinary team science translational and clinical studies
- Catalyst PTC Pilot: for innovative and novel studies focused on therapeutics discovery and development
- Faculty Support PTC Pilot: for faculty with significant family caregiving responsibilities
- Junior Faculty PTC Pilot: for instructor and assistant professor level faculty
- URM Faculty PTC Pilot: for faculty from underrepresented racial, ethnic, or economic backgrounds

Table D5. PTC Core Leadership

Name	Core Role and Qualifications
Carmela Lomonaco, PhD	**PTC Core Director:** Dr. Lomonaco is CTSI's Chief Administrative Officer. Dr. Lomonaco has extensive experience with grant review and management.
Paul Volberding, MD	RAP Lead: Dr. Volberding is a UCSF Professor and the RAP Grant Review Committee Chair.
Charles Hart, PhD	Catalyst Lead: Dr. Hart is a UCSF Adjunct Professor and the UCSF Catalyst Program Director.
Angela Sun, PhD	Stakeholder review Lead: Dr. Sun is Executive Director, Chinese Community Health Resource Center in San Francisco and a member of the ISP Core (**Core F1**) community oversight committee.

PTC RFA solicitation process. Solicitation of PTC RFAs occurs once a year and involves outreach to the UCSF community through: CTSI-generated email blasts and newsletters, outreach to departmental and school leadership, and partnership with institutional administrative units responsible for grant development (the Research Development Office and the Office of Sponsored Research). These mechanisms reach UCSF trainees, faculty and staff at UCSF, and CTSI's partner institutions, as allowable. Particular emphasis will be placed on encouraging early and mid-career investigators to apply.

PTC pilot award supplements for CTSI and CTSA network priorities. As a new initiative for the renewal period, the PTC Core is partnering with Cores C, F, and H to offer up to 10 $5,000 supplements to PTC Pilot awards annually to provide additional support for CTSI or NCATS CTSA network priority areas. Any pilot applicant may elect to be considered for a PTC supplement.

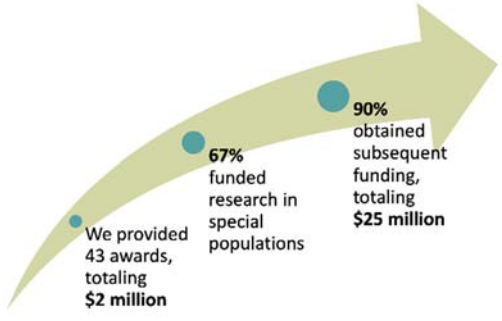


Figure D1. Return on investment, pilot studies

Priority areas (subject to change over the funding period) include: rural health; opioid addiction/pain management; partner health center/health system network capacity; workforce heterogeneity; team science (**Aim C2.1**); special populations (**Aim F2.3**); and evidence-to-practice and policy (**Aim H1**). All PTC supplement recipients will receive up to 10 hours of free research design consultation through the BERD Core (**Aim E1.1**).

Aim D2.2. Expand the pilot translational and clinical studies application process to include stakeholder review and promote community-engaged research.

New to this proposal, CTSI will implement a two-level review process for PTC Pilot award applications: scientific review and a Patient Centered Outcomes Research Institute (PCORI)-modeled stakeholder review.

PTC scientific review. All PTC applications will undergo scientific review by a RAP standing scientific review committee. This review process is rigorous and thorough, involving a multidisciplinary committee of UCSF faculty members patterned after NIH study sections. When needed, outside content expertise is added from the broader CTSI community and other CTSA-funded institutions.

PTC stakeholder review. This second level review - a "stakeholder review" - is patterned after the successful PCORI two-level merit review process and will be performed by the CTSI CAB (**Aim A2.1**), whose members will undergo training in merit review. The stakeholder review meetings will be co-chaired by the PTC Core director and a stakeholder lead. As with PCORI's merit review process, stakeholder perspectives will be discussed and priority scores provided.

Final funding decisions, regulatory review, and cost management. Aggregate scores and comments from the PTC scientific and stakeholder reviews are provided to the PTC Core leadership, who will make final funding decisions. The Core leadership will make final recommendations for PTC Pilot funding based on the scientific and stakeholder review scores and the above considerations. All funded human and animal studies will be required to receive IRB or IACUC approval before the completed prior approval package is submitted to National Center for Advancing Translational Sciences (NCATS). Investigators will be oriented to award reporting and financial policies; awards are bound by terms and conditions that detail grant policy and funding requirements and restrictions. Funding will only be awarded once prior approval has been granted. Funded Pilot awards requesting PTC supplements for priority areas will receive consideration by CTSI leadership and an award recommendation made.

PTC award tracking and evaluation. Scientific and financial progress reports are required at the beginning of the calendar year and at the pilot award's conclusion. Follow-up progress reports are submitted one and four years after completion, and focus on acquisition of follow-on funding, publications, and presentations.

PTC Core evaluation occurs as part of CTSI's overall evaluation and process improvement efforts (**Aim A2.2**). The PTC Core is an active participant in the CTSA-wide Common Metrics initiative and performs extensive impact assessments. CTSI has developed a robust tracking system to supplement the follow-up progress reports, allowing for comprehensive, efficient assessment of the impact of completed PTC pilot awards. This system has been shared with a dozen other CTSA hubs in the current grant period. CTSI plans to work with the CTSA network through the Center for Leading Innovation and Collaboration (CLIC) to coordinate cross-Hub experiments of optimal PTC Core models.

Table D6. Pilot Translational and Clinical Studies Core Milestones and Metrics

Aim D2.1. Provide pilot grant funding to investigators in support of innovative and novel research.	
Milestones	*Metrics (#, %, rating)*
PTC Pilot awards	COMMON METRICS # of pilot research projects that have expended pilot funds
PTC supplements for priority areas	# of pilot submissions in priority areas # of supplements awarded/% of pilots with supplements
Dissemination	COMMON METRICS % of pilot awards with at least 1 research publication % of pilot awards with at least 1 subsequent research award
Aim D2.2. Expand pilot studies application process to include stakeholder review/promote community-engaged research.	
Stakeholder review of PTC applications	# committee members/# reviews/# stakeholders All applications received stakeholder review (y/n)
Cross-Hub experiments of optimal PTC core models	# new models piloted

CORE E. RESEARCH METHODS: SPECIFIC AIMS

CTSI's Research Methods Core combines consultation services in biostatistics and other clinical and translational research methods (Biostatistics, Epidemiology, and Research Design Core) with regulatory and regulatory science support (Regulatory Knowledge and Support Core) in service of the UCSF clinical and translational science community. In this renewal, the Research Methods Core will continue to provide high impact, high value consultative and regulatory support, with an emphasis on developing new methods and services. Particular emphasis will be given to developing resources to support clinical trials and the transformative potential of digital health and electronic patient data.

Section E1: Biostatistics, Epidemiology, and Research Design (BERD)

Aim E1.1. Provide expert consultation in biostatistics, epidemiology, and research design.
The BERD Core will continue to provide expert consultations through its core biostatistics and bioinformatics, study design, and data management units, accessed through a single common portal that matches researchers with the consultants that best fit their needs.

Aim E1.2. Develop innovative consultative methods that address researchers' developing needs.
The BERD Core will develop and disseminate new resources, online videos, and consultations to meet developing needs in clinical and translational science, including community-based and special populations-focused research, broadly engaged team science, and management and analysis of electronic health data.

Aim E1.3. Create a Clinical Trials Design Unit to integrate and expand support for clinical trials.
The BERD Core will integrate and expand consultative expertise to comprehensively address clinical trial development and implementation with a new Clinical Trials Design Unit (CTDU). The CTDU will provide seamless local support and integration with the CTSA network's Trial Innovation Network (TIN), including facilitating the participation of UCSF researchers in TIN-sponsored trials and activities.

Section E2: Regulatory Knowledge and Support (RKS)

Aim E2.1. Provide a single institutional source for regulatory and regulatory science support.
The RKS core will continue to provide training, resources, and support services for a wide range of regulatory areas including FDA requirements for development of new products, electronic health data use, human subjects' approval including the use of single IRBs, and clinical trial reporting requirements. Access to these resources will be through a single common portal.

Aim E2.2. Develop and disseminate a community-informed ethical framework and methodology for research using electronic health data.
The RKS Core will develop a community-based ethical framework for electronic health data. A key component of this framework will be patient and community input and determining how patients will be engaged in long-term governance of electronic health data. The RKS Core will constitute an electronic health data research oversight committee (e-ROC) to develop draft policies that govern data use and can be disseminated to the larger CTSA community.

Aim E2.3. Provide support for individual participant-level clinical trial data sharing and reuse.
US federal legislation mandates that summary results be posted for all applicable trials, as of 2016. Building on UCSF's national leadership in clinical trial data sharing, the RKS Core will partner with the Informatics Core to demonstrate and disseminate tools and resources to support sharing of individual patient data (IPD) in alignment with recommendations in the National Academy of Medicine's clinical trial data sharing report.

Abbreviations used in Core E.

BERD = Biostatistics, Epidemiology, and Research Design	CAB = Community Advisory Board
RKS = Regulatory Knowledge and Support	IRB = Institutional Review Board
SFBayRIN = San Francisco Bay Research Infrastructure Network	SFHIP = San Francisco Health Improvement Program
	CLIC = Center for Leading Innovation and Collaboration
CTDU = Clinical Trials Design Unit	SMART IRB = Streamlined Multisite Accelerated Resources for Trials Institutional Review Board
FDA = Food and Drug Administration	
REDCap = Research Electronic Data Capture	CERSI = Center of Excellence in Regulatory Science and Innovation
TIN = Trial Innovation Network	
e-ROC = Electronic Health Data Research Oversight Committee	EQuIPT = Enhancing Quality in PCI Trials
LHS = Learning Health System	IPD = Individual Participant-Level Data
SPHERE = Special Populations and Health Equity in Research and Education	CD2H = Center for Data to Health
	CDISC = Clinical Data Interchange Standards Consortium

CORE E. RESEARCH METHODS: RESEARCH STRATEGY

Section E1: Biostatistics, Epidemiology, and Research Design (BERD)

The University of California, San Francisco (UCSF) CTSI's Biostatistics, Epidemiology, and Research Design (BERD) Core serves as the main institutional resource for expert consultation on clinical and translational research methods. Biostatistics, epidemiology, and research design consulting are the Core's primary focal points, with a roster of faculty and staff consultants that are drawn primarily, but not exclusively, from the UCSF Department of Epidemiology and Biostatistics. However, the Core has also broadened its scope to include the development and dissemination of innovative new services, tools, and methods to address emerging needs of the research community with a broader range of consultants drawn from across the campus. This includes the key roles of serving as a unified platform to disseminate resources developed by CTSI's other Cores and maintaining a common, established, and already familiar virtual front door to efficiently connect researchers with subject matter and methodologic experts. BERD offers professional development seminars and intramural development grants to its large roster of consultants and additional didactic continuing education covering translational research design topics. Formal coursework, as well as degree and certificate programs in clinical and translational biostatistics, are addressed in **Core D. Table E1** presents significant accomplishments achieved by BERD in the current funding cycle.

Table E1. Selected Accomplishments of the BERD Core

Identified need	Implemented change and outcome
Addressing volume and breadth of BERD consultation requests	Expanded BERD Core to 75 faculty and 7 staff consultants, providing 16,308 hours of consultation to 2,176 unique research projects. A substantial majority of consultations (78%) are provided to early investigators including 38% to trainees.
Expertise in EHR-enabled research/data queries	Developed the Data Management Unit, which provides EHR-data extraction consultations using honest-broker data programmers, providing >115 consultations in 2019; New EHR-enabled research consultations helped researchers create EHR-embedded projects that are feasible within the EHR's complex data and governance structure, providing >30 consultations in 2019.
Expertise in natural language processing	Developed Natural Language Processing (NLP) consultations to provide expertise in NLP text analysis and information extraction.
Expertise in health services research; analyses of large real-world datasets	Developed Population Health and Health Services (PHHS) consultations, which facilitate dataset selection and access and provides dataset-specific expertise in support of population health, health services, and outcomes research.
Expertise in recruiting diverse research participants	Developed two specialty recruitment consultation areas: diversity consultations guide development of recruitment strategies for underserved populations; plain language consultants review and evaluate participant-facing copy for accessibility and readability.

APPROACH

Aim E1.1. Provide expert consultation in biostatistics, epidemiology, and research design.

The BERD Core (see **Table E2** for Core leadership) collaborates closely with the UCSF Department of Epidemiology & Biostatistics (DEB) to provide comprehensive consultative support. The UCSF DEB (chaired by CTSI MPI Kirsten Bibbins-Domingo) has a world-class faculty with a robust array of educational programs and research activities.

Table E2. BERD Core Leadership

Name	Core Role and Qualifications
Anthony Kim, MD	**BERD Core Director**: Dr. Kim is a UCSF Associate Professor. Dr. Kim is an experienced clinical trialist and is the Study Design Unit Lead.
Kirsten Bibbins-Domingo, PhD, MD, MAS	Biostatistics Unit co-Lead: Dr. Bibbins-Domingo is a UCSF Professor, Chair of the Department of Epidemiology and Biostatistics, and MPI of CTSI's U54 and UL1 awards. Dr. Bibbins-Domingo is the Translational Workforce Development (TWD) Core Director.
Isabel Elaine Allen, PhD	Biostatistics Unit co-Lead: Dr. Allen is a UCSF Professor of Epidemiology and Biostatistics and a faculty biostatistician.
Mark Pletcher, MD, MPH	Data Management Unit co-Lead: Dr. Pletcher is a UCSF Professor and Chair of UCSF's IT Governance Research Technology Committee. He is the Informatics Core Director.
Jennifer Creasman, MSPH	Data Management Unit co-Lead: Ms. Creasman is a trained biostatistician and programmer supervisor for UCSF's Academic Research Services.

Working with DEB leadership, the BERD Core has developed three foundational units that provide consultation across three primary domains of expertise:

- BERD Biostatistics and Bioinformatics Unit: consultation including sample size estimation, multivariate modeling, causal inference, Bayesian statistics, mixed-effects/hierarchical modeling, pharmacoeconomic

analysis, bioinformatics, and reproducibility

- BERD Epidemiology and Study Design Unit: consultation including study design methods (e.g., case-control, cohort, clinical trial, sampling strategies, measurement, quality control, randomization and blinding schemes) and qualitative research methods
- BERD Data Management Unit: consultation including data cleaning and formatting, database platform selection, REDCap database design, and electronic health dataset development and management

Incoming requests are assigned by staff using a robust software backend that tracks assignments and the effort/time spent for each project electronically and facilitates the collection of user satisfaction data into the BERD Core's quality improvement processes. Researchers are matched with consultants that best fit their needs based on detailed knowledge of each consultant's areas of expertise. The consultant communicates directly with the researcher to arrange the first meeting, which occurs within a median time of one week from the initial request. All trainees (across UCSF and the larger SF Bay Research Infrastructure Network (SFBayRIN)), early career faculty, and pilot award researchers will continue to receive an initial free hour of consultation per project from each unit, and then are charged a partially subsidized hourly rate.

The BERD Core will continue to expand access to affiliate institutions and partner health systems. The Core already reaches local partner health systems and the other University of California health campuses. A major effort of this renewal is to further expand services to new health system partners across SFBay-RIN (**Aim A1.3**).

Aim E1.2. Develop innovative consultative methods that address researchers' developing needs.
In the renewal, BERD will continue to provide access to innovative methods and processes that are developed across the Cores through the familiar investigator-facing portal. The Core will continue to leverage its extensive experience in quickly orienting and onboarding new experts and consultants to meet present and future needs as identified by an ongoing review and analysis of incoming consultation requests, specific outreach to previous clients and current consultants, and polling trainees and senior faculty members.

- Broadly engaged team science: Leveraging the SFBay-RIN in a newly developed Aim in this renewal (**Aim A1.3**), the BERD Core will provide access to experts across these health system networks in support of community-based and rural health research. In addition, the Core will develop novel methods and processes for broadly engaged study design, interpretation, and dissemination (**Aim C2.2**).
- Special populations research: The BERD Core will facilitate access to the Integrating Special Population Core's special population's program (**Aim F1.1**) by providing consultations focused on enhancing engagement of pediatric, geriatric, URM, and other special populations in research design, conduct, interpretation, and dissemination.
- Electronic health data: CTSI expertise and investments in health system-enabled and embedded research has grown rapidly (**Aim B1 and B3**). The BERD Core will serve as the front door to access EHR-embedded trial support and other Learning Health System consultations.
- Online "just-in-time" educational videos: In collaboration with the Translational Workforce Development (TWD) Core (**Aim D1.1**), the BERD Core will develop online "explainer" videos and other online resources to address frequently asked consultation questions based on a review of incoming consultation requests.
- Impacting Practice and Policy by Accelerating Translation (IMPACT) Core (**Core H**): With increased CTSI resources deployed to development of a coordinated home for evidence to policy and practice research, the BERD core will expand its consultation services in implementation science and dissemination.

Aim E1.3. Create a Clinical Trials Design Unit to integrate and expand support for clinical trials.
CTSI has increasingly focused on supporting clinical trials, in particular through its active participation in CTSA's Trial Innovation Network (TIN). The BERD Core has received an increasing number of consultation requests for various aspects of clinical trial design. These include commonly encountered operational challenges where specialized knowledge and practical experience are key (e.g., study start-up, implementation, and close-out; clinicaltrials.gov and other reporting requirements), as well as requests for assistance with new methodologies (e.g., design simulation, synthetic control arms, and adaptive study design). Although expertise for certain components are available individually, the task of navigating and coordinating the clinical trial design process is left to the investigator. This can lead to clinical trials that are not well-conceived, significant delays in clinical trial start-up, and reduced clinical trial quality and impact.

To address this increasing need for coordinated clinical trial design support, the BERD Core proposes to create an integrated Clinical Trials Design Unit (CTDU) that will provide coordinated, comprehensive access to

consultation across the wide range of activities and expertise required to support clinical trials (**Figure E1**). CTDU intake will include an initial meeting with a CTDU navigator who will subsequently facilitate and coordinate access to consultation teams and will perform an initial needs assessment to determine the particular domains that will be accessed for each investigator. These teams may include a combination of experienced clinical trialists, biostatisticians, clinical research coordinators, research administrators, financial analysts, regulatory experts (including clinicaltrials.gov compliance), and community stakeholders. The CTDU will work closely with the Participant and Clinical Interactions (PCI) Core's EQuIPT program (**Aim F2.2**) to provide comprehensive protocol development support to selected PCI investigators. Through the initial intake and engagement process, the CTDU will also be able to identify multicenter clinical trials that would benefit from working with the TIN Hub Liaison Team (HLT, **Aim G1.1**) and will work to directly facilitate access to the TIN. As part of the CTDU effort, the Core will also work with the TIN HLT to develop a curated library of clinical trial protocols that will serve as a resource for potential clients.

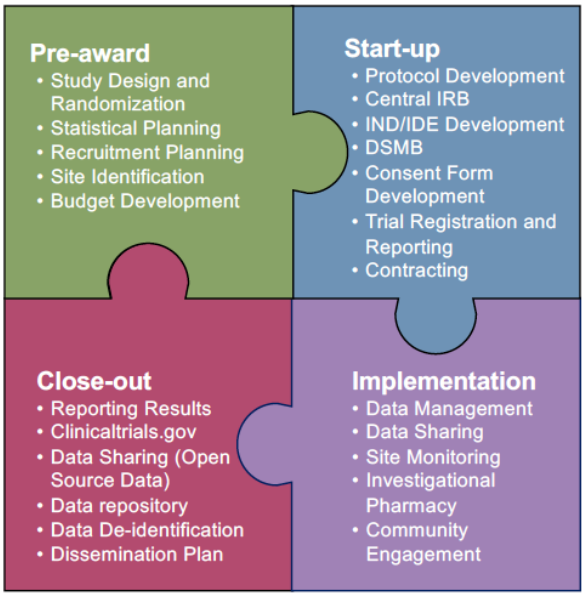


Figure E1. BERD Clinical Trials Design Unit.

Table E3. Biostatistics, Epidemiology, and Research Design Core Milestones and Metrics

Aim E1.1. Provide expert consultation in biostatistics, epidemiology, and research design.	
Milestones	Metrics (#, %, rating)
Support high-quality, timely consultation services	Mean time from request to first meeting # of consultations/hours; # new consults by unit Mean quality and impact rating by unit
Aim E1.2. Develop innovative consultative methods that address researchers' needs.	
Community-based/rural health research Learning Health System (LHS) consults	# of community-based/rural health consults # of LHS consults
Community-engaged research FAQ videos	# of community-engaged research consults # of FAQ videos produced, # of video views
Outreach to special populations health services/Dissemination research	# of special populations outreach consults # of health services/dissemination research consults
Extend consultations to partner institutions	# of consultation hours for partner institutions # of new consults by partner institutions
Aim E1.3. Create a Clinical Trials Design Unit to integrate and expand support for clinical trials.	
Develop the CTDU to support clinical trial development	# of new CTDU consults; # of consultation hours provided # of proposals referred to TIN; # of clinical trials successfully launched # of curated protocols added and accessed

Section E2: Regulatory Knowledge and Support (RKS)

CTSI's Regulatory Knowledge and Support (RKS) Core has focused on improving the efficiency and effectiveness of UCSF's regulatory services for human subjects-based researchers and has become a central partner in institutional regulatory leadership. The Core has been responsible for implementation of improvements in protocol submission and review, board review, and regulatory reporting, helping UCSF investigators to understand and comply with institutional, NIH, and other regulatory requirements. In the current cycle, the Core has increasingly focused on the unique regulatory and ethical challenges posed to clinical and translational researchers by the digital revolution. Building on UCSF's half-century of leadership in the field of bioethics, and in collaboration with UCSF's robust communities of social scientists and data scientists, the RKS Core has achieved several foundational accomplishments in the current cycle (**Table E4**).

Table E4. Selected Accomplishments of the RKS Core

Identified need	**Implemented change and outcome**
Increase knowledge of and compliance with human subjects' regulatory requirements	• Created a suite of remote learning lectures to introduce the concepts and practices of conducting ethical and regulation-compliant human subjects research (1,200+ views) • Partnered with the School of Medicine to develop and deliver curriculum and concierge services to students conducting summer research projects (eliminated IRB submission errors from 20% baseline level) • Developed and implemented embedded, real-time IRB application support materials to improve investigator and staff understanding of the components of the IRB application and

	reduce time to approval by 21%
Regulatory guidance and operational governance for digital research	Partnered with CTSI and UCSF data security and compliance groups to develop methods and processes to ensure that all research requests for EHR data are approved by the IRB prior to data delivery and use
Guidance regarding clinical and genomic data use for research	Created two advisory boards, one on Big Data/AI applications in research and one on data sharing with industry; Developed the Critical Assessment of Genomic Interpretation (CAGI) Ethics Forum as a novel form of governance for digital data

APPROACH

Aim E2.1. Provide a single institutional source for regulatory and regulatory science support.

The RKS Core (see **Table E5** for Core leadership) collaborates with the BERD Core, leveraging the BERD-managed research portal to provide a single point of contact location for clinical and translational researchers in need of guidance and support on a wide range of regulatory issues.

Table E5. RKS Core Leadership Team

Name	Core role and qualifications
Barbara Koenig, PhD	**RKS Core Director:** Dr. Koenig is a UCSF Professor and Director, UCSF Bioethics Program. She is a fellow of the Hastings Center and has pioneered the use of empirical methods in the study of ethics in medicine and health.
Sherry Felchlin, PMP	IRB Co-Lead: Ms. Felchlin is Director, IRB and Human Research Protection Program, UCSF.
Victor Reus, MD	IRB Co-Lead: Dr. Reus is a UCSF Professor and Chair, UCSF Health Parnassus IRB.
Christine Cassel, MD	Regulatory Ethics Lead: Dr. Cassel is a UCSF Professor and Senior Advisor for Strategy and Policy, Department of Medicine, UCSF. She has previously served as the President of the National Quality Forum, was President of Physicians for Social Responsibility, and is a member of the National Academy of Medicine.
Ida Sim, MD, PhD	Data Sharing co-Lead: Dr. Sim is a UCSF Professor and the Director of Digital Health for the Division of General Internal Medicine; she has served on multiple advisory committees of the National Research Council and National Academy of Medicine.
Chris Shaffer	Data Sharing Co-Lead: Mr. Shaffer is Associate Vice Chancellor, Library, UCSF and the University librarian. He serves on the board of directors for the Medical Library Association.

These efforts include FDA requirements for development of new products, the use of electronic health data for research, human subjects' approval including the use of single IRBs, and clinical trial activation and reporting requirements.

FDA regulatory guidance: An area of growth in the renewal period will be working more closely with the UCSF-Stanford Center for Excellence in Regulatory Science and Innovation (CERSI) to provide guidance on, and improve efficiencies around, investigational new drug and device applications and reporting, clinicaltrial.gov reporting requirements, and other regulatory issues related to improving the time to development of new medical products.

Use of electronic health data for research: The RKS Core will greatly enhance guidance to investigators using electronic health datasets regarding data security, use of institutional data resources such as MyResearch (a secure data hosting service for UCSF researchers) and REDCap, and general issues of data stewardship.

Human subjects' approval: The RKS Core works closely with UCSF's Human Research Protection Program (HRPP) to provide support to the IRB. An area of continued focus is providing training and support around the IRB review process to faculty and staff, in particular clinical research coordinators through collaboration with the TWD Core's development program (**Aim D1.1**). This includes working closely with the CTSA network's SMART-IRB single IRB network and UCSF's reliance agreements to provide guidance to multicenter clinical trialists developing protocols.

Clinical trial efficiency: The RKS Core will work closely with the Administrative (**Aim A3.1**), PCI (**Aim F2.2**) and Network Capacity (**Aim G1.1**) Cores to improve faculty and staff administrative efficiencies and improve clinical trial activation, start-up times, and conduct. The Core will look for opportunities to liaise and partner with CERSI on this effort, leveraging the involvement of the UCSF CERSI Director, Dr. Kathy Giacomini, on CTSI's Strategic Advisory Council (**Aim A1.1**).

Aim E2.2. Develop and disseminate a community-informed ethical framework and methodology for research using electronic health data.

In this Aim, the RKS Core will expand and accelerate its efforts to address the regulatory and ethical issues resulting from the digital revolution in health care.[1] Current regulations allow sharing of de-identified patient data without explicit patient authorization or consent, a practice that provokes mistrust from a public that is increasingly

suspicious about tracking of every aspect of digital life. The use of health data in artificial intelligence/machine learning applications also has the potential to raise ethical concerns.[2] This Aim will develop a community-based ethical framework for electronic health data and work to have it adopted as a policy document by UCSF. A new framework is critical because patients, acting as individuals, cannot assure ethical use of their data in the digital health era; patient involvement in governance is needed.

Development of a new ethical framework for use of electronic health data in research: To establish a new ethical framework, the RKS Core will work closely with UCSF's IT Governance Committee on Enterprise Information and Analytics to perform the following:

- Stakeholder working group development: The RKS Core will convene a working group of UCSF stakeholders to oversee the development of this framework. The working group will include the RKS and Community Engagement Core (**Aim C1.1**) leadership teams, selected members of the CTSI Community Advisory Board (CAB, **Aim A2.1**), health system leaders, electronic health data-based researchers, and UCSF Health patients or family members.
- Landscape analysis of data use policies: The RKS Core will map out existing practices governing data use and sharing and present them to the working group for review and discussion.
- Ethnographic assessment of patient views on data use: The RKS Core will partner with UCSF Health to observe patients interact with the health system and data generation in real time, soliciting their questions about the information they receive, and about how personal health information may be used for research.
- Patient focus groups: The RKS Core will conduct a series of focus groups with UCSF Health patients and family members using a quasi-deliberative method. Participants will imagine and create policies and practices that apply to the entire population of patients, rather than simply expressing personal preference.

Leveraging these results and building on the 2018 University of California's Ad Hoc Task Force on Health Data Governance[3] and the UCSF Chancellor's Data Sharing and Security Comprehensive Report (not yet public), the RKS Core will oversee the development of a new framework for electronic health data use in research. The draft framework will be presented iteratively to key groups, including IT Governance Steering Committee, the IRB, the CTSI CAB, and other institutional leadership. The framework will also be presented at UCSF Health Patient Family Advisory Committees and UCSF's Clinical Ethics Committee. A final public meeting will be held to gain input from the local community.

Development and implementation of methodology for use of electronic health data in research: Based on the patient and community-informed framework and principles developed above, the RKS Core will constitute an electronic health data research oversight committee (e-ROC) to develop and draft policy in this space. The e-ROC will be chaired by the RKS Core Director and will include key stakeholders from the above working group. This policy will recognize the primacy of ethical and regulatory compliance while allowing for adaptive governance that addresses the continually changing landscape of research using electronic health data.[4] The following represents topics that the e-ROC might address:

- deciding when IRB review is required (e.g., quality improvement vs research)
- mechanism for non-human subjects' research, including anticipation of Common Rule changes
- operational definitions of de-identification (e.g., genomic sequence data, natural language processing data)
- sharing of data with for-profit technology companies[5]
- sharing of stigmatizing personal health information
- use of patient data for artificial intelligence/machine learning applications[6]
- assessing risk levels in coordination with FDA Investigational Device Exemption (IDE) evaluations[7]
- deciding which projects require specific review and approval by a patient and community governance group
- sharing of individual-level data generated in clinical trials (**Aim E2.3**)

Draft policies developed by the e-ROC will be tested by UCSF, UCSF Health's IT Governance, and the Informatics Core. Policies deemed effective in facilitating electronic health data-based research (e.g., feasible, efficient, safe) will be disseminated to the larger CTSA community through the CLIC.

Aim E2.3. Provide support for individual participant-level clinical trial data sharing and reuse.

Clinical trials generate some of the most valuable evidence for advancing our understanding of human health and disease. To increase transparency, accountability, and scientific value of costly clinical trials, US federal legislation mandates the posting of summary results for all applicable trials as of 2016, regardless of the direction of findings or publication status. The next step is sharing individual participant level data (IPD). The International Committee of Medical Journal Editors now requires all manuscripts on clinical trials to include a detailed IPD

sharing plan and requires all trials enrolling in 2019 or later to include an IPD sharing plan in their initial trial registration. Major foundation funders such as the Gates Foundation and the Wellcome Trust condition funding on IPD sharing. An NIH draft data sharing policy endorses the scientific importance and value of data sharing with requirements for data sharing plans and compliance.[8]

Building on the national leadership in clinical trial data sharing of the RKS Core data sharing co-leads, the RKS Core will develop and disseminate training, tools, and resources to support and promote effective and efficient sharing and reuse of IPD in alignment with recommendations in the Institute of Medicine's seminal clinical trial data sharing report. The Core will also seek patient and community input into data sharing practices.

Provide a central resource for IPD sharing: The RKS Core will partner with the UCSF Library and other institutional stakeholders to develop outreach and education to all UCSF clinical trialists regarding data sharing requirements from journals and funders. For commercially sponsored trials, we will ensure that faculty trialists are clear as to who is responsible for what sharing, and who gets credit.

- For clinical research datasets that have privacy concerns, the RKS Core will partner with Vivli, a non-profit organization (co-founded by RKS Core leadership team member Ida Sim), that manages a data sharing platform that currently holds over 4,600 trials representing over 2 million participants(see **Letter of Support from Vivli** in Core E). The Core will support faculty use of Vivli services for IPD sharing, which includes a data de-identification service and long-term data storage. Vivli, which is partnered with most of the major industry and funder-specific data sharing platforms, allows UCSF to meet all clinical trial IPD data sharing needs.
- For clinical research and other biomedical datasets that do not have privacy concerns, do not need to request review, and can be fully downloaded (a minority of cases), the RKS Core will work with the UCSF Library to support additional platforms, including CD2H partner InvenioRDM and Dryad (https://datadryad.org/stash).
- The RKS Core will work with CD2H's Resource Discovery Core to ensure UCSF datasets are discoverable and comply with FAIR standards (findable, accessible, interoperable, and re-useable) to the extent possible for the platform that they are shared on.
- The RKS Core will develop methods and mechanisms to track the percentage of clinical trial IPD datasets available for sharing, actual sharing and reuse, and number of publications and citations to demonstrate the value of this RKS innovation.

Facilitate aggregation and analysis of shared clinical trial data: Aggregating IPD across clinical studies is a highly complex process requiring clear data definitions, aligned data variables, and data cleaning and transformation. An emerging approach is to leverage Clinical Data Interchange Standards Consortium (CDISC) standards, which will shortly be available at no charge to academic institutions. CDISC is a large, global standards organization whose standards are required for submission of clinical trial data to FDA and other regulatory agencies. The RKS Core will work to introduce CDISC standards and tools (e.g., CDISC Common Data Element browser) to trainees and consultees and will work with CDISC to explore lightweight versions of their main dataset standards to reduce overhead(see **Letter of Support from CDISC** in Overall section). The above initiatives will begin to accelerate the effective reuse of data to advance science and to reduce the cost and effort needed to generate value from data sharing. This work will directly contribute to clinical trial efficiency and stewardship efforts described in **Aims A3.1, E1.3, F2.2**.

Table E6. Regulatory Knowledge and Support Core Milestones and Metrics

Aim E2.1. Provide a single institutional source for regulatory and regulatory science support.	
Milestones	Metrics (#, %, rating)
Provide regulatory support to CTSI researchers	COMMON METRICS Median IRB Review Duration (Time from IRB submission to IRB approval) # portal requests; # regulatory consultations provided # of uses of SMART-IRB for multicenter clinical trials; institutional governance of clinical trial reporting (e.g., clinicaltrials.gov)
CTSI/CERSI clinical trial improvement project	Quarterly RKS/CERSI strategic planning meeting; # proposals submitted
Aim E2.2. Develop and disseminate a community-informed ethical framework, methodology for research using electronic health data.	
Stakeholder working group convened	# members; meeting minutes
Framework development	Landscape analysis; # ethnographic assessments; # focus groups
Policies implemented	e-ROC convened; # draft policies; adoption by UCSF and UCSF Health governance groups; # of CTSA sites reviewing/implementing policies
Aim E2.3. Provide support for individual participant-level clinical trial data sharing and reuse.	
Central resource for data sharing	Vivli membership; # investigators using service; # of data sets available for sharing; publications resulting from data sharing
CDISC available for data aggregation	# CDISC tools developed # researchers utilizing CDISC for aggregation

CORE F. HUB RESEARCH CAPACITY: SPECIFIC AIMS

Race, ethnicity, and age have profound effects on health. Eighty to ninety percent of participants in clinical trials of new drugs seeking FDA approval are white, yet 40% of the population belongs to a racial or ethnic minority.[1,2] Children and the elderly are also grossly underrepresented. Results of clinical trials demonstrating safety and efficacy of medical interventions in adult white Americans are not generalizable to other groups, yet this is precisely what occurs. The CTSI's Hub Research Capacity Core will be leveraged and deployed to focus resources on improving representation of children, elderly, and underrepresented minorities in clinical research.

Section F1: Integrating Special Populations (ISP)

Aim F1.1. Increase integration of special populations in clinical and translational science.
The ISP Core supports targeted efforts to provide special populations with access to clinical research opportunities. CTSI will substantially enhance this effort with the launch of an innovative clinical trial support strategy led by a new committee called Special Populations and Health Equity in Research and Education (SPHERE) that will engage academic and community-based faculty in clinical research design, implementation, evaluation, and training. SPHERE will guide a "concept to completion" approach that includes stakeholders across the research lifecycle to ensure that researchers develop impactful projects. Key elements that SPHERE will oversee are development of a core set of special populations-focused educational materials; a cultural/language/linguistic assistance program; access to community reviewers; assistance with special populations recruitment for clinical trials, and a consultation service for researchers seeking to optimize the participation, recruitment, and retention of special populations.

Aim F1.2. Enhance training in research with special populations and enable workforce heterogeneity.
The ISP Core will leverage CTSI's community-academic collaborative to enhance inclusion of special populations in research and in the clinical and translational science. Led by SPHERE, special populations stakeholders will train medical students, residents, post-docs, fellows, and K Scholars in seminars and community activities concerning special populations engagement, and academic trainees will teach stakeholders about clinical and translational research. The ISP Core will also undertake specific efforts to promote research capacity and readiness in the community and increase diversity of the research workforce.

Section F2: Participant and Clinical Interactions (PCI)

Aim F2.1. Facilitate access to and provide oversight of UCSF's Clinical Research Center resources.
The PCI Core will support a limited number of nurses and research staff to facilitate access to CTSI's fee-for-service Clinical Research Centers (CRCs) and to provide oversight and quality assurance for the CRCs. The PCI Core will work closely with UCSF Health and the Hub Research Network (**Aim A1.3**) to coordinate and share best practices for supporting PCI-based research at community partner health systems. The PCI Core will continue to provide CTSI's scientific review of protocols that have not undergone NIH or NIH-style review.

Aim F2.2. Enhance the quality of clinical research protocol development and conduct.
The PCI Core will establish a pilot program to test the utility of comprehensive protocol planning support through the Enhancing Quality in PCI Trials (EQuIPT) Program. The EQuIPT Program, in coordination with the PCI Core Scientific Review Committee, will randomize poorly-reviewed investigator-initiated protocols to local consultation in study design and planning, data sharing, scientific review, and staff training to determine whether a "start-to-finish" consultation improves research study quality, implementation, and completion.

Aim F2.3. Establish a Special Populations Patient and Clinical Interactions (PCI) Management Program.
To catalyze research involving special populations, the PCI Core will partner with the ISP Core's SPHERE program to create a PCI Management Program that will solicit, review, prioritize, and provide support for studies relevant to these populations. This Program will award one year of PCI Core services of up to $10,000 in value for nursing and other technical staff effort, laboratory testing and processing, and/or other activities necessary for the conduct of the study.

Abbreviations used in Core F

SPHERE = Special Populations and Health Equity in Research and Education	CAB = Community Advisory Board
	URM = Underrepresented Minority
CRC = Clinical Research Center	EQuIPT = Enhancing Quality in PCI Trials
CBO = Community-based Organization	

CORE F. HUB RESEARCH CAPACITY: RESEARCH STRATEGY

Section F1: Integrating Special Populations (ISP)

The Integrating Special Populations (ISP) Core works to transform clinical and translational science research and education at the University of California, San Francisco (UCSF) and across the CTSA network in pursuit of better health equity. Children, the elderly, and racial and ethnic minorities remain underrepresented in clinical and translational research.[1-4] In California, children, the elderly, and racial and ethnic minorities represent 23%, 14%, and 63% of the population, respectively.[5] Underrepresentation of special populations in clinical research biases benefits toward the majority through the choice of research priorities and causes problems with generalizability and dissemination of research findings. Moreover, underrepresentation has impeded policy decision making and the development of guideline recommendations specific to these populations. Major ISP Core efforts in the current cycle have focused on building a strong research relationship with UCSF's newly-partnered Benioff Children's Hospital in Oakland, working with community partners to provide research opportunities in long-term care and other geriatric priorities, and leveraging institutional efforts to increase diversity in clinical and translational research. **Table F1** describes selected accomplishments during the current cycle.

Table F1. Selected Accomplishments of the ISP Core

Identified need	Implemented change and outcome
Increased opportunities for research across the lifespan	Through partnership with Benioff Children's Hospital Oakland, increased capacity for pediatric research enrollment, specifically for asthma (AsthmaNet), sickle cell, developmental disabilities, cystic fibrosis, congenital heart diseases, and type I diabetes; increased capacity to conduct geriatric research through partnership with The San Francisco Campus for Jewish Living (residential and community-based long-term care facility), and strengthened relationships with the UCSF Pepper Center.
Greater diversity of researchers and research focused on disparities	Promoted use of NIH diversity supplements, doubling number received, totaling $1 million in 2018-2019; created a collection of validated translational research survey instruments applicable to NIH “special populations”; with Translational Workforce Development (TWD) Core, convened an annual health disparities research symposium with 471 attendees and 110 research abstracts in 2019.
Involvement of stakeholder communities in special populations research	Implemented Diverse eCohort to recruit diverse participants in technology-based research, co-led by African American, Chinese, and Latinx community leaders; developed research portal for those populations; institutionalized engagement of minority patients and communities in clinical research; built infrastructure for research engagement with diverse communities in pediatric research through the UCSF Center for Child and Community Health’s Transforming Research as Usual for Equity (TRUE).
Support for research into adult survivors of formerly lethal childhood diseases	Collaborated with community agencies that promote leadership, program development, and advocacy in adults with developmental and behavioral disabilities; partnered with the Cystic Fibrosis Foundation, the UCSF adult CF program, and the adult congenital heart program to study transitions of care.

APPROACH

Aim F1.1. Increase integration of special populations in clinical and translational science.

The primary objective of the ISP Core is to increase involvement, recruitment, and retention of special populations in clinical and translational research. Working in close collaboration with the Community Engagement core, the Core will utilize an innovative, multidimensional, and multidirectional approach to engaging academic and community-based stakeholders from special populations in this effort. The ISP Core (see **Table F2** for Core leadership) will be governed by an oversight committee called the Special Populations and Health Equity in Research and Education (SPHERE), which includes the ISP Core and a stakeholder executive board of community leaders from local community-based organizations (CBOs) working with special populations (see **Table F3** for members). These leaders and CBOs have long-standing collaborative relationships with CTSI and are knowledgeable regarding clinical and translational research. The SPHERE Committee will meet bi-monthly to review and guide ISP Core activities and to identify and pursue opportunities to diversify partnerships and institutionalize successful efforts for sustainability. This model has been successfully applied in the Diverse eCohort project, which was initiated by the CTSI’s Community Engagement and Informatics Cores and included SPHERE community leaders. The Core will also have culturally and linguistically concordant staff members including an African American, a bilingual Latinx, and a bilingual Chinese American, with experience working with research participants across the lifespan. Thus, adhering to best practices in participatory research, input into and guidance of Core activities will come from academic faculty, community leaders, and research staff from the special populations.

Table F2. ISP Core Leadership

Name	Core Role and Qualifications

Tung Nguyen, MD	**ISP Core Director:** Dr. Nguyen is a UCSF Professor with extensive experience in community-based participatory research. Dr. Nguyen is the School of Medicine Dean's Leader for Research Diversity, Director of the Asian American Research Center on Health.
Alicia Fernandez, MD	Disparities Co-Lead: Dr. Fernandez is a UCSF Professor. She is Director of the UCSF Latinx Center of Excellence. She is the PI of the HRSA-funded UCSF Latinx Center of Excellence.
Monica McLemore, RN, PhD, FAAN	Disparities Co-Lead: Dr. McLemore is a UCSF Associate Professor. Her expertise includes reproductive health, community-based participatory research, and Black/African American culture.
Janice Tsoh, PhD	Disparities Co-Lead: Dr. Tsoh is a UCSF Professor. Her expertise includes smoking cessation and Chinese American culture.
Kenneth Covinsky, MD	Geriatrics Co-Lead: Dr. Covinsky is a UCSF Professor and PI of UCSF's NIA-funded Pepper Center. He is CTSI's geriatrics lead.
Rebecca Sudore, MD	Geriatrics Co-Lead: Dr. Sudore is a UCSF Professor. Her expertise includes advanced planning and medical decision making in vulnerable older adults. She directs the Pepper Center's Research Core.
Roberta Keller, MD	Pediatrics Co-Lead: Dr. Keller is a UCSF Professor and the Associate Chair, Research, for UCSF's Department of Pediatrics. She is CTSI's pediatrics lead.
Anda Kuo, MD	Pediatrics Co-Lead: Dr. Kuo is a UCSF Professor. She is Co-Director of the UCSF Center for Child and Community Health and Founding Director of Pediatric Leadership for the Underserved training program.

Table F3. Special Populations and Health Equity in Research and Education (SPHERE) oversight committee *

Name	Core Role and Qualifications
Monique LeSarre, PsyD	African American Community Leader; Executive Director, Rafiki Coalition
Angela Sun, PhD, MPH	Chinese American Community Leader; Executive Director, Chinese Community Health Resource Center
Estela Garcia, DMH	Latino Community Leader; Executive Director, Instituto Familiar de la Raza
Shireen McSpadden MNA	Geriatric Community Leader; Executive Director, San Francisco Dept of Disability and Aging Services
Juno Duenas	Pediatric Community Leader; Executive Director, Support for Families of Children with Special Needs

** Plus members of the ISP Core leadership*

The ISP Core will work to integrate special populations through the following initiatives:

- *Community engagement.* The ISP Core will work with the SPHERE Committee and the Community Engagement (CE) Core to promote community engagement with the goal of increasing participatory research specifically for special populations. ISP Core staff will assist the Geriatric, Pediatric, and Disparities Leaders to facilitate such community engagement in those communities. In addition, the ISP Core will facilitate external community stakeholder feedback on study development and materials using a newly developed Virtual Feedback Advisory Platform (VFAB) online software to connect researchers with project-specific SPHERE community reviewers and other experts. SPHERE will work with the CTSI Community Advisory Board (CAB) to maintain a list of community-based, ISP-relevant reviewers and will coordinate matching projects with SPHERE community reviewers.
- *Educational materials.* The ISP Core will work with the Translational Workforce Development (TWD) Core to develop and disseminate a set of print and web-based educational materials on best practices for working with, recruiting, and retaining special populations. Materials will be continuously updated with new resources and based on input from users. Quarterly workshops will be held to disseminate best practices on recruitment of special populations in the UCSF research community.
- *Cultural and language assistance program.* The ISP Core will work with investigators to develop consent forms and recruitment materials. The Core will use a professional plain language consultant to generate materials at an appropriate health literacy level in English, with further translation and adaptation in Spanish, Chinese, and Vietnamese, the three most common non-English languages in San Francisco. Other languages will be included as appropriate to individual studies. Pictures and graphics will be reviewed for cultural appropriateness.
- *Consultation expertise.* The ISP Core will develop this service with key faculty, staff, and community leaders to provide consultations to researchers seeking to optimize the participation, recruitment, and retention of special populations. This service will encourage integration of special populations throughout the research process, from proposal development to implementation and dissemination.
- *Recruitment of special populations for clinical research*. This service, with a Diversity Recruitment Support Navigator, will assist researchers to identify potential special population study participants through a variety of technology-enabled methods that will match special population participants to study criteria. The CTSI, through the Participant Recruitment Program, has developed tools for recruitment through Facebook, Instagram, and Google advertisements and will pilot test Twitter campaigns. The SPHERE recruitment service will maintain a list of traditional ethnic media, such as Spanish-language radio stations or Chinese-language newspapers, to assist researchers in accessing these resources. The Core will work with CBOs to recruit potential participants

and will collaborate with the Pepper Center's Vulnerable Aging Recruitment Core to diversify geriatric participants.

Aim F1.2. Enhance training in research with special populations and enable workforce heterogeneity.
The ISP Core proposes building on CTSI's community-academic collaborative to enhance the inclusion of special populations in research, and among the clinical and translational science workforce (see **Letter of Support from San Francisco Joint Health Equity Coalition** in Overall section). This effort will engage the SPHERE committee leadership and initiatives to explicitly acknowledge and address the limited resources that exist in both communities and academics to enhance research in special populations.

Inclusion of special populations in research. ISP Core training activities will closely coordinate with the many pre-professional and professional training activities of the CTSI (**Core D1**). Specifically, the ISP Core will utilize a "collaborative learning" approach to train translational researchers (research staff, medical students, residents, post-docs, fellows, and K Scholars) to work with diverse populations. While researchers learn from patients, community leaders, and other experts, they will also teach these co-learners about the precepts of clinical and translational science behind the research topics. This approach has been shown to bridge the knowledge gap often created by the separation of academic knowledge from community knowledge and will help create a mutually beneficial relationship based on shared knowledge and the trust necessary for better integration.[6-8] Training activities will include:

- Understanding the history of special populations in clinical and biomedical research
- Research practices that perpetuate exclusion of special populations
- Best practices for engaging special populations (e.g., stakeholder engagement, trust building, power sharing, budgeting, dissemination techniques and content)
- Building a supportive community for trainees and junior faculty committed to special populations research

The ISP Core will also directly promote research capacity building and readiness in special populations communities. A recently completed local needs assessment including special populations identified the following topics requiring particular attention: how to create and sustain partnerships; how to write stakeholder-engaged grants; how to participate in research as stakeholders and the role of power and power dynamics in community-academic interactions; how to work with institutional review boards; research literacy for participants and communities; and how to disseminate research findings to communities. The Core's SPHERE will work closely with the CTSI CAB, the CE Core, and other community partners to reach special populations communities with resources and information addressing these topics. Dissemination will involve a variety of methods including community meetings, SPHERE educational materials, webinars, and social media.

Diversifying a special populations workforce. Investigators of all backgrounds have a responsibility to consider and work to include special populations in the conduct of their research, and the ISP Core will ensure its work is disseminated broadly among UCSF clinical and translational investigators. Through institutional work led through the School of Medicine's Differences Matter initiative, UCSF has recognized that diversifying the scientific workforce is an important and related step to ensuring diversity and inclusion in scientific studies. Accordingly, the Core will leverage a framework built through Differences Matter, called Joining URM Students and Trainees with Investigators in Collaborations and Education (JUSTICE). Using the NIH Diversity Supplement mechanism as its catalyst, JUSTICE brings together UCSF researchers with URM trainees who can serve as members of the researchers' teams. The Core will develop an interactive online mechanism for this partnering as part of the renewal. Assistance will be provided to paired teams to develop successful diversity supplement applications, leveraging an existing library of successful applications and near-peer mentoring with previously successful diversity supplement applicants. JUSTICE will work with the TWD Core (**Aim D1.2**) to provide additional research opportunities and career development advice for URM trainees and to develop a diverse Clinical Research Coordinator workforce.

Table F4. Integrating Special Populations Core Milestones and Metrics.

Aim F1.1. Increase integration of special populations in clinical and translational science.	
Milestones	*Metrics (#, %, rating)*
SPHERE	# academic and community-based stakeholders engaged # projects with ISP focus (across CTSI Cores) # meetings/workshops with ISP present
Collaborative learning approach	#/% culturally and linguistically concordant ISP staff # co-learners trained on science

	#/% recommendations from patients, community leaders, and other experts that led to quality improvement # SPHERE resources (clicks/downloads)
Increased recruitment and retention of special populations	# SPHERE consults # SP enrolled/retained in clinical research (across strategies)
Aim F1.2: Enhance training in research with special populations and enable workforce heterogeneity**.**	
Community-academic collaborative	# academic researchers trained by community member # community stakeholders trained by academic researchers # community meetings/educational materials/webinars and social media posts
Special populations workforce	#/% URM trained, hired; average tenure of URM #/% URM pilot awardees # Diversity Supplements

Section F2: Participant and Clinical Interactions (PCI)

The **Participant and Clinical Interactions (PCI)** Core facilitates access to institutional resources and infrastructure and provides scientific review of research protocols for investigators conducting research directly involving participants. The Core is directly responsible for oversight and quality assurance of UCSF's Clinical Research Centers and its affiliated sample processing Core. These CTSI-supported centers provide investigators with space and technical support for a wide range of research procedures including delivery and administration of complex, high-touch investigational therapies, pharmacokinetic studies and other sample-based assessments, and specialty tests such as bronchoscopy, smoke exposure, and exercise physiology testing. **Table F5** lists selected accomplishments of the PCI Core in the current cycle.

Table F5. Selected Accomplishments of the PCI Core.

Identified need	Implemented change and outcome
Administrative oversight and quality assurance for UCSF's clinical research centers	The PCI Core administratively supported five clinical research centers and over 650 individual research studies a year. Approximately 250 faculty representing numerous departments (e.g., medicine, surgery, pediatrics, psychiatry, neurology, dermatology, radiology, ophthalmology) utilized the PCI core.
Support for research enrolling pediatric and elderly participants	Number of studies enrolling children increased from 70 (2016) to 85 (2019); number of studies enrolling elders increased from 158 (2016) to 180 (2019).
Centralized web-based research budget and management system	Implementation of CTSA-network SPARC (Services, Pricing, & Application for Research Centers); number of PIs utilizing PCI services increased from 205 (2016) to 264 (2019).
Online scheduling of research participants at Clinical Research Centers	Adoption of Harvard Scheduler allowing multi-clinical site operational resource and staffing alignment of cross-trained staff during a specified shift.
Improved turnaround time for scientific review	Establish a second scientific review committee, halving turnaround time from 4-8 weeks to 2-4 weeks.

APPROACH

Aim F2.1. Facilitate access to and provide oversight of UCSF's Clinical Research Center resources.

The PCI Core will continue to support UCSF's Clinical Research Centers (CRCs), primarily through providing a limited number of administrative nurses and staff for CRC management and by providing scientific review for CRC-eligible protocols.

CRC management: CTSI has a strong partnership with UCSF Health and its two core partner institutions, Zuckerberg San Francisco General (ZSFG) and The San Francisco Veteran's Administration (SFVA). Together, CTSI and these three health systems provide UCSF researchers with access to five CRCs across sites: UCSF Parnassus Heights, UCSF Mission Bay, ZSFG, and SFVA. In addition to space, nursing and other technical support, these CRC units provide liquid sample collection and processing for research protocols. Studies across the lifespan are supported, including services in the neonatal intensive care units. CRC services are provided through a fee-for-service mechanism (recharge) that is subsidized by the medical systems and UCSF. PCI staff will provide oversight and quality assurance for the resources and services provided by the CRCs.

PCI Core (see **Table F6** for Core leadership) will provide administrative and financial oversight of UCSF's CRCs; management of CRC scheduling and protocol management infrastructure; facilitation for CTSI investigators requiring access to CRC services; and consultation on budget preparation for use of CRCs. A major initiative in this proposal is to expand the reach of PCI facilitation beyond the three core partner institutions to UCSF's affiliates and CTSI's Hub Research Network (**Aim A1.3**). Efforts will focus on coordinating and sharing best practices for supporting research within community partner health systems, and core leadership will consult on partner CRC operations and provide access to CTSI resources and tools to support partners' needs.

Table F6. PCI Core Leadership.

Name	Core Role and Qualifications
Payam Nahid, MD, MPH	**PCI Core Director:** Dr. Nahid is a UCSF Professor and the Associate Director of Clinical Trial Operations in UCSF's Office of Research. Dr. Nahid is an experienced clinical trialist and is also the Director of CTSI's Trial Innovation Core.
Susan Smith, MD	UCSF Health Lead: Dr. Smith is a UCSF Professor and Senior Vice President for Faculty Practice at UCSF Health. Dr. Smith oversees the clinical operations and professional activities of UCSF's outpatient practices.
Deborah Zeitschel, RN, MSN	Nursing Administration Lead: Ms. Zeitschel is the Interim Nursing Director for the CRCs supported by the PCI Core.
Michael Potter, MD	PCI CRC Outreach Lead: Dr. Potter is a UCSF Professor and the Administrative Core Lead for CTSI's Hub Research Network. Dr. Potter has extensive experience working with partner health systems as Director of the SFBay Clinical Research Network, a practice-based research network of community clinics across Northern California.

Scientific review for CRC-eligible protocols: Selected clinical research protocols conducted using CRC services will undergo scientific review by the PCI Core scientific review committee. Approximately two-thirds of study protocols will have been reviewed and funded by a UCSF-approved external (e.g., NIH, AHRQ, PCORI, DOD, FDA, Bill and Melinda Gates Foundation) or internal (e.g., Resource Allocation Program (RAP), Comprehensive Cancer Center) review body and do not require PCI Core scientific review. The remainder (about 30-40 proposals each year), most of which are early-stage, exploratory, and investigator-initiated, must undergo review by the PCI Scientific Review Committee. Protocols are evaluated by two scientific reviewers and a biostatistical reviewer according to NIH review criteria and scored on the 9-point NIH scale; those scoring a five (good) or better are allowed to proceed to activation. The committee, chaired by the PCI Core Director, meets face-to-face twice monthly. It includes standing members with expertise in study design and data analysis and ad hoc members as needed for content expertise. In the renewal, two KL2 scholars (rotating semi-annually) will serve as ex officio members to provide them with hands-on experience in the scientific review process.

Aim F2.2. Enhance the quality of clinical research protocol development and conduct.

In Aim F2.2, the PCI Core will pilot the Enhancing Quality in PCI Trials (EQuIPT) program (**Figure F1**). This program is designed to provide an integrated, comprehensive local CTSI-based review of the protocol design and planning process. Clinical trial protocols reviewed by the PCI Core Scientific Review Committee that score a six or worse (i.e., are not approved) will be randomized 1:1 to the EQuIPT program and its impact evaluated over the course of the renewal, as detailed below.

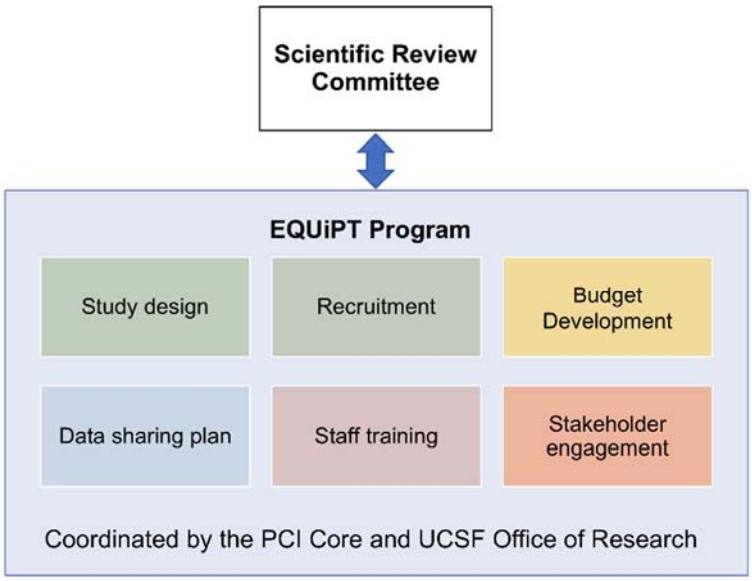


Figure F1. Key components of PCI's EQuIPT program

The EQuIPT program will bring together resources from other CTSI Cores and UCSF's Office of Research to provide the following components:

Stakeholder engagement. Patient and community-centric design is aligned with the CTSA network's core principle of community engagement. The PCI Core will leverage the Administrative Core's CAB (**Aim A2.1**) to provide consultation to investigators on key aspects of the protocol revision process relevant to enhancing community engagement.

Study design, recruitment planning, and budget development. EQuIPT will leverage the BERD Core's Clinical Trial Design Unit (**Aim E1.3**), which coordinates the expertise of clinical trialists, biostatisticians, clinical research coordinators, research administrators, and regulatory experts to support revision of study design, recruitment, and budget planning.

Data sharing. Leveraging the RKS Core's data sharing resources (**Aim E2.3**), the PCI Core will ensure that all revised protocols contain plans for data sharing, with an emphasis on sharing of participant-level data.

Staff training. Clinical research coordinators in need of general or protocol-specific training will be provided with resources through the Office of Research and the Clinical Research Coordinator Training Program (**Aim D1.1**).

The effectiveness of the EQuIPT program will be assessed by performance metrics including time to resubmission of the protocol to the PCI Scientific Review Committee, re-review approval rates, time to subsequent IRB approval, time to study implementation, actual versus projected recruitment, actual versus projected time to study completion, number of protocol deviations per enrolled subject, and qualitative assessments of investigators and administrative staff (**Table F7** below). Results from studies that have undergone the program will be compared with results of studies that have not. Based on an approximate non-approval rate of 25%, the Core projects that a 3-year pilot period should provide approximately 50 studies for randomization, a sufficient sample size for a preliminary analysis of the EQuIPT program's impact.

Aim F2.3. Establish a special populations PCI management program.

Both NIH and UCSF prioritize increasing special populations research involving health disparities, rare diseases, children, the elderly, and others with unique health needs. To catalyze research involving special populations, the PCI Core will partner with the ISP Core (**Aim F1.1**) to create a special populations PCI Management Program. This program will provide financial supplements (**Aim D2.1**) and operational support targeted to inclusion of special population in PCI-based clinical research projects.

- Solicitation: The PCI Core, in coordination with the ISP Core, will solicit proposals for research on special populations twice a year, reaching out to all stakeholders to encourage a wide range of proposals.
- Review: Scientific and stakeholder review will be provided by the PCI's scientific review committee (**Aim F2.1**) and the ISP Core's SPHERE Committee (**Aim F1.1**); funding decisions will be made by PCI, ISP, and Administrative Core leadership.
- Funding level and justification: In coordination with the PTC Core (**Aim D2.1**), one year of CRC services of up to $5,000 in value per project will be provided to support administrative and operational costs for nursing and other technical staff effort, laboratory testing and processing, or other study activities.
- Prioritization: Priority will be given to early career faculty (instructor or assistant professor level) and faculty from backgrounds typically underrepresented in medicine in accordance with the related goal of diversifying the scientific workforce.
- Business and cost management: Financial management of the PCI program will be provided by the CTSI's core financial team in coordination with UCSF's grants management program and in accordance with NIH rules and regulations. Emphasis will be placed on ensuring management consistent with the operational goals of supporting the needs of studies that enroll and are focused on special populations in close collaboration with the SPHERE committee.
- Progress tracking: Program participants will provide quarterly progress reports on predefined milestones and metrics; these will be reviewed by the PCI Core and barriers to success will be promptly addressed.

The PCI Management Program will be carefully evaluated by the PCI leadership in collaboration with the Administrative Core (**Aim A2.2**). The PCI Core will further engage program participants in evaluation and continuous process improvement efforts.

Table F7. Participant and Clinical Interactions Core Milestones and Metrics.

Aim F2.1. Provide access to and oversight of Hub clinical research center resources.	
Milestones	Metrics (#, %, rating)
Increased utilization of PCI Core services by CTSI investigators	# protocols utilizing Clinical Research Centers; faculty and staff satisfaction with resources; # of clinical research studies at SFBay-RIN partner organizations
Increased clinical research activity at partner organizations (e.g., SFBay-RIN)	
Aim F2.2. Enhance the quality of clinical research protocol development and conduct.	
Efficient EQuIPT administration	Time to protocol completion; average scientific review score; # of protocols returned for revision; # of trials successfully completed; % on-time completion
Improved quality of research protocols	
Increased number of successful trials	
Aim F2.3. Establish a PCI Management Program to advance research involving special populations.	
Program active, first solicitation completed	# of applications for funding support; # of projects funded; # of special populations-based research protocols approved and active
First five program projects completed	
Increased number of special populations research protocols utilizing PCI core services	

CORE G. NETWORK CAPACITY: SPECIFIC AIMS

CTSI is committed to supporting CTSA network-wide studies through participation in the Trial Innovation Network (TIN) and collaboration with CTSA's Center for Leading Innovation and Collaboration (CLIC) and National Center for Data to Health (CD2H). The Network Capacity Core's Hub Liaison Team (HLT) functions as the interface between UCSF and these national collaborative activities. In the current cycle, the Core has implemented a TIN infrastructure to identify site investigators for TIN trials and to connect UCSF clinical trialists with TIN resources. The Core has also made a number of important contributions to UCSF's network capacity, including coordinating the implementation of an enterprise-wide clinical trials management system, consolidating UCSF's clinical trial administrative units into one central office, and developing resources and services to support participant recruitment. The Core has participated fully in the CLIC Common Metrics and other activities and collaborated with CD2H across its four Community Cores. In this renewal, the Network Capacity Core will continue to lead CTSI's efforts to support the TIN, CLIC, and CD2H as described in the Specific Aims below.

Section G1: Hub Liaison Team and the Trial Innovation Network

Aim G1.1. Facilitate engagement with the TIN through integrated clinical trial operations.
This Aim describes how the Network Capacity Core will effectively communicate with the UCSF community about TIN services, actively reaching out to faculty to increase engagement by UCSF investigators and UCSF partner institutions. Comprehensive engagement with the TIN is the top priority. The Core will assist local investigators with proposal submissions to the TIN and external TIN investigators with identification of potential UCSF site investigators. The Core will continue to work closely with UCSF's clinical trial administrative units to streamline the clinical trial activation process and address barriers to multicenter clinical trial efficiency.

Aim G1.2. Provide innovative services to enhance participant recruitment in TIN clinical trials.
Improving participant recruitment is a high-impact and high-value service provided by the Network Capacity Core. The Core will continue to provide investigators with assistance in recruitment planning and with technology-enabled strategies such as EHR-based outreach (e.g., via MyChart portal) to eligible subjects and the use of social media and digital apps in direct-to-participant outreach. These resources will be made available to the CTSA network through collaboration with the CLIC and CD2H.

Section G2: Hub Liaison Team and other CTSA Program Central Resources

Aim G2.1. Assist CLIC in collection of data for strategic management of the CTSA network and for cross-CTSA network coordination and communication.

This Aim describes how the Network Capacity Core will work closely with the CLIC to advance its priority initiatives. These include active participation in the Common Metrics initiative and the CTSA Enterprise Committees, promoting UCSF faculty and staff participation in network-wide activities such as "synergy papers" and "un-meetings," and communication of CLIC activities and initiatives across the Hub network.

Aim G2.2. Assist CD2H in its mission to harmonize the data ecosystem, realize a software and people ecosystem, and catalyze ideas to implementation.
This Aim describes how the the Network Capacity Core will participate in CD2H's four Community Cores (resource discovery, informatics maturity and best practices, next-generation data sharing, and tool and cloud infrastructure) to advance CD2H's priority initiatives.

Aim G2.3. Collaborate with CD2H to disseminate cutting-edge biomedical informatics solutions to integrate biospecimen-derived and clinical data.
The Core will actively collaborate with CD2H to disseminate a novel, cutting-edge bioinformatics solution developed by CTSI's Informatics and precision medicine Cores. This partnership between CTSI, CD2H, and the CTSA network will result in the dissemination of innovative tools to visualize and search biospecimen data that is linked to well-characterized clinical data sets, enabling precision medicine-based research and discovery.

Abbreviations used in Core G

TIN = NCATS's Trial Innovation Network	CLIC = NCATS's Center for Leading Innovation and Collaboration
HLT = CTSI's Hub Liaison Team	CD2H = NCATS's National Center for Data to Health
UC BRAID = Biomedical, Research, Acceleration, Innovation and Development	BERD = Biostatistics, Epidemiology, and Research Design (Core E)
EHR = Electronic Health Record	SMART = Self-monitoring Analysis and Reporting Technology
ACT = NCATS's Accrual to Clinical Trials	FHIR = Fast Healthcare Interoperability Resources
HEAL = NIH's Helping to End Addiction Long-term Initiative	OMOP = Observational Medical Outcomes Partnership

CORE G. NETWORK CAPACITY: RESEARCH STRATEGY

Section G1: Hub Liaison Team and the Trial Innovation Network

Active engagement with the CTSA's Trial Innovation Network (TIN) is a major CTSI priority in the renewal period. In the current funding cycle, the CTSI Network Capacity Core has coordinated and led the development of a substantial clinical trial infrastructure at the University of California, San Francisco (UCSF), including the coordination of an integrated clinical trial activation process to ensure compliance with regulatory requirements and efficient trial start-up and the implementation of a Hub Liaison Team (HLT) to engage UCSF faculty directly with TIN resources (**Table G1**). CTSI has also successfully co-led the UC BRAID consortium, a regional CTSA collaborative network that has worked to develop, demonstrate, and disseminate solutions to improving multi-center clinical trials.

Table G1. Selected accomplishments of the Network Capacity Core

Identified need	Implemented change and outcome
Solutions for improved administration of multi-center clinical trials	Through UC BRAID, developed cross-CTSA solutions to contracting, human subjects approval (including the development of a single UC-wide institutional review board), and participant recruitment. For example, UC-wide master contracting agreements (developed by UC BRAID) decreased time from contract receipt to finalization by an average of 43 days (97 to 54 days).
Implementation of TIN infrastructure to identify site PIs for TIN clinical trials and connect UCSF trialists to TIN resources	Developed the Hub Liaison Team and initial implementation of processes to identify site investigators for TIN trials and connect investigators with TIN resources. There have been 26 TIN studies supported through CTSI's HLT.
Efficient identification of eligible study participants for clinical trials	Created IT solution to use the EHR patient portal (MyChart) to contact eligible study participants through real-time automated searches; 12 studies have piloted this service with >5,500 recruitment messages sent and an average of 44% of study participants recruited. Participated in the development of the Accrual to Clinical Trials (ACT) platform as a first wave site and shared experience with UC-ReX, a precursor to ACT.
Organized UCSF addiction and pain management community response to TIN-centered HEAL initiatives	Partnered with UCSF leadership to develop the Pain and Addiction Research Consortium (PARC) to organize the UCSF research community and provide training and research opportunities in pain management and addiction; created Pain and Addiction-focused RFA to fund research relevant to NIH HEAL initiative. UCSF has recently been awarded a HEAL grant to participate as a core member in the NIH back pain consortium (BACPAC), a $150 million investment to improve the understanding of and treatment for chronic low back pain.
Participation in CLIC Common Metrics evaluation and CD2H initiatives	Successful implementation of and participation in Common Metrics reporting for "Careers in Clinical and Translational Research," "Median IRB Review Duration," Informatics Common Metric," and "Pilot Funding Publication and Subsequent Funding." Preparing CTSI for implementation of "Median Accrual Ration Metric" Common Metric for 2020 data. Worked closely with CD2H to coordinate and integrate Informatics Core B activities with CD2H's communities.

APPROACH

Aim G1.1. Facilitate engagement with the TIN through integrated clinical trial operations.

The central objective of the Network Capacity Core (see **Table G2** for Core leadership) is to increase the efficiency and effectiveness of UCSF's clinical research infrastructure in support of CTSA program-wide initiatives. A major focus for these efforts will continue to be facilitating engagement of UCSF faculty and staff with the TIN. This involves the HLT leading improvements in enterprise-wide clinical trial infrastructure and active engagement with the UCSF community to identify and connect researchers with TIN resources. The HLT membership includes expertise across the spectrum of required expertise.

Table G2. Network Capacity Core leadership.

Name	Core Role and Qualifications
Payam Nahid, MD, MPH	**Network Capacity Core Director/HLT Scientific Lead:** Dr. Nahid is a UCSF Professor and the Associate Director of Clinical Trial Operations in UCSF's Office of Research. Dr. Nahid is an experienced clinical trialist and is also the Director of CTSI's Participant and Clinical Interactions Core.
Carmela Lomonaco, PhD	HLT Operational Lead/CLIC Lead/Point of Contact: Dr. Lomonaco is CTSI's Chief Administrative Officer and directs CTSI's local and network operations.
Vanessa Jacoby, MD, MAS	HLT Recruitment Lead: Dr. Jacoby is a UCSF Associate Professor and directs CTSI's participant recruitment activities.
Mark Pletcher, MD, MPH	CD2H co-Lead: Dr. Pletcher is a UCSF Professor and directs CTSI's Informatics Core.
Leslie Yuan, MPH	CD2H co-Lead: Ms. Yuan is CTSI's Chief Information Officer.
Rohit Gupta	CD2H co-Lead: Mr. Gupta is UCSF's Chief Biobanking Officer.

Disseminating information about the TIN to UCSF investigators. The Network Capacity Core will continue to expand its efforts to communicate with the UCSF community about the TIN. The communications strategy employs multiple approaches:

- Enhancement and promotion of information on CTSI and network TIN websites
- TIN-focused presentations and discussions at divisional, departmental, and school-wide faculty meetings
- Direct, in-person consultation with clinical research coordinator community regarding TIN resources
- Highlighting TIN resources and "success stories" in regular CTSI and UCSF research e-newsletters
- Orientation of new faculty and staff to TIN resources
- Technology-enabled just-in-time investigator notification of TIN resources through integration with pre-award grants management workflow

The Core is well-positioned to disseminate information across the UCSF community. The scientific lead, Dr. Payam Nahid, and the operational lead, Dr. Carmela Lomonaco, are the top faculty and staff administrators, respectively, for clinical trial operations at CTSI. In this capacity they work closely and collaboratively on the entirety of UCSF's operational support and have integrated the TIN fully into this effort. The HLT includes managers for TIN data, proposals, and trial activation.

Assisting investigators with proposal submissions to the TIN. The Network Capacity Core will continue to work with UCSF investigators to identify appropriate local CTSI and TIN resources to support their clinical trial proposals. It will assist local PIs with submitting proposals to TIN for an initial consultation. The Core will work directly with all interested investigators, leveraging the BERD Core's (**Core E**) established "front door" mechanism to quickly and efficiently connect. The HLT will consult with interested investigators to design opportunities into their protocols to test innovative clinical trial methods and to work with the TIN to develop this aspect more fully. The Core will also educate investigators about and encourage investigators to consider efficacy-to-effectiveness trial design that seamlessly connects effectiveness trials to efficacy trials through innovative cohort development approaches (e.g., engagement with TIN "design labs").

Identifying local investigators for TIN studies. In addition to continued outreach by the Core to its established network of campus leaders and researchers, the Network Capacity Core will utilize technology to systematically search the entirety of the UCSF research community for potential PIs of TIN-supported trials. Using UCSF's CTSI-supported web-based catalog of all faculty (UCSF Profiles), HLT will identify investigators' areas of research (through the use of “Concept Clouds” and “Radial Network Views”) and generate clusters of connectivity among related investigators, thereby enabling direct digital outreach to these investigators. CTSI's technology team (led by Leslie Yuan, CD2H co-lead) has extensive experience with the above approaches.

Working with UCSF's Office of Research to fully institutionalize TIN services. In close coordination with Cores A (**Aim A3.1**) and F (**Aim F2.2**), the Core will integrate TIN and successfully pilot CTSI services into the larger Clinical Trials Operations (CTO) program at UCSF. The CTO program is embedded in UCSF's Office of Research and provides support across the lifespan of clinical trials, from initial research design, to study initiation and execution, to data sharing and dissemination. The Core DirectorLead, Dr. Nahid, also serves as the Core F lead and is the Director of the CTO program, streamlining the administrative aspects of incorporating TIN resources and opportunities across UCSF.

Table G3 lists UCSF's metrics for NIH-funded multi-site clinical trials activated during the 6-month period prior to compilation of this application. During that time period, the average time from protocol receipt by our Office of Clinical Trial Activation to activation (i.e., coverage analysis, clinical trial management system build, contract execution, IRB approval) was 197 days and demonstrated a reduction of 154 days (44%) from a year prior.

Table G3. NIH-funded multi-site clinical trials activated over prior six months

Multisite Trials (shortened titles)	Contract Receipt to Execution**	Protocol Receipt to IRB Approval**	Contract Executed to First Patient Visit**	IRB Approval to First Patient Visit**
Low vs Moderate Exposure Busulfan for Infants with SCID	19	338	No FPV	No FPV
First-in-Human with HIV Neutralizing Antibody*	0	181	1	182
Blinatumomab with Chemotherapy in Patients with Newly Diagnosed Lymphoblastic Leukemia*	0	67	4	13
COMMIT-D to Improve Adherence to Depression Treatment*	0	43	185	228
Adalimumab vs. Conventional Immunosuppression for Corticosteroid-sparing Uveitis Trial	62	130	113	200

Randomized Study of Irinotecan/Temozolomide/Dinutuximab with or without Eflornithine	39	96	1780	35
Chronic Venous Thrombosis: Relief with Adjunctive Catheter-Directed Therapy	108	195	176	112
Adaptive, Multi-arm, Adjunctive-thrombolysis Efficacy Trial in Ischemic Stroke	86	117	No FPV	No FPV
Paclitaxel/Carboplatin/Maintenance Letrozole Versus Letrozole Monotherapy in Patients with Stage II-IV Ovary Cancer*	225	24	No PRV	No FPV
De-Intensified Radiation Therapy for Patients with Early-Stage, Oropharyngeal Cancer*	225	48	1934	42
Adaptive Clinical Trial of Cognitive Training to Improve Function and Delay Dementia	7	14	No FPV	No FPV
Sleep for Stroke Management and Recovery Trial	77	86	251	141
Sphincterotomy for Acute Recurrent Pancreatitis Trial	245	395	No FPV	No FPV
T-Cell Reinfusion After Interfering with Lymphocyte Binding Location of AIDS*	0	162	No FPV	No FPV
Understanding the Role of Local and Systemic Inflammation in Male Urethral Stricture Disease	38	82	42	17

*part of a master contract or NIH-funded ** number of days

Aim G1.2. Provide innovative services to enhance participant recruitment in TIN clinical trials.

Efficient identification and enrollment of eligible participants is one of the crucial requirements for a successful clinical trial. Under-enrollment is a particular problem among racial and ethnic minority groups. In the renewal, the Network Capacity Core will build on CTSI's existing participant recruitment programs to bolster the ability of the Core to support participant recruitment for TIN clinical trials. These expanded Core services will also be made available to the broader regional and national community of CTSA-affiliated researchers through collaboration with NCATS's trial and recruitment innovation centers.

Technology-supported development of robust recruitment plans for TIN clinical trials. The Network Capacity Core will provide study teams with materials and guidance through the BERD core (**Aim E1.2**) to create an effective recruitment plan and budget and provide further guidance on writing the NIH clinical trial recruitment plan section required of all clinical trial applications. This support will focus on enabling cohort discovery, fostering community engagement, and providing recruitment strategy training. The Core will also develop additional recruitment enablers, such as an automated pre-award notification sent to each study investigator at the time they contact UCSF Grants Management. Such technology-based solutions will provide "just-in-time" notification alerting investigators to the important resources and educating them regarding available TIN and Core services. If impactful, the Core will disseminate these technology-based solutions through CD2H and the CTSA network. The Core's HLT will also assist with providing researchers with counts of potentially eligible study participants across sites through the NCATS-supported ACT network.

Innovative, technology-enabled strategies for participant recruitment to clinical trials. The Core will develop an expanded portfolio of innovative, technology-enabled services for participant recruitment that can be disseminated across the CTSA network:

- EHR-based participant searches*:* The Network Capacity Core will leverage the Informatics Core's work enabling EHR-based recruitment strategies (**Aim B3**) to automate real-time EHR-based participant searches for clinical trials utilizing the TIN. These searches will be updated on a daily basis, permitting the study team to contact eligible patients through the EHR's online patient portal. Patients will receive a brief, patient-friendly message in their portal's research inbox alerting them to the trial, its basic goals, and contact information for interested patients. Patients will have the option to opt out of contact for research studies, and strict limits on the number of contacts per patient per month are in place.
- Social media-based recruitment support*:* The Core will expand its current participant recruitment pilot to create a new social media-based recruitment service for TIN studies. This will include development of study-specific Facebook, Instagram, and Google ads and hosting of social media campaigns.
- Integration of digital app-based data for recruitment: Data input from smartphone-enabled health apps connected to wearable technology may improve identification of eligible participants for clinical trials beyond data culled in the EHR. Utilizing the Informatics Core's new Self-Monitoring Analysis and Reporting Technology (SMART) Health Apps Rapid Platform (SHARP) designed to support and integrate digital interventions (**Aim B2**), the Network Capacity Core will offer the integration of app-based data elements into the automated EHR-based participant search for TIN trials described above.

Table G4. Hub Liaison Team and the TIN Milestones and Metrics

Aim G1.1. Facilitate engagement with the TIN through integrated clinical trial operations.

Milestones	*Metrics (#, %, rating)*
Awareness of TIN across Hub	# submissions/# accepted # proposals testing innovative clinical trial methods
Targeted outreach	# studies with local PIs/% digital
TIN integration into CTO program	Time (days) to activation Median accrual ratio
Aim G1.2. Provide innovative services to enhance participant recruitment in TIN clinical trials.	
EHR-automated reminders	#/% of eligible PIs who received an alert #/% of PIs who sought support after notification
Technology-enabled recruitment strategies	# eligible patients identified/contacted # searches/day

Section G2: Hub Liaison Team and other CTSA Program Central Resources

With the transition of the CTSA Hub coordination to the Center for Leading Innovation and Coordination (CLIC) at the University of Rochester and the development of the National Center for Data to Health (CD2H), CTSI has continued to expand its productive, collaborative engagement with the CTSA network. In this renewal, CTSI proposes to maintain active coordination and communication with CLIC and CD2H and describes a novel and highly innovative informatics approach to integrating biospecimen-derived and clinical data.

Aim G2.1. Assist CLIC in collection of data for strategic management of the CTSA network and for cross-CTSA network coordination and communication.

CTSI's data-driven approach to evaluation and process improvement (**Aim A2.2**) aligns with and enables CLIC's collection and use of data for evaluation of CTSA network activities. The Core has coordinated closely with the Administrative Core to analyze and submit data for all requested Common Metrics. CTSI leadership also participated in the CTSA Program Evaluators group to identify innovative and cutting-edge approaches to measuring collective impact and is fully committed to continuing to assist CLIC in its CTSA program evaluation efforts moving forward and across a variety of other CLIC-supported activities (**Table G5**).

Table G5. CTSI Participation in CLIC-supported Activities.

Hub leader (role)	CLIC-supported activity/activities
Harold Collard, MD (CTSI Director, MPI)	CTSA Hub Pod calls (monthly) CTSA PI calls (monthly)
Carmela Lomonaco, PhD (CTSI Administrator)	CTSA Administrator calls (quarterly) TIN Point of Contact working group (monthly) Common Metrics calls/reporting (Annually) Wow story submission/newsletter submissions (ongoing)
Payam Nahid, MD, MPH (Cores F and G)	TIN Medical Director calls (monthly)
Kirsten Bibbins-Domingo, PhD, MD, MAS (MPI)	Enterprise Committee - Workforce Development
Ida Sim, MD, PhD (Cores A and B)	Enterprise Committee - Informatics, CD2H
Kevin Grumbach, MD (Core C)	Enterprise Committee - Collaboration and Engagement
Roberta Keller, MD (Core D)	Enterprise Committee - Integration Across the Lifespan
Doug Bauer, MD (Core I)	KL2 Working Group
Alka Kanaya, MD (Cores D, I, and J)	Enterprise Committee - Workforce Development
Peter Chin-Hong, MD (Core J)	TL1 working group

The Network Capacity Core disseminates CLIC communications and opportunities for CTSI participation in network-wide activities (e.g., "synergy papers," "un-meetings") and through NIH-funded programs (e.g., TIN, CD2H, SMART IRB, ACT) via monthly CTSI faculty and staff meetings and through UCSF's research e-newsletter, called Research Resources. CTSI will also actively identify and increase faculty participation in CLIC activities by targeting relevant faculty and staff through seaches of UCSF Profiles.

Aim G2.2. Assist CD2H in its mission to harmonize the data ecosystem, realize a software and people ecosystem, and catalyze ideas to implementation.

The Core is fully committed to assisting CD2H in its aims to harmonize the data ecosystem, realize a software and people ecosystem, and catalyze ideas to implementation. Specifically, the Core will substantively contribute to CD2H initiatives across all four of its Community Cores:

Resource Discovery Community Core. The Network Capacity Core will continue to focus on adoption of and contribution to open software, specifically in the arena of research networking (e.g., Profiles), working closely with CD2H. This work will include integrating CD2H-developed translational workforce personae for active use in UCSF Profiles. This Core will also ensure that activities in **Aims A3.1** and **E2.2,** designed to share UCSF's

clinical trial datasets and other clinical research lifecycle outputs, are aligned with and advance CD2H Resource Discovery.

Informatics Maturity and Best Practices Community Core. The Network Capacity Core will contribute to and utilize the informatics maturity models and self-assessment tools supported by CD2H. CTSI's activities with the CD2HCommunity Core will center around integrating shareable clinical trial datasets into the CD2H Discovery Engine, contributing frameworks, tools, and resources for ethical resource sharing and research data licensing (**Aim E2.3**), and applying CD2H Maturity Models to research informatics deployment and data and software sharing (**Aim B3** and **Aim E2.2**).

Next Generation Data Sharing Community Core. The UCSF community is developing a fully de-identified Observational Medical Outcomes Partnership (OMOP) Clinical Data Warehouse (CDW) available for use by the research community (**Aim B1**), and has fully embraced Fast Healthcare Interoperability Resources (FHIR) and SMART on FHIR (**Aim B2**). Ongoing efforts will address streamlining open source “dev ops” and an FHIR object model interface, expansion of the standard with “SQL on FHIR,” and leveraging FHIR to enable consumer access to EHR data on the Android platform. The Network Capacity Core will contribute to the HL7 Engagement, CDM-FHIR Gap Analysis, and FHIR Server Options task forces supported by CD2H.

Tool and Cloud Infrastructure Community Core. The Network Capacity Core will continue to promote sharing of tools and platforms for collaborative reuse across the CTSA network. For example, the Informatics Core's SHARP platform aims to establish a common cloud computing architecture that is an affordable, easy to use, rapid deployment environment for SMART on FHIR apps (**Aim B2**). The SHARP platform and apps will be independently shareable. The first app, called NEWT (https://www.newbornweight.org/, but available via SMART on FHIR) will be shared on UCSF’s github/CD2H cloud for the CTSA community to deploy in their own SMART on FHIR-compliant EHR. Additionally, CTSI will contribute CommonHealth (**Aim B2**) and BioCatalyst (**Aim G2.3**) source code to the CD2H cloud. The CommonHealth code leverages FHIR to allow patients to easily and securely bring their own EHR data to their Android smartphone and makes that data available for clinical care or research, similar to Apple Health. CTSI will actively promote CD2H Challenges to our growing machine learning trainee and practice community.

Aim G2.3. Collaborate with CD2H to disseminate cutting-edge biomedical informatics solutions to integrate biospecimen-derived and clinical data.

The current funding cycle supported the creation of CTSI's Precision Medicine program as an Optional Core, which developed a centralized infrastructure for high-quality biospecimen collection, storage, and annotation. This successful Optional Core has now been fully integrated into UCSF's Office of Research, allowing CTSI to focus on increasing the impact of the biospecimen-derived datasets as part of next-generation biobanking.

Most academic biorepositories lack both the technology and expertise required to efficiently leverage biospecimen data in support of systems biology and precision medicine.[1] Notably, despite significant focus on clinical data solutions, most CTSAs also lack innovative tools and infrastructure to integrate biospecimen data with other datasets. To address this need, the Precision Medicine program has developed BioCatalyst (**Figure G1**), a first-of-its-kind search engine/application that allows biobanks to connect both clinical attributes and biological/molecular data to existing biospecimens in a central, easy-to-use virtual ecosystem.[2] By providing this framework as a common crosswalk among biobanks, BioCatalyst aims to empower researchers across the CTSA network with a self-service, collaborative tool for identifying existing biospecimens by both clinical and biological annotations.[3] This creates a perfect opportunity for collaboration with CD2H, working to expand and

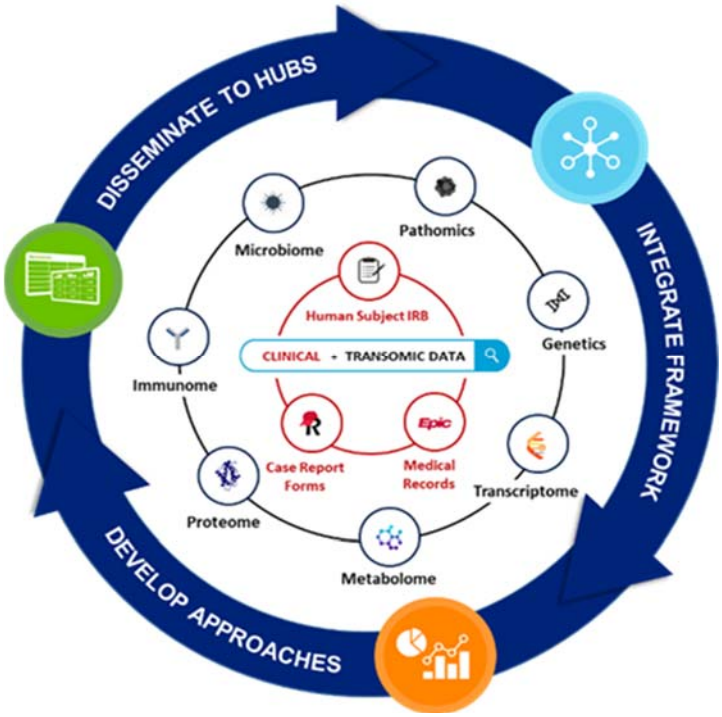


Figure G1. BioCatalyst

disseminate the BioCatalyst informatics platform to CD2H's collaborative informatics community and integrate it with CD2H's efforts at developing Good Data Practice and interoperability across the CTSA network(see **Letter of Support from CD2H** in Overall section). Specific activities will include:

Dissemination and sharing of BioCatalyst infrastructure. The Network Capacity Core will collaborate with CD2H to disseminate and share BioCatalyst across the CTSA network. This work is now underway as part of CD2H's Phase III strategic plan and will involve introducing the platform to other CTSA sites through CD2H's cloud infrastructure, utilizing the consortium's communications and activities aimed at improving researchers' proficiency in data science and developing educational and training resources for patients and research teams at other interested CTSA Hubs. To promote the dissemination and adoption of BioCatalyst at other CTSAs, the Core and CD2H will utilize sandboxes and other sharing mechanisms available to promote collaboration. They will also demonstrate how an emphasis on developing common standards and Good Data Practice facilitates BioCatalyst deployment and maximizes the impact of integrated biospecimen data in clinical research.[4]

Development of innovative tools to visualize and search biospecimen data. In the renewal, the Network Capacity Core will work collaboratively with the Informatics Core and CD2H to crowdsource and pilot innovative tools and models for BioCatalyst-based data visualization and searches from across the CTSA network.[5] This will involve further co-implementation of the OMOP common data model to annotate and link biospecimen-derived data to clinical data. OMOP offers a useful unified target model for mapping data across multiple contexts, fostering interoperability for both clinical and biospecimen data and software from different CTSAs in the cloud. The Core will apply FAIR principles (findable, accessible, interoperable, and re-useable) to determine how the data model harmonization and terminology services endeavors may be useful in creating interoperable biobanking resources for the CTSA network. The Core will work with CD2H to create universal sets of FHIR Adapters (using the FHIR for Research framework) that can be used at different CTSAs to connect their individual de-identified CDWs with biospecimen data in BioCatalyst.[6] For example, we could assess if implementing the new Global Alliance for Genomics and Health (GA4GH) standard, Phenopackets, would facilitate case-level de-identified phenotype data sharing among CTSAs' biobanks.[7] This work could also leverage CD2H efforts in designing novel cloud architecture to rapidly deploy BioCatalyst at each CTSA and enable capture, storage, and linkage of data for biological data derived by sample consumption at the benchside. Novel tools to automate data syncing (e.g., Trans-Omics Data Manager) are available and allow users to leverage machine learning tools to populate records based on unstructured data elements. The Core will work with CD2H to pilot these and other initiatives and share information about discoveries and accomplishments using BioCatalyst with stakeholder groups across the CTSA network.

Table G6. Hub Liaison Team and CTSA Central Resources: Milestones and Metrics

Aim G2.1. Assist CLIC in collection of data for strategic management of the CTSA network and for cross-CTSA network coordination and communication.	
Milestones	Metrics (#, %, rating)
Partnership with CLIC	Submission of Common Metrics data requests # CTSI faculty/staff active in CLIC projects and committees
Communication of CLIC activities across Hub network	Establishment of monthly CLIC section in CTSI's clinical research newsletter # UCSF participants in CLIC activities (e.g., synergy papers, un-meetings)
Aim G2.2. Assist CD2H in its mission to harmonize the data ecosystem, realize a software and people ecosystem, and catalyze ideas to implementation.	
Creation and sharing of open software	CD2H-developed translational workforce personae integrated for active use in UCSF Profiles # clinical research lifecycle outputs aligned with and shared through CD2H Resource Discovery community core
Participation in CD2H cloud infrastructure	# apps/source code shared on CD2H cloud
Aim G2.3. Collaborate with CD2H to disseminate cutting-edge biomedical informatics solutions to integrate biospecimen-derived and clinical data.	
Integration of Biocatalyst informatics platform and CD2H efforts	API (y/n); # specimens in Biocatalyst linked to real-time "return data" from lab instruments in Cloud platform; # software tools available for dissemination
Biocatalyst at other CTSA Hubs	# other CTSA hubs using biocatalyst platform # PIs using Biocatalyst and contributing data at UCSF and other CTSAs
Innovative tools to visualize and search biospecimen data	# new tools/data visualizations # sub-cohorts with existing specimens leveraged for new studies without additional recruitment needed; # sub-cohorts identified for callbacks into new studies # biospecimens distributed across CTSAs as a result of search engine

CORE H. IMPACTING PRACTICE AND POLICY: SPECIFIC AIMS

Evidence generated by clinical and translational researchers plays a critical role in informing decision making about health at governmental, health system, private industry, and community levels. Unfortunately, efforts to incorporate evidence into practice and policy are often under-resourced or overlooked.

CTSI's new Impacting Practice and Policy by Accelerating Translation (IMPACT) Core is designed to change this reality by creating an institutional accelerator for the translation of evidence to practice and policy. The IMPACT Core leverages UCSF's extensive expertise as a leader in bringing evidence to bear on practice and policy decisions to create a central home within CTSI for relevant resources and training. IMPACT will facilitate the development and dissemination of scientific evidence that supports the work of decision makers. IMPACT will also work closely with UCSF leadership to incentivize investigators to translate research outside the walls of academia. Best practices for establishing connection and collaboration between investigators and decision makers will be cultivated and disseminated across the wider network of CTSAs. The IMPACT Core proposes to achieve its goals through three Specific Aims:

Aim H1. Identify and expand resources to support translation of evidence into practice and policy.

This Aim describes how IMPACT will undertake asset mapping to identify and assemble existing campus capacities and initiatives designed to bridge the evidence-to-practice and policy gap into a unified, CTSI-based virtual home serving the entire campus community. This virtual home will identify relevant campus training opportunities, funding sources, mentorship and support, and other resources. IMPACT will create a library of evidence-to-practice and policy research products, including case examples of academic research leading to policies, practices, and guidelines. Gaps identified during asset mapping will be filled by the creation of targeted education and training capacities (**Aim H2**) and by developing institutional policies that recognize and reward practice and policy impact. Financial support to investigators through IMPACT supplements will directly promote and enable accelerated evidence translation.

Aim H2. Provide comprehensive training in the translation of evidence into practice and policy.

UCSF currently has many of the building blocks for state-of-the-art training in the translation of evidence for practice and policy impact. However, these capacities are challenging to identify and exploit because they are not organized into coherent curricula. This Aim describes how the IMPACT Core will organize and expand training resources to provide comprehensive training opportunities to learners. This includes establishing formal competencies for successful collaboration with policy and decision makers; accessing or developing formal curricula to teach these competencies; regular seminars and visiting lectureships highlighting the impact of research on policy and practice; and an annual themed workshop open to the UC-based and broader CTSA network. These training resources will be available to trainees at all levels, and will be overseen by UCSF investigator-mentors skilled in these activities.

Aim H3. Expand the translation of evidence to practice and policy across the CTSA network.

The impact of evidence translation to practice and policy can be greatly accelerated by expanding geographic reach. This aim describes how IMPACT will disseminate its model across the CTSA network, starting with the five University of California (UC) CTSA campuses through an established cross-campus collaborative. Activities and resources targeted for this expansion include: IMPACT training resources and opportunities, identification and engagement of additional IMPACT leaders with relevant experience on other campuses, and diffusion of university career advancement policies that recognize success in supporting translation of evidence into practice and policy in the promotions process. Successful pilot approaches in the UC consortium will be shared with the larger CTSA network.

Abbreviations used in Core H

IMPACT = Impacting Practice and Policy by Accelerating Translation	NCSP = National Clinician Scholars Program
	IHPS = Institute for Health Policy Studies
UC BRAID = Biomedical, Research, Acceleration, Innovation and Development	UC = University of California

CORE H. IMPACTING PRACTICE AND POLICY: RESEARCH STRATEGY

CTSI's new Impacting Practice and Policy by Accelerating Translation (IMPACT) Core builds on UCSF's extensive experience and leadership in evidence translation to propose an institutional accelerator program promoting collaboration between investigators at the University of California, San Francisco (UCSF, and eventually the broader CTSA network) and decision makers in government, health systems, private industry, and communities(see **Letters of Support from UCSF Institute of Health Policy Studies, UCSF Office of Community and Government Relations, and California Health and Human Services Agency** in Core H). These stakeholder collaborations are essential to the translation of evidence into practice and policy and are not typically cultivated in academic environments.[1] The IMPACT Core will build capacity for clinical and translational researchers to reach and inform a broad range of decision makers, thereby influencing how policies, guidelines, and regulations are developed.

The IMPACT Core's primary goal is to provide resources and training to UCSF and the larger CTSA network that accelerate the pace at which evidence is translated into practice and policy (**Figure H1**). CTSI has been a national leader in this area over the current CTSI cycle, largely driven by the Community Engagement (CE) Core (**Table H1**). The IMPACT Core is designed to leverage the experience and knowledge of the CE Core and the larger UCSF community to create an institutional engine for evidence translation. Successful dissemination of this Core across the CTSA network (one of its stated aims) would address a significant gap in the current clinical and translational science community.

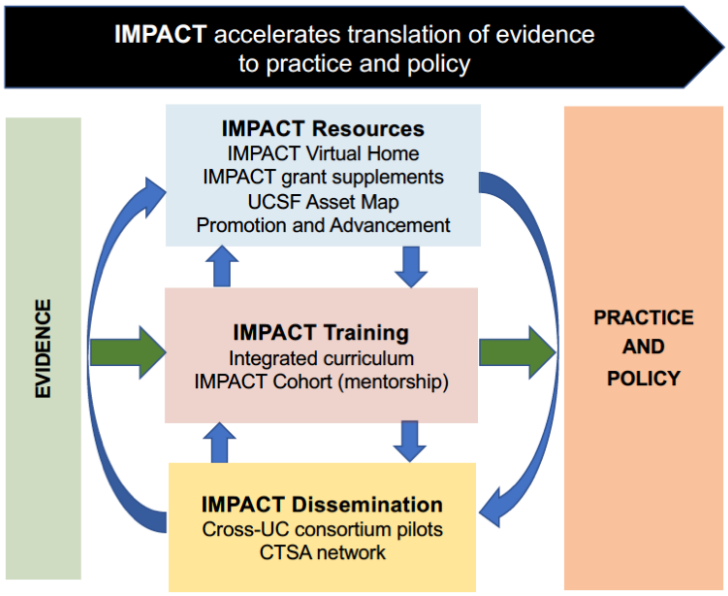


Figure H1. CTSI's IMPACT Core

Table H1. Selected accomplishments in translating evidence to practice and policy in the current cycle

Identified need	Implemented change and outcome
Formal training in translating evidence to practice and policy	CTSI supported the development of an implementation science curriculum and degree-granting training program to promote the translation of research into practice and policy settings. This is now offered to UCSF trainees by the Department of Epidemiology & Biostatistics. CTSI has provided training in evidence-to-policy translation to 40 CTSA Hubs through an NCATS administrative supplement.[2]
Community-based team science approaches to health disparity-focused evidence translation	CTSI has developed and demonstrated the effectiveness of a new model for stakeholder engagement that leverages cross-sector collaborations[3] resulting in multi-sectoral working groups that have achieved tangible improvements in narrowing health disparities in obesity, alcohol problems, hepatitis B, and childrens' dental caries.
Reduced consumption of sugary beverages	CTSI partnered with the San Francisco Board of Supervisors and community leaders to translate evidence of adverse health effects of sugar beverage consumption into policy, and passed the San Francisco "soda tax" in 2016 that placed a 1¢/ounce tax on all sodas and other drinks with added sugar. The tax has lowered consumer purchases and provides over $10 million annually to address obesity and diabetes disparities citywide.[4,5] Three other Bay Area cities (Oakland, Berkeley, Albany) collaborated to pass similar measures,[6] and our team currently works in US states and internationally to promote soda taxes, now in 40 countries.[7] The first-ever evaluation of this approach found significant reductions in waist circumference among UCSF employees 10-months after the sales ban, and improved insulin sensitivity for employees who reduced their sugary soda beverage consumption.[8] Evidence that workplace sales bans could lower employer health spending[9] led the UC Office of the President to support scaling the policy across all 10 UC campuses.
Improved access to healthy food	UCSF researchers engaged with community leaders, municipal government officials, and other stakeholders to translate evidence regarding the value of fruits and vegetables to health, and developed EatSF. EatSF now serves approximately 11,000 residents of San Francisco annually, including virtually all low-income pregnant women, through a network of 31 local corner stores, groceries, and markets providing >$2 million in fruits and vegetables and reducing food deserts.
Improved oral health for children	As above, UCSF researchers engaged with stakeholders to translate evidence regarding the value of oral care to child health and developed Cavity Free SF. This initiative brought together community stakeholders to develop a strategic plan to systematically improve children's oral

	health. Now all kindergarteners in the SF Unified School District receive dental screening and selected centers offer on-site fluoride varnish.[10]

APPROACH

The IMPACT Core contains three primary components that constitute the three following aims: IMPACT resources (**Aim H1**), IMPACT training (**Aim H2**), and IMPACT dissemination (**Aim H3**). Together, these three elements provide clinical and translational researchers with the knowledge, skills, and resources needed to successfully translate evidence to practice and policy. Working with UCSF leadership, the Core will also promote institutional policy changes that increase the opportunities for, and recognition of, clinical and translational researchers who work to provide evidence for practice and policy-based decision making.[11]

IMPACT's model for bridging the evidence-to-practice and policy gap is based on the concept of strategic science, which recognizes the value of up-front engagement with key decision makers.[11] In the ideal strategic science model, researchers and decision makers develop research questions relevant to the needs of the "community" (which may be policy makers, health system leaders, community members, industry executives, etc.), study those questions, and then communicate results to decision makers through targeted translational research products (e.g., briefs, model policies, and guidelines). Collaboration among investigators and decision makers across all of these steps increases evidence-based decision making for impact on practice and policy.

Aim H1. Identify and expand resources to support translation of evidence into practice and policy.

The IMPACT Core will be led by leaders from CTSI ANDUCSF with demonstrated expertise in translating evidence to practice and policy in various domains—government, professional organizations, health systems, community, etc. (**Table H2**). Core leadership will support building bridges with communities in which they frequently work, ensure IMPACT materials are appropriate for each of these target communities, support the identification of gaps in UCSF's support for engagement in the communities in which they frequently work, and contribute to development of the IMPACT competencies and curriculum (**Aim H2**).

Table H2. IMPACT Core Leadership

Name	Core Role and Qualifications
Laura A. Schmidt, PhD	**IMPACT Core Co-Director:** Dr Schmidt is a UCSF Professor and has served as a co-director of CTSI's CE Core in the current cycle. Dr. Schmidt has been centrally involved in the leadership of many of UCSF's recent policy successes including the soda tax. Dr. Schmidt works closely with California state legislators on food and beverage reforms as well as internationally with WHO and the Pan American Health Organization on alcohol and food policy reforms, and on implementing a new national health insurance plan in South Africa.
Hilary Seligman MD, MAS	**IMPACT Core Co-Director:** Dr. Seligman is a UCSF Professor, the director of UCSF's National Clinician Scholars Program, and the director of UCSF's Food Policy, Health and Hunger research program. She is the founder of EatSF. Dr. Seligman has brought her research on the health impacts of SNAP, WIC, and other federal nutrition programs to policy makers in Washington DC through in-person testimony, policy briefs, and one-on-one education, and sits on the SF city and county Food Security Task Force.
Andrew Bindman, MD	Government and foundation lead: Dr. Bindman is a UCSF Professor and the former director of the Agency for Healthcare Research and Quality (AHRQ).
George Sawaya, MD	Professional organization lead: Dr. Sawaya is a UCSF Professor. He serves as the American College of Obstetrician and Gynecologist's representative to the American Society of Colposcopy and Cervical Pathology guideline group (2020), co-chairing a new committee on High-Value Care.
Naomi Bardach, MD	Health systems lead: Dr. Bardach is a UCSF Associate Professor. Her work has direct policy impact on pediatric screening in Medicaid programs nationwide and in California.
Kim Rhoads, MD, MS, MPH	Stakeholder engagement lead: Dr. Rhoads is a UCSF Associate Professor. She directs the Community Engagement Program for UCSF's Helen Diller Family Comprehensive Cancer Center. Her work is influencing national surgical society efforts to reduce racial/ethnic disparities in cancer care.
Beth Griffiths, MD, MPH	Advocacy lead: Dr. Griffiths is a UCSF Professor. Her advocacy focuses on Medicaid reimbursement and primary care workforce development policy.

The Core's Aim H1 will undertake asset mapping to identify and assemble existing campus capacities and initiatives into a unified, virtual home serving the entire CTSI and campus community. This virtual home will identify training opportunities, funding sources, mentorship and support, and campus "wins" to be used as case studies. These will be developed along with a catalogue of translational research products: summaries of academic research and model policies, practices, and guidelines. Existing barriers to engaging in evidence-to-practice and policy work will be addressed by developing institutional recognition of such efforts in the promotions process and grant supplements to support accelerated translation of targeted research efforts.

Create a virtual home for IMPACT resources that serves the entire CTSI community. UCSF contains many evidence-to-practice and policy resources and tools. However, they are currently siloed and difficult for interested investigators to identify and access. To address this gap, IMPACT will:

- Develop a comprehensive asset map across UCSF schools, departments, centers, and programs. Asset mapping concentrates attention on existing strengths, avoids creation of redundancy, and builds upon assets that might have otherwise been overlooked or taken for granted.[12] Initially, assets will be identified through a review of internal UCSF web pages for references to IMPACT activities. Using a snowball approach supported by the Core leadership, individuals responsible for one resource (e.g., a course in implementation science) will be queried for knowledge of similar resources. The catalogue of assets will be refined via feedback from institutional leaders and CTSI.
- Using the asset map as a starting point, the IMPACT Core will create an online virtual home cataloguing all IMPACT activities, resources, and capacities across UCSF. This virtual home has two target audiences. First, it will direct UCSF leadership, investigators, and trainees to the wide range of activities, resources, and capacities existing or in development across the institution so that these may be more efficiently utilized. Second, it will provide external policy and decision makers with tools and infrastructure to support collaboration with UCSF investigators and evidence-based decision making. This virtual home will include information about each of the additional activities described below, including training resources and seminars, supplements to financially support evidence-to-impact work, model policies, programs, and guidelines, case studies, and centralized services to support the development of strategic communication materials and relevant institutional guidelines and policies.

Develop and demonstrate institutional policies that reward faculty for evidence-to-practice and policy activities. The IMPACT Core ultimately seeks a broad culture change that knits the need for practice and policy impact into the fabric of clinical and translational science. A critical aspect of the Core's work will be engaging UCSF leadership to develop and demonstrate structural changes that incentivize investigators to achieve practice and policy impact, operationalized as changes in the promotion and reward structures governing career development and advancement. Current tracking of scholarly activities for promotion is heavily focused on the publication of peer-reviewed manuscripts and the generation of influence among other academic investigators. The Core will work with UCSF leadership to implement four structural changes that reward evidence-to-practice and policy efforts:

- Revise the UCSF *curriculum vitae* tracking system to elevate the importance of practice and policy impact in faculty members' promotions portfolios. There are several planned strategies. First is creating a section in which investigators explicitly articulate the practice and policy impact of their work within diverse systems (health systems, communities, clinics, hospitals, industry, etc.). This addition to the promotions material will allow investigators to highlight activities reflective of deep and/or collaborative engagement with stakeholders, such as ongoing participation in community coalitions, legislative testimony, or adoption of model policies, guidelines, or practices. Second is adding Altmetric scores (www.altmetric.com) and other metrics (as they are developed) to publication lists to capture the extent to which published work has reached stakeholders outside of academia. Third is recognizing the development of model guidelines, policies, legislation, and practice guides in "publication counts."
- Revise CTSI's UCSF Profiles to include activities that have had practice and policy impact. Strategies include creating an easily identifiable graphic designation that identifies investigators with expertise in policy and practice activities, and enhancing collaboration and mentorship opportunities by using consistent keywords for evidence-to-practice and policy activities so that faculty and learners at all levels can be more easily identified.
- Create an annual Chancellor's IMPACT Award to recognize investigators whose work is influencing policies, practices, and systems of care.
- Communicate the importance of evidence-to-practice and policy work using strategic communications from university leadership to highlight policy and practice "wins" across the institution.

Provide IMPACT supplements to selected pilot grant awardees. A key barrier to translating evidence to practice and policy is lack of funding and expertise to take research "the last mile" to the public (including those with influence over policy in government, health systems, industry, and other sectors). In coordination with the **Pilot Translational and Clinical Studies (PTC) Core**, the IMPACT Core will help address this barrier by offering Pilot Grant awardees supplemental funding of $5000 each to support translation of research findings into practice and policy (**Aim D2.1**). IMPACT supplements will support the creation of communication materials for policy makers

and decision makers and consultation with Core leadership to emphasize strategic science. Materials developed through IMPACT supplement funding will be collected and disseminated through the IMPACT virtual home.

Aim H2. Provide comprehensive training in the translation of evidence into practice and policy.

UCSF has many of the building blocks for state-of-the-art training capacity in translation of evidence into practice and policy impact. However, these capacities are challenging to identify and connect with because they are not organized into coherent curricula. These key capacities include: awareness and identification of key policy and decision makers; best practices in communication (written, oral, and social media) to non-academic audiences; criteria for when research is ready to be elevated to policy and practice decision makers; media training for investigators; differences between advocacy, lobbying, and education; and development of model policies, guidelines, and practices. In Aim H2, the IMPACT Core will develop formal competencies for evidence-to-practice and policy work, design an IMPACT curriculum (leveraging existing coursework and seminars wherever possible) to teach these competencies, and offer in-depth training and support to learners at various levels of training through the development of the IMPACT Training Cohort.

Define formal IMPACT competencies for successfully translating evidence to practice and policy. Formal competencies will be developed by scanning existing frameworks of similar initiatives from other institutions and within UCSF, and adapting these to meet the Core's goals. The Core will engage in a deliberative process that engages the following key constituencies in iterative refinement of these competencies: IMPACT Core leadership; CTSI leadership; UCSF trainees, faculty, and educational leaders; and government, health system, and community stakeholders.

Develop and disseminate a comprehensive curriculum to teach IMPACT competencies. A comprehensive IMPACT Curriculum will be developed based on the above competencies (**Figure H2 below**). Wherever possible, this curriculum will take advantage of existing training resources at UCSF, including formal coursework and seminars identified by the asset mapping efforts (**Aim H1**). For example, coursework from UCSF's existing Program in Implementation Science, launched by CTSI in the current cycle, includes relevant courses in community-engaged research and organizational behavior. Additionally, coursework on bringing evidence to policy is offered by UCSF's Nursing Health Policy Program and the Institute for Global Health Sciences.

The IMPACT Core will develop an annual themed workshop to address competencies that complement formal coursework. The two-day, annual IMPACT Workshop will be open to the entire UCSF community. It will actively engage campus leadership as a visible means to promote a culture that recognizes and adequately values research that creates practice and policy impact. The theme of the first workshop will be "Tools for Communicating Research Outside of Academia," and will include four half-day sessions focused on: Formulating Research Questions for Practice and Policy Impact; Engaging Decision Makers Across Sectors; Communications and Media Training; and Writing for Non-Academic Audiences.

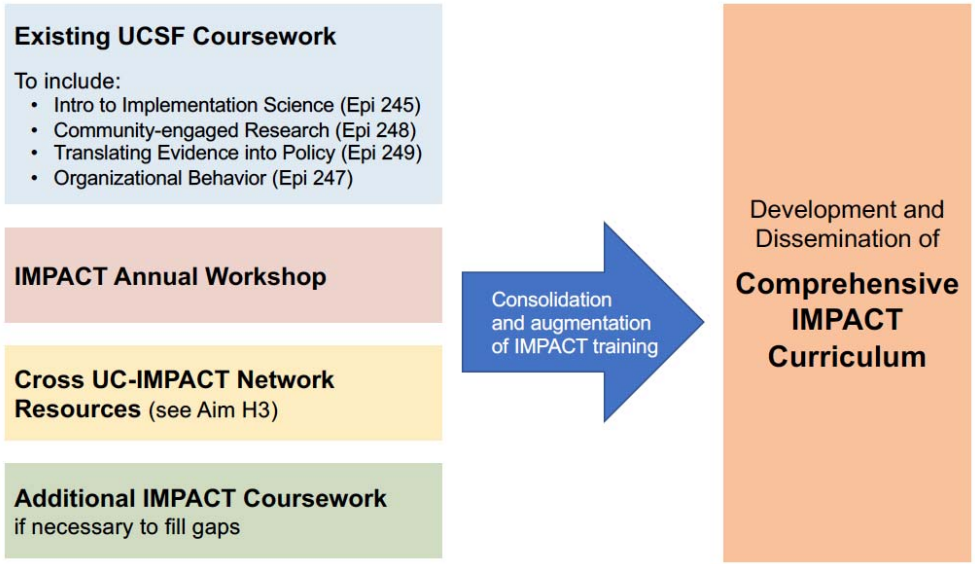


Figure H2. Developing a comprehensive IMPACT curriculum. Coursework and other resources from UCSF will be consolidated along with cross-UC network resources; additional coursework will be developed into a comprehensive IMPACT Curriculum that can be disseminated to the CTSA network.

Additional coursework and resources from across the UC campuses will be identified and incorporated (**Aim H3**). If substantial curricular gaps remain, the IMPACT Core will work with existing UCSF schools, departments,

training grants, and course directors to develop additional coursework and to expand course syllabi to include relevant material. Over time, the Core will follow the successful model of CTSI's Implementation Science Program which has leveraged federally funded institutional training grants to build a mature, robust training program.

Develop an IMPACT Training Cohort. The IMPACT Training Cohort will be modeled on CTSI's highly successful product development "Catalyst" internship program, which provides training specific to product development and nurtures collaborations between UCSF investigators and private industry. The IMPACT Training Cohort will focus on providing "evidence-to-practice and policy" skills to learners through experiential learning, didactic, and small group sessions. The IMPACT Training Cohort will include approximately 24 trainees at various level from a variety of sources: the Kaiser Family Foundation/UCSF research fellowship scholars (n=3), the National Clinician Scholars Program (NCSP) scholars (n=6), and up to eighteen scholars aligned with the Institute for Health Policy Studies, the School of Medicine Dean's Office of Population Health and Health Equity effort, and other campus constituencies. The Kaiser Family Foundation/UCSF research fellowship and NCSP are particulary aligned:

- *Kaiser Family Foundation/UCSF Research Fellowship:* In collaboration with the Kaiser Family Foundation (located in San Francisco), UCSF's Philip R. Lee Institute for Health Policy Studies has established a yearlong health policy research fellowship for medical students. As part of the fellowship, three students are embedded within projects underway or planned at the Kaiser Family Foundation. They are co-mentored by Kaiser Family Foundation staff and UCSF faculty members. This fellowship is led by Andrew Bindman, MD member of the IMPACT Core leadership team.
- *National Clinician Scholars Program:* The NCSP offers training for clinicians as change agents driving policy-relevant research and partnerships to improve health and health care. The goal of the program is to cultivate health equity, eliminate health disparities, invent new models of care, and achieve higher quality health care at lower cost. This is accomplished by training nurse and physician researchers who work as leaders and collaborators embedded in communities, health care systems, government, foundations, and think tanks in the United States and around the world (nationalncsp.org/about-us). In 2021, UCSF will welcome its first cohort of six NCSP Scholars, joining five other NCSP sites located at Yale University, University of Michigan, Duke University, UCLA, and University of Pennsylvania. NCSP at UCSF is co-directed by Dr. Hilary Seligman, IMPACT Core Co-Director.

Trainees will be supported through mentorship support from the IMPACT leadership team and in-person cohort-wide meetings quarterly for two years. These half-day meetings will include a didactic portion and a peer learning portion which build on the opportunities being offered through the home programs (e.g., Kaiser Family Foundation, NCSP) of each of the trainees. These sessions will be facilitated by the IMPACT Core's Co-Directors. Upon completion of IMPACT Cohort activities, it is expected that learners will be adequately skilled and experienced to serve as mentors to future IMPACT Training Cohorts.

Aim H3. Expand the translation of evidence to practice and policy across the CTSA network.

Practice and policy impact can be further accelerated by expanding geographic reach. The IMPACT Core aims to disseminate its resources across the CTSA network, and proposes to use an established practice and policy-focused consortium across the UC institutions to develop dissemination resources and initiatives that can then be widely shared with the CTSA network.

Cross-UC IMPACT initiatives. The IMPACT Core will collaborate with existing and new partners across the UC campuses, including the four other CTSA-supported UC campuses, to form a Cross-UC Network of IMPACT leaders. In addition to the Core leadership, this leadership group includes Wendelin Slusser MD, MS, Associate Vice Provost and Professor of Pediatrics (UCLA) and Douglas Ziedonis MD, MPH, Associate Vice Chancellor for Health Sciences (UCSD). This group has established relationships with leaders on all ten UC campuses and a track record of success in cross-campus initiatives coordinated through the UC Office of the President (see **Letter of Support from UCOP Global Food Initiative** in Core H)**.** The IMPACT Core will work with these leaders to share and bidirectionally combine IMPACT-relevant activities across CTSA sites.

- *Cross-UC IMPACT leads:* Using the strong existing relationships with the UC Office of the President, the IMPACT Core will actively recruit additional leaders across the UC campuses as emissaries and disseminators of IMPACT activities and best practices on their campuses. This expansion will better foster synergies in particular content areas. For example, a UCSF mentor with deep collaborative experience with a particular stakeholder, such as the California Department of Corrections and Rehabilitation, may provide critical support to an investigator at another UC campus who is seeking to provide more evidence-based services to a particular population at the time of discharge from prison or jail. Alternatively, an investigator at a UC campus

with expertise in EHR-based systems for better managing anti-coagulation to improve clinical outcomes may seek mentorship from a UCSF investigator with deep expertise in how similar clinical systems are implemented at UCSF.

- *IMPACT training opportunities*: IMPACT training opportunities will develop competencies and curricula and, as needed, bridge key curricular gaps. The Core will work proactively to make these materials accessible to other UC campuses using three mechanisms. First, participation in the IMPACT annual workshop will be made accessible to the other UC campuses. Second, webinars and seminars hosted by the IMPACT Core will be accessible using video technology. Third, the IMPACT Curriculum and IMPACT Cohort model will be disseminated through peer-reviewed academic publication and through dissemination of materials and hands-on support.
- *Dissemination of institutional policies*: In many cases, institutional policies created at UCSF will be relevant to other UC campuses. With the support of IMPACT champions at other UC sites, the Core will engage campus leadership to support the implementation of shared policies at multiple UC campuses. In addition, if successful at accelerating evidence-to-practice and policy at UCSF, the Core will support the development of small, supplemental funds across UC sites to support bringing research “the last mile” to decision makers.

CTSA network-wide IMPACT dissemination. The IMPACT Curriculum, learner competencies, and best practices for institutional policies that reward evidence-to-policy and practice work will be disseminated as white papers, publications, and tool kits for dissemination throughout the CTSA network through the Center for Leading Innovation and Collaboration (CLIC) and the Translation Together network (http://www.translationtogether.org/). In addition, models and best practices will be shared directly with other CTSAs and the CTSA network through "un-meetings," presentations at annual CTSA meetings, and other CTSA network-wide collaborative opportunities.

Table H3. MPACT Core Milestones and Metrics

Aim H1. Identify, coalesce, expand resources to support translation of evidence into practice/policy.	
Milestones	Metrics (#, %, rating)
Develop a targeted asset map of initiatives across UCSF	Asset map completed Report developed and available on CTSI website
Create a virtual home for online resources	Google analytics monitoring website traffic and downloads # virtual home users signing up for email alert subscribers # decision-maker consultations provided
Develop and implement institutional policies that reward faculty for practice and policy impact	# consultations with UCSF leaders # new institutional policies implemented at UCSF (e.g., revised CV protocols, Profiles)
Provide financial supplements	# applications received; # supplements administered # supplement-related “successes”, including publications
Aim H2. Provide comprehensive training in the translation of evidence into practice and policy.	
Recruitment and support for IMPACT Cohort	# Op Eds, pod casts, YouTube videos, TED talks, and fact sheets distributed # hours of testimony and direct consultation with decision makers
Develop curricula	# views of competencies and curricula # students taking IMPACT courses
Provide annual workshop	# workshop attendees Substantive findings of workshop evaluations
Aim H3. Expand the translation of evidence to practice and policy across the CTSA network.	
Engage cross-campus UC IMPACT leads	# courses and best practices adopted by other UC members # non-UCSF learners attending IMPACT trainings # decision maker consultations, policy discussions, policy changes across the system
Disseminate resources	# publications, white papers, tool kits # hearings, white papers, policy changes, clinical guidelines, resulting from dissemination

CORE I. INSTITUTIONAL CAREER DEVELOPMENT CORE (KL2) PROGRAM PLAN: SPECIFIC AIMS

The CTSI's "K Scholars Program" at UCSF integrates KL2 awardees with other K mechanism and career development awardees in what has become one of the largest and most successful clinical and translational research training programs in the nation.[1] It provides unique training that does not duplicate existing programs at UCSF and is a proven and vital resource for UCSF junior faculty from the Schools of Medicine, Nursing, Dentistry, and Pharmacy (see LOS Deans, UCSF Health Professions Schools). Our Program alumni, as individuals and as members of multidisciplinary teams, have made exceptional contributions to health sciences research across the lifespan. The proposed career development program builds upon the strengths of two decades of NIH support and experience, and continuous evolution to extend the state of science and discovery. It is led by expert K Program Faculty with lengthy mentorship track records in clinical and translational research across a broad range of methodologic and content areas. Historically, the program has supported Scholars across the entire translational spectrum, with notable impact in the area of clinical, behavioral, and health services research across the lifespan and for underserved populations.

Anticipating the need for emerging skills that will be fundamental to successful careers in team science-based clinical and translational research, this renewal focuses on new activities that provide state-of-the-art training in clinical informatics, data science, and implementation science. The K Scholars Program has long fostered a multidisciplinary team science approach, and will continue to leverage UCSF's unique strengths and partnerships to extend the impact of the Program by achieving the following Specific Aims:

Aim I.1. To continue to select and train a superb group of UCSF junior faculty KL2 Scholars from diverse scientific disciplines, and to support them for up to three years as they progress toward research independence.

We will continue all of the key training and mentoring elements of our longstanding and highly successful K Scholars Program and enrich further opportunities to promote research independence. Specifically, in partnership with other CTSI programs, we will expand existing activities and enhance training and mentorship to:

I.1.1. Facilitate the transition to research independence.

I.1.2. Integrate special populations into clinical and translational research.

Aim I.2. To provide state-of-the-art informatics and data science (DS) training, mentorship, and practical experience to advance clinical medicine and improve public health.

An increasingly important goal of many health care research projects is to extract knowledge and insights from large and/or complex datasets. In collaboration with the UCSF Department of Epidemiology & Biostatistics (DEB) and other UCSF stakeholders, the Program will:

I.2.1. Create new informatics and DS didactic opportunities for K Scholars, including seminars, hands-on boot camp experiences, and traditional coursework.

I.2.2. Increase and facilitate K Scholar research consultations and collaboration opportunities with experienced informatics and DS Faculty Advisors.

Aim I.3. To provide implementation science (ImS) training, mentorship, and practical experience to accelerate the dissemination of clinical and translational research into clinical practice and public health.

Successful translation of scientific evidence into improved practice, policy, and population health requires development of specific research skills. To achieve this goal, in partnership with the UCSF ImS Training Program, we will:

I.3.1. Create new ImS didactic opportunities for K Scholars, including seminars, hands-on workshops, and traditional coursework.

I.3.2. Increase and facilitate K Scholar research consultations and longitudinal collaborations with experienced ImS Faculty Advisors.

Aim I.4. To share and disseminate the successful elements of our K Scholars Program for local, regional, and national collaboration.

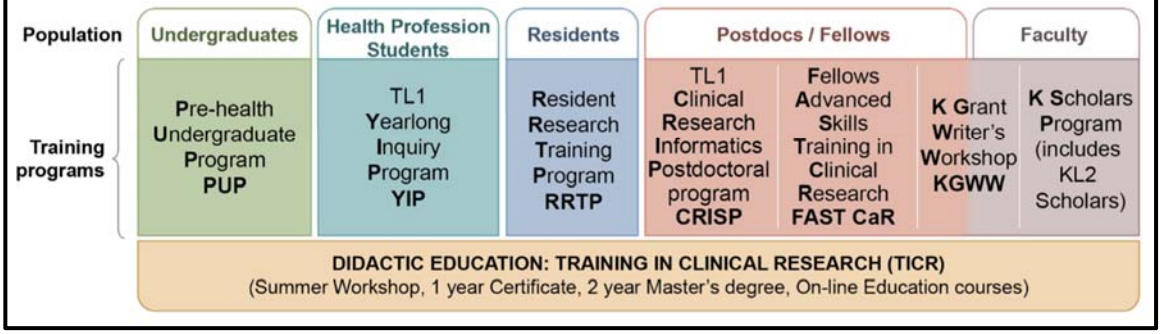
Specifically, the Program will create new opportunities for our Scholars and Faculty to interact with local and regional CTSA partners through activities coordinated through the West Coast Education Consortium.

A. BACKGROUND

A.1. The rationale and fundamental goals of the UCSF Clinical and Translational Science Institute K Scholars Program (K Scholars Program) are to train, mentor, and equip succeeding generations of exceptional and diverse junior faculty investigators to become national and international leaders in clinical and translational research. Thus, our **strategic goals** focus on equipping K Scholars with the methodologic, analytic, leadership, and team science skills required to conduct transformative clinical and translational research at UCSF and in the communities we serve. We aim to matriculate junior faculty fully able to attain research independence by obtaining NIH R or equivalent awards.

Organization of Clinical and Translational Research Training at UCSF. The K Scholars Program is integrated within the Clinical and Translational Sciences Training Programs (**CTST**) (**Figure I.1**; and see **Core D1**). CTST, led by KL2 Co-PI Alka Kanaya, MD, is composed of didactic and degree-granting programs and level-specific training programs ranging from undergraduates to faculty. Each integrated training component of CTST provides level-specific mentoring and research experience and is led by senior researchers who are recognized nationally for their contributions to teaching, research methods, and mentoring.

Figure I.1. Clinical and Translational Sciences Training Programs



A.2. History of UCSF KL2 Scholars and the K Scholars Program. Our first university-wide clinical research training program was funded in 2005 as a NIH Roadmap K12 Multidisciplinary Training and Career Development Program. In 2006, our first CTSA and KL2 Awards launched the current K Scholars Program, which enrolled both KL2 awardees and other junior faculty with career development awards. With two competitive renewals in 2011 and 2016, we have successfully recruited and trained a total of 108 KL2 Scholars, with 20 being admitted since 2016 (we anticipate 2 to 4 new KL2 Scholars will join in 2020-2021). The NIH-mandated cuts to our 2016 renewal resulted in a reduction in the number of yearly KL2 slots: from 21 to 9 over the 5-year funding period. Prior to 2016, most UCSF KL2 awardees received 4-5 years of support, but since 2016 we have limited the duration of our KL2 awards to three years. Despite these challenges, the UCSF K Scholars Program continues to flourish, as evidenced by its growing popularity (**Table I.1**) and the academic success of our alumni, described below. In addition, the disciplines and demographic diversity of the K Scholars Program have continued to expand, with greater numbers of highly qualified PhD and underrepresented in medicine (URM) investigators (**Table I.17**).

Table I.1. Enrollment of the K Scholars Program, 2006-2021

	Grant 1 (2006-11)	Grant 2 (2011-16)	Grant 3 (2016-21) estimated	Total
New KL2 Scholars	43	45	24	112
New non-KL2 Scholars	42	48	82	172
Total	**85**	**93**	**106**	**284**

A.3. Integrated Structure of the K Scholars Program. KL2 Scholars provide the critical nucleus for the broader K Scholars Program, which also includes junior faculty from all four health professions schools who have individual K awards (e.g., K23, K01, and K08), nine small institutional K12 programs, and non-NIH career development awards (e.g., VA and foundation awards). Each year, our allocated KL2 slots are competitively awarded to faculty who formally apply to the Program as described in **section B.5**. In addition, we admit 12-20 faculty each year with clinical or translational-focused individual K or K-equivalent awards to the K Scholars Program. Thus, since 2016 approximately 50-70 Scholars have participated each year in the K Scholars Program (**Table I.1**). The institutional K12 programs range from those that are primarily translational (UCSF Omics of Lung Disease, PI: D Earle) to primarily clinical (UCSF-Kaiser Building Interdisciplinary Research Careers in Women's Health, PI: C Brindis). Over the past four years, 45% (15/33) of Scholars from these K12 programs have been admitted to the K Scholars Program. The K Scholars Program collects fees from non-KL2 Scholars and receives additional institutional support from the Schools of Medicine, Nursing, Dentistry, and Pharmacy.

Other than salary and research funding support, which the Program provides *only* to KL2 Scholars, all K Scholars have equal access to and participate in the full spectrum of research training and career development, mentoring, and other opportunities. All entering Scholars (KL2 and non-KL2) are randomly assigned to a peer Works-in-Progress (WIP) group composed of 10-12 Scholars, initially grouped by year of entry. In this way, KL2 Scholars are exposed to a broad range of clinical and translational research topics and methods, with greater opportunities for multidisciplinary collaboration and team building. The popularity of our "K mother ship" for these otherwise isolated early faculty is evidenced by the increasing number of non-KL2 participants (**Table I.1**), and the re-commitment of all of the non-KL2-funded Scholars in the 2019-20 cohort to another year in the K Scholars Program.

A.4. Core Components of the Current K Scholars Program. Overview. The Program has been developed and refined for over 20 years and emphasizes multi-year, in-person, high-touch didactic content, mentorship, peer-to-peer research critique, and career development **(Table I.2)**. This is carried out every Friday morning of the academic year at our central Program space, located at Mission Hall on UCSF's Mission Bay campus, in spacious, state-of-the-art educational meeting rooms. The centerpiece of **Friday Core Training Activities** is the Scholar-led, Faculty-facilitated **WIP session**, during which Scholars present ongoing or planned work for feedback and advice. Friday activities also include Faculty-delivered substantive research and methodology seminars and career development workshops. All of these activities are conducted in the context of peer learning and support across disciplines, and naturally result in the formation of multidisciplinary teams of Scholar researchers who collaborate during and following their residence in the K Scholars Program (see ***Vignette: Interdisciplinary Collaboration,*** below).

Table I.2. Current Core Components of the K Scholars Program. (*new or expanded activities in current funding period in italics)*

Didactic Education	Weekly K seminars. Accredited coursework from Training in Clinical Research (TICR) Program or Master's in Clinical Research. ***Expanded career development workshops. New accredited TICR course offerings***
Mentored Career Development	Salary and research support (KL2 only) with access to *one-on-one research* design, biostatistics and *grant writing expertise.* ***Expanded multicenter study methods and mentorship***
K Faculty Advisors and Mentoring Teams	Two K Program Faculty (clinical research and biostatistics) assigned to each Scholar plus Lead and Co-mentors. ***New mentorship workshops, facilitated Women's Support Group***
Friday Core Training Activities	Weekly methodology and career development seminars (1 hr), Scholar-led Works-in-Progress (2 hrs) and networking lunch. ***Expanded Career Development Workshops, Team Science Grant Awards***

Didactic education. All K Scholars are required to have or achieve Master's level (or equivalent) education in clinical and translational research. Scholars may attain this by completing coursework offered by the Training in Clinical Research Program (TICR) or by enrolling in the Master's in Clinical Research (MAS) Program, both based in the UCSF Department of Epidemiology & Biostatistics (**Table I.3).** With over 45 accredited courses, TICR allows K Scholars (both with and without Master's training) to develop additional research skills across the translational spectrum, including methods, clinical trials, and implementation science as specified in their Career Development Plans. New courses are introduced each year (seven since 2017), such as EPI 228: *Measurement Theory and Practice* (added Fall 2018) and BIOSTAT213: *Introduction to Computing in the R Software Environment* (added Winter 2019). Courses are available in person, online, and with web-based offerings to enhance accessibility to the broadest possible audience within UCSF and across CTSA Hubs and research organizations.

Table I.3 TICR Program's Major Educational Programs

Clinical Research Workshop (CRW)
- 8 weeks (summer quarter)
- Didactic: 4 courses (6 units)
- ➢ **Deliverable:** clinical research protocol

Advanced Training in Clinical Research Certificate (ATCR)
- 1 year (4 quarters, including CRW)
- Didactic: 15 courses (27 units)
- Mentoring: one or more home unit mentors
- ➢ **Deliverables:**
- Implementation of a clinical research project
- Analysis and presentation of data

Master's Degree in Clinical Research
- 2 years (7 quarters, including CRW)
- Didactic: 17 required courses plus electives (36 units)
- Mentoring: 3-member Master's Committee
- Tracks: Implementation Science *or* Data Science
- ➢ **Deliverables:**
- ▪ Comprehensive literature review
- ▪ Present research findings at a national meeting
- ▪ Submission of a first-authored peer-reviewed paper
- ▪ Instructional experience in clinical research methods

Rigor and Reproducibility To ensure rigorous methods and reproducible results in all scientific studies, our didactic activities and K Program Faculty emphasize the study design, statistical methods, and ethical conduct of projects during the Scholar WIPs. All aspects of our training program emphasize the importance of reducing bias. Program Faculty use online NIH resources[2] that include video modules in the NIGMS Clearinghouse. Program Faculty who provide grant writing assistance train Scholars on how to address rigor and reproducibility in grant applications.

Mentored career development. K Scholars are

immediately immersed in a supportive learning environment, are provided with research funds, and benefit from ongoing access to Program Faculty and their peers. The K Program Faculty serve as Advisors and provide expertise and guidance in research design, measurement and questionnaire design, study coordination, data management, biostatistical analysis, publishing and presenting research, and manuscript and grant writing. All first-year K Scholars prepare an individual Career Development Plan (CDP) based on the format recommended by the NIH (see **Aim I.1.1**).

Vignette: Interdisciplinary Collaboration: *In 2015, KL2 Scholars Chloe Atreya, MD PhD, a medical oncologist who focuses on the interplay of tumor genetics and response to therapies for colorectal cancer, and Maria Chao, DrPH MPA, an integrative health researcher who studies the effects of complementary health approaches and quality of life, were placed in the same WIP group and began a long-term collaboration that has resulted in two publications. They are now co-Directors of the UCSF Diller Integrative Oncology Collaborative that recently co-sponsored a full-day integrative oncology symposium with the Osher Center for Integrative Medicine. With another K Scholar, Ai Kubo, MPH PhD, a cancer epidemiologist at the Kaiser Northern California Division of Research, they also collaborate on the "Being Present" mindfulness meditation study for patients with advanced cancer and caregivers, funded in part by a UCSF Clinical Innovation Accelerator Award.*

K Program Faculty Advisors and individual mentoring teams. All admitted K Scholars are required to enter with an established mentoring team. In addition, the Program has 13 dedicated Advisors: eight Clinical Research Advisors and five Biostatistics Advisors (**Table I.8**; **Data Table 2**) supported by this award or institutional funds. Upon admission, each K Scholar is assigned both a Clinical Research Advisor and a Biostatistics Advisor. These Advisors are established investigators with expertise in topics relevant to the Program, including underserved populations (Jacobs), multisite studies and trials (Bauer, Cummings), geriatrics and aging (Walter, Cummings), clinical research informatics (Pletcher), high dimensional data analysis (McCulloch), entrepreneurship (Allen), and scientific editors/writers (Markowitz, Mitchell). Nine of these Faculty have received UCSF Mentoring Awards, and all attend/facilitate the Friday Core Training Activities. The Program also ensures that each Scholar has strong relationships with a Lead Mentor, typically from their home school or department, and one or more co-Mentors, all selected by the Scholar for relevance to their research focus and drawn from UCSF's great depth of clinical and translational scientists (**Data Table 2**). Most Scholars also have a departmental Career Mentor.

Friday core training and peer activities. K Scholars, K Program Faculty, and invited guests meet in person every Friday. Special methodologic or career development seminars are scheduled on most Friday mornings, and more in-depth special workshops relating to career development and leadership skills are scheduled intermittently on Friday afternoons. **Table I.4** presents topics that have been covered in Friday sessions during this grant period. In the morning sessions, the first hour seminar is led by Faculty or Senior Scholars on methodology and career development topics, followed by two hours dedicated to Scholar-led WIP sessions. In the WIPs, Scholars present their research projects and obtain expert feedback and advice from peers, K Faculty, and periodically, their Lead and co-Mentors. WIPs consist of 4-6 concurrent groups of 10-12 Scholars each, who remain together as a cohort for at least two years (called 1st and 2nd Year WIPs). After two years we poll the then "Senior Scholars" with the option of continuing in their existing WIP or reconstituting according to content or methodologic interests (Senior WIPs). For example, in 2019-20 our

Table I.4. Weekly Core Training Didactic Sessions

Friday 9 AM Didactics/Seminars	Friday Afternoon Special Events (Hours)
Data Visualization: Telling Stories with Data (McCulloch)	Creative Approaches to Time Management (3)
The Writer's Algorithm: Papers without (too much) Pain (Markowitz)	Implementation Science Fall Seminar: Intersection of Implementation Science and Quality Improvement (1.5)
Writing a Thought Piece (Walters)	Projecting Credibility and Confidence (2)
Multiple Approaches to Qualitative Research (Chesla)	Alan Alda Center for Communicating Science Event (3)
How to Deliver an Elevator Pitch (Markowitz)	Introduction to Leadership Tools with the Coro Center of Northern California (4)
Research Team Management and Hiring (2 invited speakers)	Mutual Gains Negotiation with the Coro Center of Northern California (4)
Longitudinal-Repeated Measures (Neuhaus)	6-Part R Grant Writing Workshop (12)
Time Flies When You Have a K: Time Management Strategies for Success (Sarkar)	Allyship in the Workplace (2)
K to R Transition Alumni Panel (4 K Scholar Alumni)	Constructive Conflict (2)
Career Advancement at UCSF (Bibbins-Domingo)	Media & Messaging Workshop (4.5)
Team Science Pitch Session (Jacoby)	How to be a Better Presenter (2)
Predictive Modeling (Boscardin)	Transitioning from Mentee to Mentor (2)
Changing your Proposed K Research Topic (Bauer)	3-Session Workshop on Leadership with UCSF Center for Health Professions (13.5)

Senior WIPs were reorganized into those who conduct primarily clinical vs translational research. Each weekly WIP session is facilitated by two Faculty Advisors (a Clinical Research Advisor and a Biostatistics Advisor). These Faculty rotate among WIP cohorts over the course of the year, so that over time they are able to meaningfully contribute to each Scholar's research program. There is a weekly Networking Lunch (supported by institutional funds) where Scholars, K Faculty, other scientists, and UCSF academic and program leaders meet informally. Friday afternoon workshops are typically devoted to career development and leadership skills and/or didactic topics that require one to two hours and/or advance preparation. These workshops are optional for K Scholars and are often open to other UCSF learners, including TL1 trainees, fellows, and postdocs.

Other existing Program features include:

- Available/Assigned work space and UCSF network access at Mission Hall
- Financial support for courses and travel (KL2 only)
- One-on-one meetings with grant and manuscript writing Faculty (see **Aim I.1.1**)
- Statistical programming, database expertise, research financial/resource planning advice
- Teaching experience as a small group leader for residents, fellows, and faculty enrolled in our popular 8-week "Designing Clinical Research" course (Epi 202)
- Annual NCATS Translational Science meeting in Washington DC
- Annual 1.5-day off-site orientation retreat (supported by institutional funds) for Program Scholars and Faculty

A.5. Major Program Innovations and Achievements during the Current Funding Cycle. Recruitment of a superb group of KL2 Scholars, diverse in discipline, race, and ethnicity. The Program receives 20-30 applications per year for the 2-4 available KL2 slots. We have been very successful in creating a new interdisciplinary training paradigm at UCSF; since 2006 we have recruited 108 KL2 Scholars representing all four UCSF Health Professions Schools and 21 different departments (**Table I.17**). **Twenty KL2 Scholars** have been recruited since 2016, including **13 MDs, 1 MD-PhD, 2 DDS-PhDs and 4 PhDs (Table I.5** and **Data Table 8C)**. Although a majority of KL2 Scholars have come from the School of Medicine, in the current funding period we also selected KL2 Scholars from the School of Nursing (Flatt and Hunt), School of Dentistry (Chou and Jones) and School of Pharmacy (Wallander). We have successfully recruited URM faculty to apply; since 2016 **30% of KL2 Scholars** have been from groups underrepresented in the biomedical, clinical, behavioral, and social sciences (as defined by NIH NOT-OD-20-031). We continue to have particular success in attracting women (~70% of KL2 Scholars; **Table I.17**).

Table I.5. KL2 Scholars Admitted 2016-2019 (n=20) in the Current Funding Cycle

Name/Degree	KL2 funding (Overall yrs of Participation)	Current Position (Division)	Expertise	Pubs	H-Index	Extramural Funding
Brett Ley, MD	2016-18 (2016-18)	Pulmonary, Northern California Kaiser Permanente	Pulmonary fibrosis	41	18	-
Farzad Moazed, MD	2016-17 (2016-19)	Assist. Professor of Medicine (Pulmonary), UCSF	Acute respiratory distress	25	12	NHLBI K23, funded 2017
Nynikka Palmer, DrPH, MPH	2016-17 (2016-current)	Assist. Professor of Medicine (Gen Medicine), UCSF	Prostate cancer quality of care	18	10	NIA K01, funded 2017
Vicky Tang, MD, MAS	2016-19 (2016-current)	Assist. Professor of Medicine (Geriatrics), UCSF	Advanced care planning	18	6	NIA K76, funded 2019
Annie Chou, DDS, PhD	2017-18 (2017-18)	Associate Director, Myovant Sciences, Brisbane, CA	Sjogren's biomarkers	9	5	-
Elizabeth Dzeng, MD, MPH, PhD	2017-19 (2017-19)	Assist. Professor of Medicine (Palliative Medicine), UCSF	Elder over-treatment	33	7	NIA R03, CA Alz. CDA, funded 2018
Jason Flatt, PhD, MPH	2017-18 (2017-19)	Assist. Professor of Social & Behavioral Sciences, UNLV	Alzheimer's in sexual minorities	35	10	NIA K01, funded 2018
Kyle Jones, DDS, PhD	2017-19 (2017-current)	Assist. Professor of Dentistry, UCSF	Oral cancer immunity	9	6	NIDDK K23, funded 2019
Cassie Kline, MD	2017-current	Assist. Professor of Medicine (Oncology), UCSF	Pediatric lympho-proliferative cancer	25	8	NCI K08, re-submitted 11/19
Haley Naik, MD	2017-19 (2017-current)	Assist. Professor of Dermatology, UCSF	Hidradenitis immunology	48	9	NIAMS K23, funded 2019
Melisa Wong, MD, MAS	2017-19 (2017-current)	Assist. Professor of Medicine (Oncology), UCSF	Lung cancer treatment toxicity	39	9	NIA K76, funded 2019
Krista Harrison, PhD	2018-2019 (2018-current)	Assistant Professor of Medicine (Geriatrics), UCSF	Dementia homecare	43	8	NIA K01, funded 2019
Jane Jih, MD, MPH, MAS	2018-current	Assist. Professor of Medicine (Gen Medicine), UCSF	Disease self-management	9	5	NIAMS K23, submitted 2019

Anjana Sharma, MD, MAS	2018-current	Assist. Professor of Family & Community Medicine, UCSF	Practice transformation	11	4	AHQR K23, submitted 2019
Yiwey Shieh, MD, MAS	2018-19 (2018-19)	Assist. Professor of Medicine (Gen Medicine), UCSF	Breast cancer prevention	14	7	NCI K08, funded 2019
Kieuhoa Vo, MD, MAS	2018-current	Assist. Professor of Pediatrics (Oncology), UCSF	Pediatric brain tumors	14	6	K08 planned 6/20
Lauren Hunt, PhD, RN	2019-current	Assist. Professor of Physiological Nursing, UCSF	Geriatric palliative care	12	2	K76 planned 10/20
Sachin Shah, MD, MPH	2019-current	Assist. Professor of Medicine (Hospital Medicine), UCSF	Adult social vulnerability	17	5	K76 planned 10/20
Erika Wallender, MD, MPH	2019-current	Asst. Professor of Pharmacology, UCSF	Anti-malaria pharmacology	19	7	K23 planned 6/20
Elizabeth Whitlock, MD, MS	2019-current	Assist. Professor of Neurology, UCSF	Cognition and surgery	38	16	K76 planned 10/20

Expansion of career development and mentorship workshops. We introduced several new career development workshops which provide both a broad overview as well as in-depth exposure to select career development topics (**Table I.4** and **Section B.4**). With NCATS funding and under the direction of Mitch Feldman, MD, MPhil, who leads the UCSF Mentor Training Program, we also created a web-based course for K Scholars and others interested in guidance on building productive mentor-mentee relationships.[3] These resources continue to be updated and are available to the UCSF academic community. Additional resources are available to K Scholars from the UCSF Faculty Mentoring Program, including regular lunchtime seminars such as “Tips for Mentoring Success” by Diane Havlir, MD, Associate Chair of Clinical Research (1/15/20) and “A Discussion of Advancement and Promotion” by Brian Alldredge, PharmD, Vice Provost Academic Affairs (1/22/20).

Vignette: Transition to Independent Funding. *In 2016, a KL2 award was made to Dr. Victoria Tang, an Assistant Professor of Medicine studying geriatric factors and outcomes after high-risk surgery in older adults. Dr. Tang's research suggested that geriatric factors, e.g., dementia, depression, and physical disability, are associated with 1-year mortality. The K Grant Writing Workshop then supported Tang in writing her successful K76, entitled “Improving Outcomes of Older Adults with Psychosocial Vulnerability Undergoing Major Surgery.” She continues to participate in the K Scholars Program. "**The K Scholars Program guided me closely in developing the ideas for my K76 and in translating these ideas into a successful proposal. My success has been largely due to the support and mentorship I have received from the K Program and I am sincerely grateful."***

Increased emphasis on community-based research. Although the Program welcomes Scholars representing the full spectrum of clinical and translational research, our Scholars are increasingly interested in T3 and T4 community-based research.[4] Several KL2 Scholars have concurrent appointments at UCSF centers focused on community-based research, e.g., the Center for Vulnerable Populations (Drs. Palmer and Sharma) and the Center for Aging in Diverse Communities (Drs. Palmer, Jih, and Shah). To address this growing interest, our weekly seminar series now includes invited presentations relevant to community-based research.[5]

Vignette: Community-based Research. *Nynikka Palmer, DrPH, MPH, Assistant Professor of Medicine, was awarded a KL2 in July 2016 to address disparities in prostate cancer care among African American men. Her research uses an ethnographic approach to develop a multi-dimensional understanding of current prostate cancer care and the treatment decision process, including patient-provider communication, to inform intervention development in peer navigation and patient-centered communication.* ***“I’m grateful for the KL2 as it truly helped me launch my research agenda, which informed the resubmission of a 5-year career development award proposal,”*** *states Dr. Palmer. In 2017, Dr. Palmer received a NCI-funded 5-year K01 award. Last year, she was named one of the prestigious UCSF School of Medicine Dean’s Population Health and Health Equity Scholars.*

Promotion of team science. The Program provides didactic exposure to the theory and logistics of Team Science and a rich multidisciplinary learning environment through the weekly WIPs.[6] In any given group, there may be MDs and PhDs, clinical and translational scientists, social or behavioral scientists, geneticists, and others that naturally lead to ongoing Scholar-developed collaborations.

To further enrich our commitment to team science, in 2018 we began our annual institution-supported **K Scholar Team Science Awards** which promote innovative multidisciplinary research collaborations among K Scholars.[7] Our goal is to stimulate research innovation and creativity by connecting two or more K Scholars with diverse training backgrounds and expertise to design and implement a scholarly project. Once a year we organize a competitive call for Scholar-led projects that can be completed in 1-2 years. The scope of the project varies depending on the interests of the Scholars, but teams may propose pilot studies, clinical and/or translational methodologic innovations, or other research projects that demonstrate the strength of multidisciplinary collaborations. Following internal review and peer-to-peer presentations, 1-2 projects are awarded funding of up to $10,000. Projects have addressed a wide range of conditions and utilized multiple methodologies (**Table I.6**); all have generated infrastructure or pilot data to support future extramural funding.

Table I.6. K Program Team Science Award Projects Funded to Date

Project Title (Year Funded)	Scholars	Faculty Sponsor	Progress to Date	Next Steps
Family Planning Care for Liver Transplant Recipients (2018)	Sarkar (Hepatology) Seidman (Obs & Gyn)	Jacoby (Obs & Gyn)	Survey of UCSF Liver Transplant patients and providers. Extending to other transplant units	Seeking extramural funding; paper submitted to *Liver Transplantation*
Validity of a Culturally Tailored Beverage Recall for Latino Children (2018)	Martinez (Health Policy) Beck (Pediatrics)	McCulloch (Biostatistics)	Established validity of 7d recall (vs repeated 24h recall) in Latino children; submitted two abstracts to pediatric meetings	Implement clinical use; seeking extramural funding
Early Childhood Adversity and Adult Depressive Symptoms (2019)	Roubinov (Clin Psychol) Crosswell (Psychiatry)	Mendes (Psychiatry)	Demonstrated strong positive association between childhood events and adult depression	Seeking extramural funding; abstract submitted to 2020 Society for Affective Science

With the success of the K Scholar Team Science Awards, in the next funding cycle we will expand these awards to the broader CTSI community (**Core D2**, **Aim D2.1**), and propose five new Team Science Awards to supplement the existing Pilot Translational and Clinical Studies. We will encourage our K Scholars to apply for these awards and others (see, ***Vignette: Team Science Success,*** below***)***, and share examples of prior successful team science work. We will continue to promote team science collaborations with relevant seminars, workshops, and experiential learning.

Vignette: Team Science Success. *In 2015, two K Scholars from different subspecialties (gastroenterologist Jennifer Lai, MD and nephrologist Elaine Ku, MD) met in their WIP group and discovered they had shared interests in transplant epidemiology. In 2019, they submitted a project entitled "Prediction of end-stage renal disease among patients with liver failure" and received a $100,000 award from the very competitive UCSF Department of Medicine Team Science Grant. The pilot project explores which liver failure patients will need a kidney transplant along with liver transplant to optimize allocation of resources by performing simultaneous kidney/liver transplants. Data from this pilot study will support a future NIH RO1 application.*

Women's Support Group. Motivated by evidence of continued gender inequality at UCSF and elsewhere,[8,9] the K Program Women's Support Group was launched during the current funding period with the goal of promoting inclusion and providing a safe environment to discuss topics of interest to female faculty. Women's Support Group breakfast meetings are scheduled quarterly with K Program Faculty leadership from Kit Chesla, RN, PhD (School of Nursing) and Louise Walter, MD (School of Medicine). Topics are suggested by the K Scholars and have included career advancement, work-life balance, gender discrimination, activism, allyship, salary negotiations, and cultivating personal power. Women K Scholars (n=12-18 per session) actively engage in discussions that include both peer support and information sharing. The Support Group has also sponsored presentations for all K Scholars and Faculty by the UCSF Office for the Prevention of Harassment and Discrimination and external speakers on time management.

Long-term KL2 Scholar success. The defining characteristic of our KL2 Scholars is the degree to which each stands out among the exceptional caliber of the junior faculty at UCSF—the cream of the crop. Our KL2 Scholars excel in clinical and translational research as measured by academic rank, publications, extramural funding and career appointments. **Table I.7** presents KL2 Scholar outcomes since 2006. Although not reported here, the outcome metrics for our K Program Scholars with independent K and other career development awards are similar to KL2 outcomes, but with fewer publications and NIH R awards.

Academic Rank. Of the 108 KL2 Scholars to date, 67% have attained the rank of

Table I.7. Outcomes of KL2 Scholars 2006-Present (N=108).

	Grant 1 (2006-11)	Grant 2 (2011-16)	Grant 3 (2016-now)	Overall
Current Position (number)				
Assistant Professor	1	9	18	28 (26%)
Associate Professor	20	30	0	50 (46%)
Full Professor	20	3	0	23 (21%)
Non-academic	2	3	2	7 (6%)
Current % Effort Spent in Clinical & Translational Research				
0-19%	1	1	2	4 (4%)
20-59%	11	13	2	26 (24%)
≥60%	30	31	17	78 (72%)
Peer Reviewed Publications (number)				
First or last author	2175	1062	224	3461
Total	4587	2289	468	7344
Current Grant Funding (number)				
Any as PI	184	147	43	374
NIH R03 or R21	27	16	11	54
NIH RO1or equivalent	66	36	1	103
Foundation	8	12	8	28
Industry	12	2	1	15

Associate Professor or higher and 72% devote >60% of their professional effort to research.

Scientific Publications. KL2 Scholars have an overall total of **3,461 first or senior-authored publications** (median per Scholar: 37 for Grant cycles 1 & 2; 11 for Grant cycle 3), and an overall total of 7,344 publications, (median per Scholar n = 78 for grant cycles 1 and 2; n= 23 for grant cycle 3). Our Scholars also perform exceedingly well using accepted metrics of academic success, such as the H-Index and publication Altmetrics. For example, 27 KL2 Scholars have ≥1 publication with an Altmetrics score >500, indicating that the publication received extensive news and social media attention.

Extramural Funding. Of the 108 KL2 Scholars to date, **60 (56%) have obtained extramural NIH K awards**, and the majority with these independent K awardees have continued to participate in the K Program for an additional 2-4 years. Eleven percent of our KL2 Scholars went directly to R01 or equivalent funding. During the last two funding periods, the **rate of KL2 to independent K or R award transition increased from 42% in 2006-2011, to 75% in 2016-2020.** We are particularly proud that **85% of our KL2 awardees have served as a PI on at least one NIH grant: 55% have received NIH R03 or R21 awards, and 42% have received NIH RO1 funding**.

Local/National Appointments. Perhaps the most impressive indicators of our K Program's long-term success are the prominent local and national appointments of our alumni. (**Box 1** and **Data Table 8C**).

Box 1. Selected Local and National Appointments of UCSF KL2 Program Alumni (year completed)

- **Douglas White, MD, MAS (2008)**, Prof. of Medicine, Endowed Chair and Director, Program on Ethics, Center for Bioethics and Health Law, University of Pittsburgh School of Medicine. Dr. White is PI on a R21 and 2 R01s from NIA and NINR.
- **Bradley Aouizerat, PhD, MAS (2011)**, Professor of Oral and Maxillofacial Surgery and Deputy Director, Bluestone Institute for Clinical Research, NYU. Dr. Aouizerat is PI on a U01 from NIA and 2 R01s from NCI.
- **Steven DuBois, MD (2012)**, Assoc. Professor, Pediatrics, Harvard; Director of Experimental Therapeutics, Dana-Farber Cancer Institute. Dr. DuBois is PI on an R01 from NCI.
- **Carmen Peralta, MD, MAS (2012)**, Professor of Medicine, UCSF and CMO, Cricket Health, Inc. Dr. Peralta is PI on an R01 from NIA and an R34 from NIDDK and Co-Director of the new UCSF Center for Kidney Diseases.
- **Michael Wilson, MD, MAS (2014),** Associate Professor of Neurology and founding member UCSF Next-Gen Precision Diagnostics. Dr. Wilson is PI on a KO8 and RO1 from NINDS, and has 3 NEJM publications.

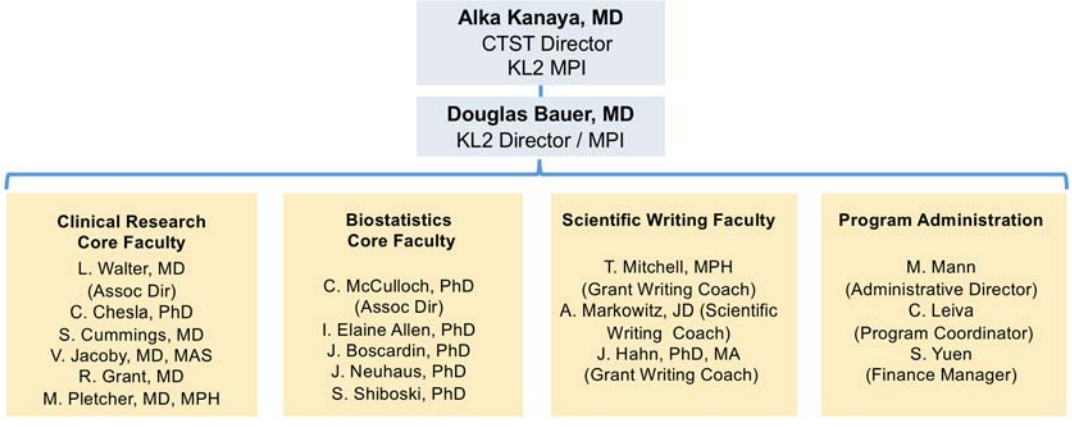
B. PROGRAM PLAN

One of the great strengths of the K Scholars Program is that most of its leaders, administrative staff, and Faculty have been involved in and shaped the Program for many years. The Director, Dr. Bauer, has led the Program since 2014. The Associate Directors, Drs. McCulloch and Walter, have served as K Faculty since 2008. Dr. Bibbins-Domingo, currently Chair of the DEB and Co-PI of the proposed UCSF UL1, directed the K Program from 2012-2014 and served as Associate Director from 2007-2011.

B.1. Program Administration Leadership. The K Scholars Program will be led by Drs. Douglas Bauer and Alka Kanaya (**Figure I.2** and **Multiple PI Plan).** Dr. Bauer will continue to serve as KL2 Program Director/ MPI at 20% effort**.** He has directed the Program since 2014 and is responsible for all aspects of operations, overseeing Scholar selection, Program evaluation, Program seminars, and other activities, and chairs the monthly K Program Faculty meetings. He will be the NIH contact for the Program. Dr. Kanaya, at 5% effort, will serve as KL2 MPI**,** providing guidance, and ensuring integration with other CTST education and training programs, as well as alignment with the goals of the CTSI. Both Drs. Kanaya and Bauer will report the progress of the KL2 to the CTSI leadership and the KL2 Internal Advisory Board (see Attachment) on an annual basis.

Douglas Bauer, MD, is Professor of Medicine and Epidemiology & Biostatistics, and is an Executive Member of the San Francisco Coordinating Center. He has been at UCSF since 1982 and developed and directed the Resident Research Training Program (a training program in the CTST) from 2006 to

Figure I.2. UCSF K Scholars Program Organizational Chart



2014, when he assumed the directorship of the K Scholars Program. He is an internationally recognized clinical investigator with expertise in osteoporosis, thyroid disease, and biomarkers. He has received NIH K23, R34, RO1, and K24 awards. Dr. Bauer is an expert in multisite studies and trials, and is currently PI of an NIH RO1 examining the relationship between bisphosphonate use and atypical femoral fractures. He was a standing member of the NIH Neurologic, Aging, and Musculoskeletal Epidemiology study section and currently serves as a standing member of FDA's Bone, Reproductive, and Urologic Drug Advisory Committee. He has published over 400 peer-reviewed manuscripts and has co-authored 160 publications with mentees. He was selected as the 2010 Mentor of the Year by the UCSF Department of Medicine. With his K24 Midcareer Award from NIAMS (2006-2016), he has extensive experience in faculty development and mentoring.

Alka Kanaya, MD, is Professor of Medicine and Epidemiology & Biostatistics, and Director of UCSF's Clinical and Translational Science Training programs (2019). She has been at UCSF since 1990, developed and led the K Grant Writer's Workshop (2010-2017), and co-led the R Grant Writing Workshop for the K Scholars Program (2012-2014). She was Director of the CTSI consultation services program (**Core E**) (2014-2019). She is an internationally recognized expert in diabetes and cardiovascular epidemiology, with continuous NIH funding since 2006, including K23, R21, R01, and K24 awards. Dr. Kanaya is PI of the multicenter longitudinal cohort study, "Mediators of Atherosclerosis in South Asians Living in America (MASALA)," an investigation of antecedents of diabetes and heart disease in a high-risk ethnic group, and has led multicenter behavioral trials for diabetes prevention. She is Human Metabolism Core Director for UCSF's Nutrition and Obesity Research Center and a standing member of NIDDK's Diabetes, Endocrinology, and Metabolic Diseases B Subcommittee. With K24 and CTST experience, she has devoted significant effort to mentoring learners at all levels on clinical research methods, scientific writing, and career development.

Associate Directors Dr. Charles McCulloch and **Dr. Louise Walter** participate in policy decisions, planning, and executing the Program. They also serve as K Faculty Advisors, leading WIPs and advising K Scholars. Dr. McCulloch organizes the Scholar WIPs and Faculty-led seminars and oversees the Biostatistics Faculty Advisors and statistical advising. Dr. Walter oversees and organizes the Scholar selection process and oversees the Clinical Research Faculty Advisors and career advising of Scholars.

Charles McCulloch, PhD, is Professor and Head of the Division of Biostatistics at UCSF and Vice Chair of the Department of Epidemiology & Biostatistics. He is an expert on the development and use of statistical methods for longitudinal data analysis and mixed models. He has authored over 500 publications. Dr. McCulloch has extensive mentorship experience. At UCSF, he regularly serves on committees for Master's in Clinical Research candidates. He has served as a biostatistics mentor in the K Program since 2007. This mentoring has resulted, to date, in over 200 refereed, jointly authored publications with mentees or former mentees. He is also the Training Director for a Rare Diseases Clinical Research Network.

Louise Walter, MD, is Professor of Medicine, Chief of the Division of Geriatrics, and an internationally known clinical researcher in aging. Her research focuses on how health and life expectancy affect the use and outcomes of cancer screening tests in older adults, which has transformed the approach to cancer screening in this population. She has received a VA Career Development Award and VA Merit Review (IIR) as well as R01 and K24 awards from the NIH. She is Director of the Career Development Core for the UCSF Claude D. Pepper Older Americans Independence Center, which allows her to devote a substantial amount of time to mentoring students, residents, fellows, and junior faculty. In 2010, she received the UCSF Academic Senate Distinction in Mentoring Award, one of the most prestigious awards at UCSF. Dr. Walter joined the K Program Faculty in 2008 and has authored 96 peer-reviewed publications, 60 with current or former mentees.

Administrative Leadership. Madeline Mann, with over 20 years of higher education administration leadership, is Administrative Director of Clinical and Translational Science Training. She manages the K Scholars Program and directly supervises the Program Coordinator (C. Leiva) to handle scheduling of WIP groups, Faculty-led seminars, special workshops, as well as updating the Program website and the online collaborative learning environment used by Scholars and Faculty for communication, information, and scheduling. Ms. Mann oversees all grants management, including annual progress reporting, oversees Common Metrics initiatives, and liaises with CTSI's administrative leadership on matters related to NCATS.

B.2. K Program Faculty. Every K Scholar (KL2 and non-KL2) is assigned a Clinical Research Advisor **and a** Biostatistics Advisor **(**Table I.8 **and** Data Table 2**). All are senior faculty; most have been at UCSF for at least 15 years; 5 have received K24 Midcareer Investigator Awards and 5 have received mentoring awards. They represent a broad range of clinical and translational research and biostatistical areas of expertise.**

Clinical Research Advisors provide ongoing research and career development advice. Along with weekly interactions in Friday Core Training Activities, they meet formally with the Scholar twice in the first year, annually thereafter to review the Career Development Plan (**Appendix 1**) and as needed at any time.

The **Biostatistics Advisors** provide expert advice on biostatistical methodology and issues particular to the Scholar's research and frequently become collaborators and co-authors on Scholar publications.

In additional to Faculty Advisors, the Program supports two experienced grant writers, Dr. Judy Hahn and Mr. Tom Mitchell, who meet one-on-one with Scholars weekly over a 1-2 month period to provide grant writing advice and feedback. Since 2016, 43 Scholars have received one-on-one grant writing assistance. Lastly, our Program features individual editorial and presentation support from Amy Markowitz, JD, who has worked with 48 K Scholars since 2016 (**Aim I.1.1**).

Table I.8. K Program Faculty Advisors

Clinical Research Advisors	Research Expertise; NIH Funding (2016-resent)
Douglas Bauer, MD, Professor of Medicine and Epidemiology & Biostatistics, KL2 Director and MPI	Multisite studies and trials, osteoporosis, biomarkers; K24 and RO1 PI
Alka Kanaya, MD, Professor of Medicine and Epidemiology & Biostatistics, CTST Director, and KL2 MPI	Diabetes and cardiovascular disease epidemiology and behavioral trials; K24 and RO1 PI
Louise Walter, MD, Professor of Medicine, Chief of Geriatrics, KL2 Associate Director	Life expectancy, cancer screening in the elderly; K24 and P30 PI
Catherine Chesla, PhD, RN, Professor of Family Health Care Nursing	Family health, behavioral diabetes treatment, mixed methods
Mark Pletcher, MD, MPH, Professor of Epidemiology & Biostatistics, Director CTSI Informatics Innovation Program	Cardiovascular disease prevention, risk prediction, direct to participant methods, biomarkers; R01 PI
Richard Grant, MD, MPH Senior Research Scientist, Kaiser Division of Research	Diabetes, primary care, technology enabled research, delivery science; K24, RO1 and T32 PI
Vanessa Jacoby, MD, MAS, Associate Professor of Ob/Gyn, Reproductive Sciences	Surgical gynecology, treatment of fibroids, patient-centered registries; PCORI PI
Steve Cummings, MD, Emeritus Professor of Epidemiology & Biostatistics	Remote clinical trials, longevity, breast cancer and osteoporosis; RO1, U19, U24, R56 PI
Biostatistics Advisors	**Research Expertise; NIH Funding (2016-present)**
Charles McCulloch, PhD, Professor and Chief of Biostatistics, KL2 Associate Director	Development and use of statistical methods for longitudinal data analysis, mixed models and latent class models; U54 PI
Elaine Allen, PhD, Professor of Epidemiology & Biostatistics	Meta-analysis and synthesis research, analytics & data visualization, biometrics
John Boscardin, PhD, Professor of Medicine and Epidemiology & Biostatistics	Analysis of longitudinal/repeated measures data, missing data, Bayesian statistical modeling, computational statistics
John Neuhaus, PhD, Professor of Epidemiology & Biostatistics	Statistical methods for complex dependent data, effects of model misspecification
Stephen Shiboski, PhD, Professor of Epidemiology & Biostatistics	Statistical methods for infectious disease research, survival analysis, stochastic processes

Dr. Bauer leads a monthly faculty meeting where K Program Faculty provide updates on their responsibility areas, engage in discussions of all aspects of the Program and provide suggestions for improvement. Each year, over the course of three monthly meetings, Faculty Advisors present each Scholar to the group, summarizing progress and raising issues in mentoring, achievement, departmental support, or personal challenges. Other Faculty often provide excellent advice, with new perspectives on how to support a Scholar whose progress may not be as expected, whether with respect to completion of research or publications.

B.3. Mentors and Mentorship Training. Developing a successful clinical research career requires strong relationships with mentors and a research team.[10] Specifically for the KL2 awardees, one of the five selection criteria is the quality, appropriateness, and multidisciplinary complementarity of the proposed mentors (see **Section B.6**. for complete selection criteria), although *all* K Scholars are expected to have strong mentoring teams and the Program's expectations for these mentors is identical, no matter the K mechanism. Each KL2 Scholar must identify a Lead Mentor and at least one Co-Mentor from a different discipline (Data Table 2). These mentors are generally from outside of the K Program Faculty. The Program does not match Scholars and Mentors, as we believe that mentoring is an organic relationship that cannot be imposed. However, as noted, each K Scholar is assigned a K Program Clinical Research Advisor and Biostatistics Advisor. In addition, many Scholars have a Career Mentor who is frequently their Division Chief or Department Chair.

Role of the mentoring team. *Lead Mentors* have overall responsibility for helping Scholars develop creative and independent careers in research. In addition to being an expert in a scientific area, a Lead Mentor must be familiar with faculty, resources, and databases at UCSF, and have resources and research staff to support the Scholar's research. Lead Mentors provide guidance to ensure that projects are progressing satisfactorily toward

presentations, publications, and grant applications, and provide advice about career directions, national networking, and academic promotion. They also help ensure that 75% of the Scholar's effort is protected from clinical and administrative duties. *Co-Mentors* work with the Lead Mentor on these responsibilities, and provide guidance in complementary areas of expertise. *Career Mentors* ensure that the Scholar is fulfilling responsibilities to the home Division or Department, meeting academic milestones, planning for promotion, and ensure that 75% of the Scholar's effort is protected for research. Scholars are required to meet at least monthly with their Lead Mentor, both individually and in conjunction with other members of the research team. Scholars also meet regularly with their Co-Mentors, and at least twice a year with all of their Mentors as a group. Mentors are encouraged to participate in the Scholar's WIP sessions.

Program expectations of mentors. All mentors of KL2 Scholars are senior faculty (virtually all at the Professor level) with active research programs, and extensive experience mentoring postdoctoral fellows and junior faculty. Most have received formal mentorship training (see below). Their biosketches are included in the KL2 application and provide evidence of their success as PIs in clinical and translational research and in publishing their research results. KL2 mentors are required to have independent research support to cover the costs of proposed research projects that exceed the dedicated Scholar research funds. The Candidate's Mentor completes a 1-page statement describing the specific resources the Mentor will provide to the Scholar, including access to the Mentor's research resources, space, staff, clinical and laboratory resources, and adjunct research funding for the Scholar. The selection committee considers the strength and commitment of the mentoring team as well as these resources as critical indicia of the Mentor's commitment to the Scholar. **Data Table 2** illustrates mentors' broad range of research areas, and mentoring track records.

Mentorship training. UCSF has a well-established and robust Faculty Mentoring Program that resides within the Office of Academic Affairs and is available to all UCSF faculty.[3,11] With CTSI support and led by Dr. Mitch Feldman MD, MPhil, this Program has created a web-based Mentor Training Program (MTP). The modules address mentorship responsibilities, mentoring models, goals and expectations, mentoring communication, and mentoring challenges. Of particular relevance to the K Program, the MTP also includes modules on "Mentoring Across Differences" that focus on the specific mentoring needs of women and URM.[12] Becoming an accomplished mentor helps K Scholars develop multidisciplinary teams, increase productivity, and develop lifelong colleagues. Senior K Scholars and others with ongoing mentoring responsibilities are encouraged to complete the MTP. The MTP in-person workshop and online modules, described below, are supported by institutional resources and are available to all K Scholars.

Training K Scholars to be Mentees. The MTP features several web-based modules (lectures, reading materials, videos, exercises) aimed at working effectively within a mentoring team. Content helps Scholars clarify mentee roles and responsibilities; how to use a CDP to focus their career, project goals, and expectations with their Mentors; and how to play an active role by learning to "manage up." By completion of the MTP, Scholars understand the roles of types of mentors, will have assessed the appropriateness of their current mentoring team, and will be actively using their CDP to align their goals with those of their Mentors.

Training K Scholars to be Mentors. To build successful academic careers, K Scholars must learn to become effective mentors. Although K Scholars rarely serve as Lead Mentors, Senior Scholars have a very strong command of research methods and clinical expertise and begin to act as research mentors for junior colleagues, such as clinical fellows/post-docs, residents, and students.

Program evaluation of K Scholar mentors. A key role of the Clinical Research Advisor is to monitor the Scholar's mentoring relationships.

Table I.9. Proposed Enhancements to K Program Activities

Aim I.1.1 Additional Support for Transition to Independence
• Enhanced scientific writing support and skills development, expand "K-to-K" and "K-to-R" Grant Writing Workshops • Mock study sessions • Launching your clinical research boot camp—2 half-day sessions • Standardized online Career Develop Plans to track Scholar progress
Aim I.1.2 New Integration of Special Population Research
• Invited introductory 9AM seminars • Community member panels to discuss community-centered research • Community-engaged research consultations
Aim I.2 Provide Informatics and Data Science Training
• Seminars and workshops on informatics and data science • Didactic courses in informatics and data science • Consultations, collaboration, and mentorship from experts
Aim I.3 Provide Implementation Science Training
• Seminars and workshops in Implementation Science • Didactic courses in implementation science • Consultations, collaboration, and mentorship from experts
Aim I.4 Share and Disseminate Elements of the K Scholars Program
• Local, regional, and national collaborations

If a K Advisor has a concern, the Advisor may, as appropriate: discuss the issue directly with the mentor; bring the problem to the attention of K Program leadership, who may then intervene to help the mentor improve; or help the K Scholar select a new mentor. The Program is especially attentive to the importance of holding mentors, Division Chiefs, and Chairs accountable to their signed commitments as part of the application process (particularly protected time for research). In our experience, with advice and support, Scholars have been able to resolve differences and very rarely have changed mentors, except in cases where the mentor has left UCSF.

B.4. Proposed Training: Aims of the Career Development Program. The overarching goal of the UCSF KL2 Program is to train outstanding clinical and translational investigators skilled at leading multidisciplinary research teams to develop innovative approaches to diagnose and prevent disease, improve health, relieve symptoms, and improve function**. Although we have an enviable track record of training future clinical and translational investigators, we are committed to further improving the likelihood that our Scholars successfully transition to independence by acquiring critical and increasingly complex skills in clinical informatics, data science, and implementation science.**

Table I.9 displays linked Aims that build on our proven activities and enhance support for Scholars in the important transition from KL2 to NIH K Awards (K-to-K) and K-to-R independence (**Aim I.1**); expand didactic and experiential opportunities at the frontiers of clinical informatics and data science (**Aim I.2**); train Scholars to increase the reach and impact of their research with contemporary implementation science methods (**Aim I.3**); and outline strategies to share and disseminate key programmatic features across the CTSA network and beyond (**Aim I.4**).

Aim I.1. To continue to select and train a superb group of UCSF junior faculty KL2 Scholars from diverse scientific disciplines and to support them for up to three years as they progress toward research independence.

We will build on our highly successful CTSI K Scholars Program by continuing the core elements discussed above **(Table I.2**); these include the current didactic and hands-on training, and we will further enhance our support for the transition to individual K and R awards.

Proposed number and duration of KL2 Awards. For the current renewal, we propose to support a total of nine KL2 positions (three new, three 2nd year, three 3rd year) in each of the grant years (see **Aim 1.1.1),** allowing us to provide up to three years of KL2 funding per Scholar.

Increased financial support. To remain competitive with other NIH K awards**,** we will increase KL2 salary support from $85,000 to $100,000/year to ensure 75% protected time for mentored research and provide an additional $25,000/year for research funds. Departments or other institutional sources are expected to provide additional support to cover the full salary.

Aim I.1.1. Facilitate the transition to research independence.

Didactic and individual training and support for grant and manuscript writing are consistently rated among the most valuable aspects of the K Program. Our grant writing program features three components: introductory seminars, longitudinal workshops, and one-on-one grant coaching with K Program Scientific Writing Faculty. During the next funding period, we will enrich these programs as described below and track the impact on the timing of successful transition to independence:

1. Scientific writing support and skills development.

a. Increased support for transition from KL2 to individual K awards. Because of the relatively short duration of our current KL2 awards (a maximum of three years) most KL2 Scholars require substantial support and guidance to successfully transition to an individual NIH K award. With frequent Advisor meetings and feedback to assess progress, we will encourage KL2 Scholars to enroll in the existing "K Grant Writing Workshop,**"** (see **Core D, Aim D1.1**). Most KL2 Scholars will enroll in this Workshop before the end of their first year of KL2 support, and we expect them to submit (or resubmit) a NIH K award application (K01, K08, K23) by the end of the second year. This goal is feasible, because successful KL2 applicants submit a K23-like application for admission to the KL2 Program which serves as a foundation for an independent K proposal (see **section B.6**, below). Our existing K Grant Writing Workshop**,** led by two very experienced UCSF faculty, Drs. Naomi Bardach and Sei Lee, began in 2010 and consists of six intensive 3-hour sessions focused on writing the three most important and challenging sections of a mentored K award application: Specific Aims, Significance and Innovation, and the Career Development Plan. Each session is held in small groups (3-4 junior faculty) providing focused feedback on each grant section. Demand often exceeds space in this popular workshop, and to accommodate all of our KL2 Scholars during the next funding period, the number of small groups will be

increased, with priority given to current KL2s. Between 2016-2019, 14 KL2 Scholars participated in the K Grant Writing Workshop; eight have obtained an independent K award, three are pending decisions.

b. Increased support for the transition from K-to-R awards. As noted by others,[13,14] we have identified that early formulation of robust Specific Aims, Significance, and Innovation sections of the R01 grant is the primary barrier to the development of successful applications. We strongly encourage selected K Scholars to participate in our "R Grant Writing Workshop." This intensive workshop, led by Program Faculty members Richard Grant, MD and Judy Hahn, PhD, consists of five small group feedback sessions for 4-6 Scholars actively writing NIH R grants. For this application cycle we will offer the R Grant Writing Workshop more frequently (twice per year) to accommodate increased K Scholar demand and encourage Senior and Alumni K Scholars planning an RO1 to participate. Since 2016, 38 K Scholars have participated in this Workshop and 13 successfully competed for a NIH R award. In additional, we recently piloted a new seminar, "Tips for the K-to-R Transition," led by four K Scholar alumni who have one or more RO1s, and will plan to repeat this annually.

c. Additional one-on-one grant writing assistance (for both K-to-K and K-to-R). Following the successful completion of the K or R Grant Writing Workshop, Scholars may elect to work with our two designated Faculty, Dr. Judy Hahn and Tom Mitchell, who collectively have over 30 years of experience providing one-on-one grant writing assistance. Consultations occur weekly for the 12 weeks preceding the proposal submission. After the introductory session, the Scholar creates a timeline with weekly deliverables to be sent to the Faculty member for review, typically one to two days before the planned meeting. Our Faculty provide written and verbal feedback on presenting a compelling scientific question to fill an urgent knowledge gap, demonstrating the significance and innovation of the proposed work, and presenting clear, feasible methodology with appropriate R-level sophistication. Although these consultations have traditionally been in person, we recently conducted a successful pilot of remote meetings by phone or Zoom for Scholars who travel or work off-site. The K grant one-on-one consultations follow a similar Scholar-driven process, with special attention paid to the K-specific sections of Candidate's Background, Career Goals, and Career Development and Training Plan. To further support grant development, Scholars have access to consultation from Clinical Research and Biostatistics Advisors and broad expertise available from the CTSI consultation service. Since 2016, 43 K Scholars have received one-on-one grant writing assistance from our Faculty with a 56% success rate.

d. Expanded editorial and presentation assistance. Since 2016, 48 K Scholars met with Ms. Markowitz for editorial support on 57 writing projects, primarily K and foundation grants and manuscripts. In addition to traditional research grants and manuscripts, Ms. Markowitz also assists K Scholars with op-eds, thought pieces, editorials for scientific and mainstream print publications, and oral presentations. It has become increasingly important for Scholars to develop written and oral communication skills to propel their research "the last mile" to dissemination, and these activities will continue in the renewal period.

2. Initiation of mock study sections. Based upon the successful experience at other UC Hubs (Davis, UCSD, UCLA, and Irvine) and elsewhere, twice a year we propose to conduct mock study section reviews of K Scholar independent K or R01 applications. Led by two K Program Faculty with NIH study section experience and open to any Scholar who wishes to participate or observe, we will organize these sessions approximately two months prior to submission to provide constructive feedback.

3. Launching your clinical research boot camp. A common barrier that K Scholars face is navigating the logistics of starting up a new clinical study. To address this, we will work with the CTSI Clinical Research Coordinator leadership (see **Core D, Aim D1.1**) to create a new series of interactive seminars that cover topics such as writing IRB applications and consent forms, hiring and managing clinical research coordinators, managing budgets, working with community and institutional stakeholders, participant recruitment methods, data collection methods, specimen collection and storage options, data safety monitoring, regulatory issues and audit readiness. These talks will be given in two separate boot camp sessions on Friday afternoons, lasting four hours each. We will use feedback from Scholars to refine topics and collaborate with our online education service to create modules that can be accessed any time by Scholars, as well as the broader CTSA community. Accelerating the pace of study start-up can enable Scholars to have greater productivity with manuscripts, research dissemination, and with new grant proposals.

4. Implementation of a flexible online Career Development Plan (CDP). Our K Program has used a paper-based CDP since 2006. While crucial for career development, we have observed significant variability in completeness, clarity of goals, and most importantly, missing or unrealistic timelines for key products and milestone achievements such as submission of a NIH proposal. In addition to increased efforts to educate K Scholars, their Advisors, and Mentors about CDP goals and best practices, we are one of 26 CTSAs participating

in a NCATS-funded 2-year clustered randomized trial (PI Rubio, University of Pittsburgh) evaluating the superiority of a Customized Career Development Platform (CCDP) to improve career outcomes of K Scholars and T Fellows compared with the individual development plans (IDP) that sites currently use. The online platform enables trainees to document competency-based goals, objectives, and milestones related to research and career progress. Trainees, mentors, and Program administrators have access to the interactive CCDP, thus serving as an efficient communication tool. As specified in the NCATs proposal, the CCDP will be made available to all participating Hubs at the end of the study. Informed by the results of this study, which should be available in 2022-23, and with input from our CTSI research technology experts, we will launch our online K Scholars CDP in 2023-24. We recognize that several other CTSI Hubs (e.g., Washington University and UC Davis) currently use an online CDP, and we plan to review their approaches to further improve the functionality and usefulness of our CDP. We will share the finished product with other CTSA Hubs.

Aim I.1.2. Integrate special populations into clinical and translational research.

In partnership with **Core F** (see **Aim F1.2**) and Special Populations and Health Equity in Research and Education (SPHERE), we will introduce our K Scholars to the "collaborative learning" approach to working with diverse populations. This novel approach bridges gaps between academic knowledge and community knowledge to create mutually beneficial relationships based on trust and knowledge integration. The goals of this enhanced training for K Scholars is to both increase the integration of special populations into their clinical and translational research and to learn new techniques for community-engaged research.

Seminars with community panels. With SPHERE partnership, K Scholars will interact with community panels invited to participate in the K Scholar Friday morning seminar sessions. The seminars will be interactive, with community panels sharing their experiences with academic partnerships. We will create a special series of morning seminars with select K Scholars presenting research ideas that are in the early planning phase with the aim of soliciting community stakeholder input. Seminars will be tailored to include **Core F** faculty and staff with expertise in the Scholars' specific research population/area and community members experienced with working with academic partners. Witnessing these interactions between academic and community partners will be instructive for all K Scholars, with the goal of promoting broader use of community-engaged research.

Consultations for community engagement expertise. Scholars will have access to the SPHERE consultation and recruitment services to enhance their planning and methodology for community-based research. They will have access to educational materials on how to work with, recruit, and retain special populations. They will be able to use cultural and linguistic services to create materials at appropriate literacy levels in English and translation and adaptation into Spanish, Chinese, and Vietnamese, the three most common languages spoken among lower English-proficient individuals in the greater Bay Area. They will be able to access the Diversity Recruitment Support Navigator through **Core F**, and use both ground-level recruitment strategies as well as social media campaigns with support from the CTSI Participant Recruitment Program.

Expected outcomes and evaluation. We anticipate that this innovative and unique collaboration between SPHERE and the K Scholars Program will improve K Scholar community engagement knowledge and skills and improve Scholar projects and future proposals by highlighting the importance of community engagement and feedback as a foundation for scholarship.[15] We will assess impact by collecting semi-annual feedback from K Scholars and by tracking both SPERE consultations and utilization of SPHERE services.

Aim I.2. To provide state-of-the-art informatics and data science (DS) training, mentorship, and practical experience to advance clinical medicine and improve public health.

Informatics at UCSF. Informatics is highly relevant to clinical and translational research in the current era of electronic health records (EHRs).[16] To help clinical data systems fulfill their potential,[17-21] major new technologies (including EHR features and external technologies that integrate with the EHR), data standards,[22,23] and other informatics-related efforts (e.g., SMART on FHIR[24]) are underway at CTSI (**Core B**). UCSF is also home to a wealth of relevant informatics resources, including the Bakar Institute for Computational Health Sciences, the Biomedical Informatics program, the Institute for Health Policy Studies, the Center for Digital Health Innovation, the Center for Clinical Informatics and Improvement Research, and the Center for Healthcare Improvement and Medical Effectiveness. We see important opportunities for clinical and translational research to innovate, improve, inform, and evaluate these informatics-related efforts, and our K Scholars are now clamoring for training that can help them pursue these opportunities.

Aim I.2.1. Create new informatics and DS didactic opportunities for K Scholars, including seminars, hands-on boot camp experiences, and traditional coursework.

Current Informatics Training at UCSF. The only formal informatics training that UCSF currently offers is a 2-

year Clinical Informatics Fellowship for three fellows per year, designed for physicians who have completed an ACGME/ABMS residency, to provide “experience and training necessary to become a productive academic contributor, a Chief Health or Medical Information Officer or a successful informatician in the world of industry.” Graduates take the Clinical Informatics exam to become board-certified in Clinical Informatics. **There is minimal focus on research**. While UCSF offers a rich environment and mentorship for clinical research informatics and world-class training in clinical research methods, specific informatics training for clinical and translational researchers is largely missing. The didactic and training programs proposed here and in **Core B. Informatics and Core J - NRSA** aim to fill these gaps.

Emerging Informatics Training. Over the next five years of CTSA funding, CTSI will develop and provide state-of-the-art informatics training that complements our world-class training in clinical research and our emerging data science (DS) curriculum. These disciplines are highly synergistic, and the training we develop will be tightly coordinated by the Department of Epidemiology & Biostatistics (DEB), which hosts our clinical research training program and data sciences curricula. The Informatics Core (**Aim B.4**.) will partner with DEB to co-lead development of informatics curriculum coursework, ensuring complete coordination between informatics infrastructure development and our training programs. We will teach investigators to use the infrastructure and train leaders who can help us innovate on informatics infrastructure into the future. Given the recognized need for curriculum and program in informatics at UCSF, the institution has committed substantial resources to support development of a new Clinical Informatics Master’s Degree Program and an eventual PhD program (see LOSs, Chancellor Hawgood, Dean King). Our CTSA funding represents modest co-investment with institutional partners that is specifically earmarked for development and launch of two new courses that fill identified gaps for our K Scholars: *Introduction to Clinical Informatics* and *Working with Electronic Health Record Data* (course descriptions below). Along with these elective courses, which will be available to all UCSF trainees, CTSI will support development of other training opportunities, including a new clinical research informatics postdoctoral fellowship (**Core J, NRSA Training**).

Course 1: Introduction to Clinical Informatics. Clinical Informatics encompasses a set of knowledge domains that has only partial overlap with clinical research methods and data science. Our planned *Introduction to Clinical Informatics* course is designed as a survey that covers several domains of knowledge and core competencies, as described by the American Medical Informatics Association (AMIA).[25] While focused on training of professionals who will implement and oversee informatics systems that support health care delivery, this discipline is also highly relevant for clinical and translational researchers who aim to implement, improve, innovate, and study informatics-related approaches to improve care. The course will focus on informatics fundamentals, theory, and standardized vocabularies, which are often mysterious to clinical researchers; health system theory and economics and how they intersect with health care information systems; data and information flow and the information systems architecture necessary to support efficient workflow within a health system; clinical data standards and ontologies: what clinical decision support is, how it works, how to engineer clinical workflows, and critical design principles. We are fortunate to have a very strong set of courses in epidemiologic methods, biostatistics, decision theory/analysis, and implementation science, such that these topics need not be covered in depth by our introductory course. The course will feature lectures by Core Faculty as well as UCSF Health informatics leaders and practitioners, readings, problem sets, and discussion sections.

Course 2: Working with Electronic Health Record Data. Our trainees desperately need both a big-picture understanding of how EHRs work and practical skills that enable them to access and analyze data derived from EHR systems. This course will provide in-depth lecture content describing generation, storage, data flow, data modeling, extract/transform/load operations, data messaging/integration systems (e.g., HL7) and ontologies relevant to EHR data. Lectures will provide both contextual and applied information about how these systems are configured and used at UCSF and at other institutions within and collaborating with the CTSI. Specific descriptions and information about the data resources available for clinical and translational researchers at UCSF will be provided. Learners will be required to have proficiency with a statistical analysis package as a prerequisite for the course. To make the training relevant and build required skills, the course will require completion of a set of computer lab assignments and a research project that will require access to UCSF’s de-identified clinical data warehouse (see **Core B**) and analysis of the various primary domains of data available in the warehouse. The final element will be a series of presentations by clinical research informatics practitioners that describe completed, high-impact analyses of UCSF EHR data and the challenges and solutions they encountered along the way, emphasizing practical lessons learned. A list of clinical research informatics faculty can be found in the NRSA **Core J, Data Table 2**, and **Table I.11**.

Clinical Informatics experience for K Scholars. Along with the two formal Clinical Informatics elective courses,

we will develop a set of shorter offerings designed for learners and K Scholars who may not need the depth of a formal course. Key concepts from the two courses will be distilled and imparted via 1-hour seminars, 3-hour workshops, and 1- or 2-day short courses. We will host these seminars during the Friday morning K Program seminar slot and an optional afternoon workshop, appropriate for high-value, but informal didactics.

Additional planned courses in Clinical Informatics at UCSF. **Table I.10** below presents additional courses that round out the DEB's clinical informatics curriculum for clinical and translational researchers. These courses will be offered in a new clinical informatics track in the Master's Degree in Clinical Research.

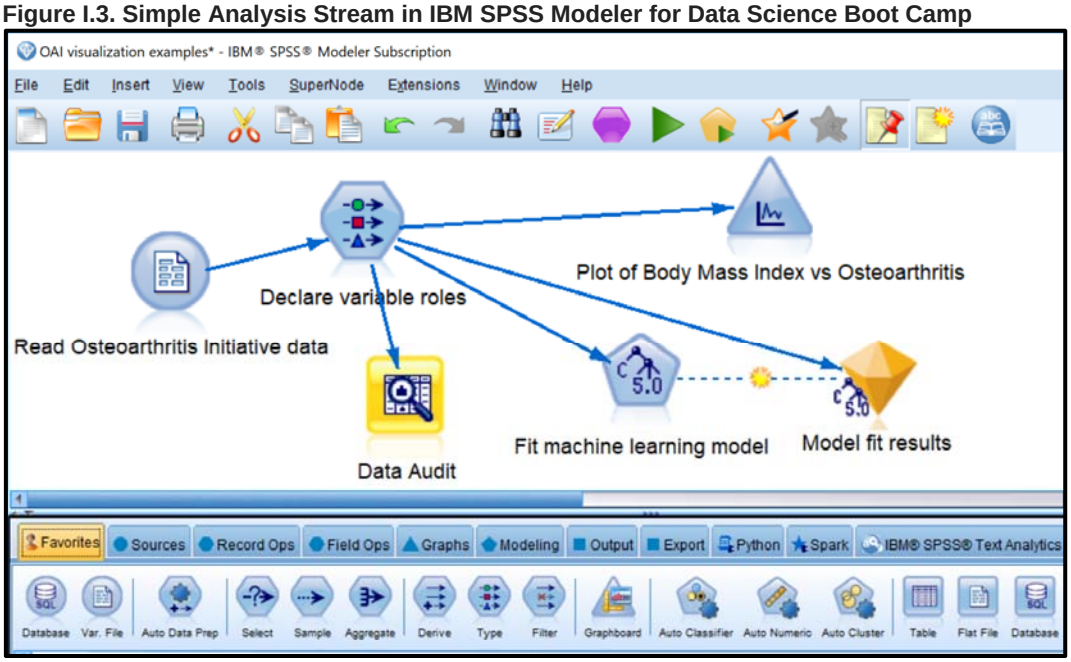
Data Science Training at UCSF. As defined by the NIH, data science is *an interdisciplinary field of inquiry in which quantitative and analytical approaches, processes, and systems are developed and used to extract knowledge and insights from large and/or complex sets of data that are increasingly needed to conduct research*. These competencies are embedded within NIH's 2018 Strategic Plan.[26] We will provide this training to all interested K Scholars and other UCSF faculty through a series of courses tailored to their time and interest level. CTSI will offer a new data science track in the TICR curriculum, and a Master's Degree program for Scholars who want a "deep dive" into data science. For K Scholars who want a critical overview but not deep training, we will offer introductory data science training through a hands-on, K Scholar-specific workshop. All K Scholars will have opportunities for data science mentorship. As described above, and in **Core D** and **Core J**, the CTSI supports an extensive training program in partnership with the DEB. **Table I.10** presents existing and planned courses for which the target audience is clinical faculty researchers, health systems quality improvement leadership, and academic staff clinical data scientists. Courses will be developed as workshops and evaluated by the Hub and institutional leadership, anticipating that they will form the foundation of the establishment of a Master's in Health Data Science (MiHDaS) at UCSF by 2021.

Table I.10 Course List (partial) for Curricula in Data Science and Clinical Informatics

Courses in Data Science	Courses in Clinical Informatics
Introduction to Data Science (BIOSTAT 202)	Introduction to Clinical Informatics (Proposed 2021)
Introduction to Computing in R (BIOSTAT 213)	Research Using EHR Data (Proposed 2021)
Advanced R/Data Wrangling (Planned, 2020)	Leadership in Informatics Systems (Proposed, 2022)
Machine Learning I (BIOSTAT 216)	Human-centered Design (EPI 243)
Machine Learning II (Planned, 2021)	Health Systems and Health Policy (Proposed, 2022)
Stochastic Simulation (Proposed, 2021)	Consumer Technology and Digital Health (Proposed, 2023)
Data Visualization Methods (Proposed, 2022)	Cloud Platforms for Data Storage and Analytics (Proposed, 2023)

Practical experience in data science for K Scholars. To provide a critical introduction to data science to all K Scholars, we will use three of our Friday morning seminars to cover: "*The role of machine learning: help or hype*?," "*An introduction to machine learning methods*," and "*Using EHR data for clinical and translational research*." These seminars will be recorded to make them available more widely. In addition, we will dedicate one of our Friday afternoon workshops to a machine learning methods boot camp. Using innovative software (IBM SPSS Modeler – free for faculty and students) that requires no programming, we will go from ground zero to testing state-of-the-art methods in a single 3-hour session. Instead of writing programming statements, in SPSS Modeler, the data analysis "pipeline" is developed graphically, like a directed acyclic graph. **Figure I.3** is a screenshot of a simple analysis "stream" that (from left to right) reads in the data, declares variable types and roles (outcome vs predictors), does a data

Figure I.3. Simple Analysis Stream in IBM SPSS Modeler for Data Science Boot Camp



quality control check, generates a plot, and fits a state-of-the-art classification tree model (called C5.0). This will be structured as an active learning session with a script to walk through and teaching assistants on hand to help Scholars as they work through the script. We will package the honed script and the teaching assistants' instructions for dissemination to other CTSAs. Additionally, the UCSF Library offers R/Python boot camps and beginner instruction in data visualization.

Aim I.2.2. Increase and facilitate K Scholar research consultations and collaboration opportunities with experienced informatics and DS Faculty Advisors.

In addition to didactic training, Scholars need mentored experience in clinical informatics and data science. In addition to the K Program Biostatistics Advisors, **Table I.11** presents other UCSF faculty with clinical informatics, data science, and bioinformatics expertise who will be assigned mentoring roles and will provide opportunities and guidance on relevant projects.

Table I.11. Clinical Informatics and Data Science faculty

Advisor, Role	Research Area/Expertise
Mark Pletcher, MD, MPH, KL2 Core Faculty, U54 Informatics Core Director	Cardiovascular epidemiology, hypertension interventions in EHR, digital health clinical trials, learning health system
Julia Adler-Milstein, PhD, Director of UCSF Center for Clinical Informatics and Improvement Center	EHR research, health information exchange, meaningful use
Mary Whooley, MD, NRSA Training Core MPI, Director of the Clinical Research Informatics Program (CRISP)	VA EHR research, CMS datasets, cardiovascular disease
Ida Sim, PhD, MD; Professor of Medicine, Director of Digital Health for UCSF Division of General Internal Medicine	Research with mobile apps and sensors integrated into health record data
Chuck McCulloch, PhD, KL2 Assoc. Director, Prof. of Biostatistics	Methods to understand bias in EHR data, use of data science in applications
Marina Sirota, PhD, Asst. Prof Institute for Computational Health Sciences	Drug repositioning, computational biology, premature birth, autoimmune diseases
Fei Jiang, PhD, MS, Asst. Prof of Biostatistics	High dimensional data analysis, adaptive randomization in clinical trials
Aaron Scheffler, PhD, MS, Asst. Prof of Biostatistics	Functional data analysis, including data generated from digital imaging and wearable technologies

Evaluation of K Scholar Informatics and DS Activities. To assess the success of each aspect of the K Scholar Informatics and DS program and to determine if additional activities are needed, we will add specific questions about these two programs to our twice-yearly request for Scholar feedback.

Aim I.3. To provide implementation science training, mentorship, and practical experience to accelerate the dissemination of clinical/translational research into clinical practice and public health.

There is a tremendous gap between what we know can optimize health and health care and what actually happens in everyday practice.[27] This gap reflects the paucity of evidence about effective implementation strategies. Many innovations fail to improve health because implementation is unsuitable or incomplete.[28] Translation of scientific evidence into improved practice, policy, and population health requires development, testing, and dissemination of beneficial interventions. Although most interventions designed to improve health target individuals, implementation depends on communities, health care delivery systems, health care professionals, and government agencies. All clinical and translational investigators benefit from basic skills in implementation science (ImS), defined as *the scientific study of methods to promote the systematic uptake of research findings and evidence-based practices into routine practice to improve the quality and effectiveness of health services and care*.[29] A growing number of our K Scholars wish to develop deep expertise in ImS with the goal of using and improving ImS methods. Hence, we propose to add formal instruction in the theories, methods, and practice of ImS.

Table I.12 Course List for Certificate Curriculum in Implementation Science

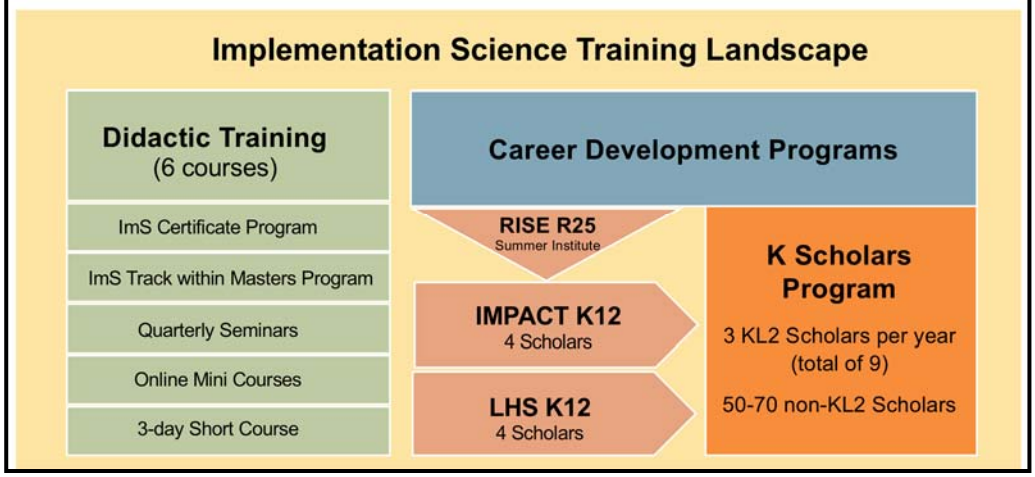
Fall (September–December)
IMS 245A Introduction to Implementation Science Theory and Design (A. Cattamanchi, Director)
IMS 248A Community-Engaged Research (S. Ackerman, Director)
Winter (January–March)
IMS 242A Program Evaluation in Clinical and Public Health Settings (J. Myers, Director)
IMS 246A Designing Individual-Level Implementation Strategies (M. Handley, Director)
Spring (April–June)
IMS 247A Designing Interventions to Change Organizational Behavior (L. Schmidt, Director)
IMS 249A Translating Evidence into Policy (B. Hollister, A. Bindman, Directors)
IMS 241A Study Designs for Intervention Research in Real-World Settings (M. Handley, S Shade, Directors)

The History of UCSF's ImS Training Program. With institutional and CTSI support, UCSF was among the first institutions to develop a

formal ImS Training Program.[30] Since 2009, we have offered a series of eight courses that form an ImS Track in the Master's in Clinical Research and provide a stand-alone ImS Certificate Program. To date, more than 350 students, fellows, and faculty have taken at least one ImS course, and over 75 have completed the ImS Certificate Program. The Program has expanded in recent years to meet the increasing demand for ImS training at UCSF as well as nationally and internationally, but relatively few faculty (<20% of enrollees) have participated. The Program now offers seven courses, using in-person and online formats (**Table I.12**) and also delivers quarterly seminars on ImS methods, an online introductory course, and a 3-day short course.

Existing UCSF ImS Career Development Programs. UCSF is home to three new career development programs in ImS and learning health systems that are directly relevant to the new goals of the K Scholars Program (**Figure I.4**).

Figure I.4. Implementation Science programs and the K Scholars Program



Research in **I**mplementation **S**cience for **E**quity. RISE (R25, MPIs Bibbins-Domingo, Fernandez, Handley) is a NHLBI-funded 2-year training program that has enrolled 46 URM health sciences junior faculty from across the country. The program includes a 2-week RISE Summer Institute focused on ImS and career mentoring, which is jointly hosted by the DEB and the Center for Vulnerable Populations. RISE Scholars also receive distance mentoring, a mid-year in-person meeting, monthly tele-WIPs, and then return to complete a second summer institute.

IMplementation Science for **P**ulmonary **A**nd **C**ardiac Research **T**raining. The IMPACT K12 (MPIs Cattamanchi and Bibbins-Domingo) is an institutional K12, funded by NHLBI in 2018, that trains UCSF junior faculty in the science of improving the delivery of interventions proven to improve heart and lung health. Four IMPACT Scholars per year are supported for up to three years to complete coursework in implementation science, an embedded health care delivery experience in a local health system, and an ImS-focused research project. All current IMPACT Scholars participate in the K Scholars Program. (Please note: this is a distinct program, with different curriculum from new **Core H:** Impacting Practice and Policy by Accelerating Translation [IMPACT].

The **L**earning **H**ealth **S**ystem. LHS (MPIs Gonzales and Sarkar) is an institutional K12, funded by the Agency for Health care Research and Quality in 2018, that supports the career development of scientists at UCSF and affiliates who conduct patient-centered outcomes research within learning health systems. It is aimed at helping accelerate the translation of research and evidence into practice. LHS Scholars receive intensive training in quality improvement methods such as LEAN and A3 Thinking. LHS provides two or more years of support to four junior faculty per year, and all are currently participating in the K Scholars Program.

Aim I.3.1. Create new ImS didactic seminars, workshops, and traditional coursework.
K Scholars have access to all ImS programs offered at UCSF as well as our CTSI-coordinated efforts to improve and expand access to community-based research (**Aim I.1.2. Integrating Special Populations)**. In addition, we propose to increase awareness and further support those engaged in ImS research or interested in adopting ImS methodology by offering the following didactic experiences designed for K Scholars:

1. ImS introductory seminar. The ImS Training Program, co-led by Drs. Cattamanchi and Handley, will deliver an annual ImS introductory seminar to K Scholars. Courtney Lyles, PhD, an ImS Program faculty member and former UCSF KL2 Scholar, will lead this seminar to introduce Scholars to key concepts and theories in ImS.

2. ImS quarterly seminar. New ImS seminars will be offered quarterly on Friday afternoons to encourage participation from K Scholars already attending Friday K Program activities. Seminar topics will include 10 case studies illustrating the steps involved in implementation science with pre-intervention planning, intervention design, intervention evaluation, and appropriate/feasible study designs, and two special topics in ImS (e.g., rapid qualitative methods, mixed methods research, improvement science, or human-centered design).

3. ImS short course. We will offer an expanded, annual 3-day, in-person *Implementation Science Short Course,* led by Dr. Lyles. The intensive course will allow K Scholars to understand and apply key concepts of ImS in a small group setting with individualized faculty support. The short course is ideal for busy clinicians and researchers unable to devote time to the semester-long ImS courses. The major content areas covered include: core principles of ImS; identifying evidence and making the case for translation; reflections on community engagement; defining the evidence-practice gap in behavioral terms; theory-informed intervention design; and ImS measurement and evaluation frameworks. The course was successfully piloted in 2019, attended mainly by external learners. Future versions will feature a K Scholar-focused track or small group.

4. ImS Certificate courses. The current UCSF ImS Certificate courses are listed in **Table I.12** above. All are available to K Scholars. In addition, based upon K Scholar requests, two new ImS courses (*Qualitative and Mixed Methods Research* and *Improvement Science*) are planned for 2022.

5. Annual workshop. **Core H** (IMPACT, **Aim H2**) will develop an annual 2-day workshop to address competencies that complement the ImS coursework and extend to policy. The theme of the first workshop will be "*Tools for Communicating Research Outside of Academia*." K Scholars will be encouraged to attend.

6. Collaborate with the UCSF ImS career development programs. As noted above **(Figure I.4),** UCSF is home to three career development programs in implementation sciences and learning health systems (RISE, IMPACT, and LHS). The activities of these programs, including seminars, workshops, embedded delivery system experience, and WIP presentations, will be available to K Scholars pursuing ImS projects.

Aim I.3.2. Increase and facilitate K Scholar research consultations and longitudinal collaborations with experienced ImS faculty advisors (Table I.13).

We plan to increase K Scholar interactions with specific ImS faculty by implementing the following programs:

ImS consultations. Through our successful CTSI consultation services program (**Core E1**), we will offer on-demand consultations for K Scholars working on ImS-related projects or writing ImS-related grants. The consultations will focus on ensuring grant proposals include the ten key ingredients for ImS research proposals outlined by Proctor et al[31] and address grant-specific methodological issues. The consultations will be conducted by the ImS Program Directors and other ImS faculty.

ImS mentoring teams. K Scholars who demonstrate a strong commitment to ImS projects or who wish to expand or develop ImS methods will be paired with an experienced ImS faculty member who may act as lead mentor, co-mentor, or research mentor.

Additional ImS experts embedded in the weekly K Program activities. ImS experts (Gonzales and Sarkar) joined the K Program on a trial basis in 2019 to serve as WIP leaders and to advise Scholars interested in ImS careers. Feedback from Scholars and other K Faculty has been overwhelmingly positive. They will continue to participate and we will add two additional faculty leaders of the IMPACT K12 and RISE programs (Drs. Cattamanchi and Handley) as new Advisors to assist with relevant WIPs and to mentor interested Scholars.

Table I.13. Implementation Science Faculty Embedded in the K Scholar Program

Advisor, Role	Research Area/Expertise
Adithya Cattamanchi, MD, ImS Program Co-Director, MPI IMPACT K12	Global Health, intervention design, community-based trials
Margaret Handley, PhD, MPH, ImS Program Co-Director, MPI RISE	Intervention development for public health and primary care settings; chronic disease prevention; health communication, quasi-experimental design; mixed methods
Ralph Gonzales, MD, MSPH, MPI LHS K12, UCSF Assoc. Dean for Clinical Innovation and CIO	Health care interventions, drug utilization, comparative effectiveness trials
Urmimala Sarkar, MD, MPI LHS K12	Safety and quality interventions in safety-net hospitals

Evaluation of K Scholar ImS Activities. To assess the success of each aspect of the K Scholar ImS Program and to determine if additional activities are needed, we will add specific questions about the ImS Program to our twice-yearly request for Scholar feedback.

Aim I.4. To share and disseminate the successful elements of our K Scholars Program for local, regional, and national collaboration

Since its inception in 2006, the K Scholars Program has become the largest and most comprehensive career development program at UCSF[1] and an active regional and national participant in CTSA educational endeavors. (**Table I.14**).

Local activities. The most important local impact of the KL2 Program has been the **expansion of the Program**

to the much larger K Scholars Program that also serves individual NIH K and institutional K12 awardees across UCSF (see **Sections A.2 and A.3**). All UCSF junior faculty with suitable career development awards are invited to participate, and a substantial number of our K Faculty and Scholars have primary affiliations with the SFVA and our safety-net health system, Zuckerberg SF General Hospital. Our career development expertise has been acknowledged by Dean Talmadge King (see LOS, King) who strongly supports the K Scholars Program. In 2019, Dean King invited Drs. Bauer and Kanaya to serve on the UCSF K Best Practices Task Force, charged with standardizing and improving departmental support for NIH K awardees.

Table I.14. UCSF K Program Impact-Local, Regional and National.

Area of Impact	Product
Local – Campus	• Expansion of K Scholars Program to non-KL2 K awardees
Regional - Bay Area	• K Scholars and faculty from UCSF-affiliated institutions • Co-sponsor of Annual Bay Area Clinical and Translational Research Symposium
Regional - West Coast	• Leadership of West Coast Education Consortium • Multiple UC Campus (BRAID) and USC ImS needs assessment
National	• CTSA Workforce Development Task Force • KL2 Program Director Quarterly Calls and in person meetings • Service to other CTSA education programs as grant reviewers and external review committee members

Regional Bay Area activities. Regionally, the K Program promotes our activities throughout the greater Bay Area and includes Faculty and Scholars from UCSF-affiliated institutions, such as UC Berkeley, and the San Francisco Department of Public Health. Additionally, one of our K Program Faculty (R Grant, MD) and several K Scholars are employees of the Kaiser Division of Research in Oakland, California. In January 2020, the K Scholars Program co-sponsored the inaugural *Bay Area Clinical and Translational Research Symposium*, a regional collaboration with several San Francisco Bay Area health care institutions designed to promote multidisciplinary collaboration among research faculty. The 1-day conference was held at the UCSF Mission Bay Conference Center and included faculty and trainees conducting clinical and translational research from UCSF, Stanford, California Pacific Research Institute, and Kaiser Division of Research. As Co-Chair, Dr. Bauer helped with planning, reviewed abstracts, and presented an award for "Best Oral Presentation by a Junior Investigator" to Jade Benjamin-Chang, PhD, a first-year UCSF K Scholar. The Symposium reached the limit of 170 attendees within two weeks of the initial announcement and had excellent K Scholar participation (4 of the 12 oral presentations and 9 of the 53 poster presentations were current K Scholars). Based on this success, we plan to continue our co-sponsorship in a larger venue to accommodate additional participants. Finally, K Faculty have had a leadership role in a California multi-Hub ImS needs assessment and development of ImS curriculum and competencies.[30]

Table I.15. KL2 Milestones, Timeline, and Metrics

Aim 1. To recruit and train a superb group of professionally and ethnically diverse UCSF junior faculty to become KL2 Scholars and to support them for up to 3 years as they progress towards research independence.	
Scholar Diversity	#/% of URM applicants and selected Scholars
	#/% of women applicants and selected Scholars
Scholar Progress 5 years after program completion	#/% of Scholars who obtain individual NIH K awards during program #/% of Scholars submitting R01 grant during program # of Scholar publications as first or last author during program # of Scholar publications during program
	#/% of alumni Scholars engaged in clinical and translational research (% URM, % Women) #/% of alumni Scholars with individual K grant #/% of alumni Scholars with R01 or equivalent grants # alumni Scholar publications as first or last author \ # alumni Scholar publications
Aim 2. To provide state-of-the-art informatics and data science training, mentorship, and practical experience to improve clinical medicine and public health.	
	#/% of Scholars taking courses and workshops in clinical informatics and/or data science #/% of Scholar publications involving research technology and informatics, digital health
Aim 3. To provide ImS training, mentorship and practical experience to accelerate the dissemination of clinical and translational research into clinical practice and public health.	
	#/% Scholars participating in ImS training: online ImS certificate; short course, ImS quarterly seminar series, 1:1 mentoring and consultation. #/% Scholar publications involving research technology and informatics, digital health
Aim 4. To share and disseminate the successful elements of our K Program as a model for regional collaboration.	
	# of UCSF online courses and workshops offered to other KL2 programs # of collaborations undertaken with other CTSAs UCSF leadership roles in western regional educational activities

Regional West Coast activities. The K Scholars Program leadership participate in the West Coast Education Consortium (WCEC), which includes leaders of training programs from CTSAs throughout California, Oregon, and New Mexico. Participant institutions include UCSF, UCLA, UC San Diego, UC Davis, UC Irvine, Stanford, Scripps Research Institute, USC, Oregon Health Sciences University, and the University of New Mexico. The Consortium convenes quarterly webinar meetings and meets annually face-to-face. In 2020, UCSF will assume leadership of the group and will host the 2020 face-to-face meeting in San Francisco (see LOS, WCEC). The WCEC group focuses on several key areas, including tracking and evaluation of alumni; increasing diversity and supporting URM Scholars; mentorship; Common Metrics; leveraging online courses across the consortium; online career development plans, and novel educational enhancements from each institution. A new initiative is to organize a multi-Hub KL2 scientific conference in Fall 2020, creating a larger community for our Scholars and fostering new opportunities for scientific collaboration and team science across institutions.

National activities. Dr. Bauer participates in the quarterly KL2 Program Directors meetings, and Dr. Kanaya participates in the Workforce Development Domain Task Force. The KL2 Administrative Director works in conjunction with the CTSI Administrative Core to ensure that we properly integrate national CTSA Common Metrics and initiatives into our training program[32] (see U54, **Core A).** Lastly, several current and past K Program Faculty have served as external grant reviewers, invited external reviewers, and on external advisory boards for other KL2 programs, including Washington University, UCLA, Oregon Health Sciences University, Scripps, University of Minnesota, and USC. In the renewal period we plan to continue our current collaborative efforts across multiple Hubs and further share our educational activities and products.

B.5. Training Program Evaluation. The K Scholars Program will continue to track metrics aligned with Program Aims and incorporate Common Metrics developed by NCATS (**Table I.15**). The metrics emphasize Scholar progress during the Program and career outcomes following its completion. Measures of Scholar satisfaction with Program components inform ongoing improvement efforts. Metrics for each of the Aims of this proposal will be evaluated and tracked at least semi-annually in the context of the CTSI's overall program planning, evaluation, and tracking.

Table I.16. K Scholars Evaluation of Program Activities (2014- 2019) Rating 1-5 (5 best)

Program Element	*N Responses*	*Mean score*
Overall Program	135	4.60
WIPs	137	4.41
Pilot R01 Didactics Overall	24	4.61
K Program Faculty	79	4.65
Seminars	99	4.42

Scholar satisfaction. We survey our Scholars twice per year to evaluate Program activities: Works-in-Progress sessions, Grant Writing Workshops, faculty-led seminars, and individual K Program Faculty. Scholars are asked to evaluate these elements as to their value to the Scholars' career development on a scale of 1 to 5 (5 = most satisfied). **Table I.16** presents results of Scholar evaluations from 2014-2019. K Scholar satisfaction for all aspects of the Program is high and has been consistent over the years, with no difference in ratings between KL2 and other K Scholars in the Program. We also meet in person with Scholars at a year-end lunch to solicit their collective feedback on what went well during the year, what they would like to do differently, and what new activities they recommend in the coming year. Examples of changes made in 2019-20 based on Scholar feedback are: 1) reconstituting WIP groups based on scholarly interests when Scholars begin their third year in the Program; 2) video access to Friday K activities to accommodate off-site Scholars; and 3) emphasizing Scholar preferences for seminar topics.

Scholar career outcomes. Scholars who have completed the Program are surveyed every two years, up to ten years after completing (or leaving) the Program, to assess their subsequent career outcomes and to rate how participation in the K Scholars Program affected their current skills and expertise, ability to obtain a desired position, and ability to obtain grants. Surveys are created and collected using the Application, Review, and Tracking (ART) system developed by CTSI for this purpose (see **Data Table 8C**). This funding cycle we began to use the Digital Science Dimensions software,[33] a web-based research analytic tool that aggregates relevant data, such as publications, grants, patents, clinical trials, and policy documents from multiple sources.

B.6. KL2 Scholar selection. The KL2 application is designed for UCSF junior faculty from any of our four professional schools who conduct clinical or translational research with an appointment at the Assistant Professor level but have not been PI of an NIH RO1 or career development award, or project leader of an NIH P01, U54, P50, or P60. The pool of candidates is deep – approximately 275 individuals are appointed at the Assistant Professor level each year at UCSF. Due to the number of highly competitive applications we receive, the KL2 Selection Committee has established pre-application requirements that potential applicants must have at least one first-authored, peer-reviewed publication in the topic area of the KL2 proposal; strong lead and secondary mentors from more than one discipline, and clear commitment and resources from the Scholar's home

department. **Table I.17** shows characteristics of the 74 applicants and 20 accepted KL2 Scholars from 2016 to 2019. For the 2020 application cycle, we have already received 24 KL2 applications for 2 confirmed places.

Table I.17. KL2 Applicants and Accepted KL2 Scholars (2016-2019)

	Applicants	Scholars
Total N	**76**	**20**
Sex		
Male	24 (32%)	6 (30%)
Female	52 (68%)	14 (70%)
URM		
Latinx, African American, Native American/Alaska, Disability, or Disadvantaged	18 (23%)	6 (30%)
Degree		
MD	12 (16%)	1 (5%)
MD, PhD	5 (7%)	1 (5%)
PhD	21 (28%)	4 (20%)
MD + Master's (MPH, MA)	34 (45%)	12 (60%)
PharmD	1 (1%)	0 (0%)
DDS	3 (4%)	2 (10%)
School		
Medicine	67 (88%)	16 (80%)
Nursing	5 (7%)	2 (10%)
Pharmacy	1 (1%)	1 (5%)
Dentistry	3 (4%)	2 (10%)
School of Medicine Depts.		
Anesthesia/Perioperative Care	1 (1%)	1 (5%)
Dermatology	2 (3%)	0 (5%)
Emergency	2 (3%)	0 (0%)
Epidemiology	2 (3%)	0 (0%)
Family Medicine	2 (3%)	1 (5%)
Medicine	36 (47%)	10 (50%)
Neurology	6 (8%)	0 (0%)
Ob/Gyn	1 (1%)	0 (0%)
Pediatrics	9 (12%)	2 (10%)
Psychiatry	2 (3%)	0 (0%)
Social & Behavioral Sciences	1 (1%)	1 (5%)
Surgery	3 (4%)	0 (0%)

KL2 Selection Criteria. Selection criteria focus on the strengths and potential of the candidate to become a leading multidisciplinary clinical investigator judged in five domains:

1. **Track Record:** Creativity of the candidate and potential to lead innovative multidisciplinary research based on prior training, areas of expertise, publications, funded grants, and collaborations.
2. **Research Plan**: Scientific strength, potential clinical importance, and feasibility of the proposed multidisciplinary research plan.
3. **Training Plan**: Strength, appropriateness, and multidisciplinary complementarity of the proposed mentors, mentor resources, and plan for didactic education and training at UCSF or elsewhere.
4. **Resources**: Tangible commitment and resources provided by the home department or unit (salary, space, administrative support, mentoring) and suitability of the available clinical and laboratory infrastructure and multidisciplinary team.
5. **Career Potential**: Global assessment of the likelihood that the candidate will develop a career as an outstanding investigator who will lead multidisciplinary teams and have an important impact on health.

Request for applications. We issue a call in October for applications due in February, with a start date of July 1. This call is announced in CTSI email communications distributed to all UCSF faculty. The KL2 award continues to be announced in CTSI communications until the deadline for the application has passed. The KL2 Award is well known, highly valued, and respected, and has large alumni Scholar representation among junior and mid-level faculty at UCSF; our annual call for applications is anticipated across campus.

Application format. Applicants are required to submit an online application that is modeled on the NIH K23 grant application, providing applicants the experience of preparing a rigorous application. For those who are not selected, the KL2 application may be used to apply for other career development awards. Required elements include Candidate and Mentor biosketches, Candidate Statement, Specific Aims, Research Strategy, Protection of Human Subjects, plus KL2-specific requirements addressing the KL2 selection criteria above and letters of support from Mentors and the Department Chair.

Recruitment of URM Scholars. In the annual call for applications and on our website, we strongly encourage applications from URM faculty. Although we are in part dependent upon the representativeness of the UCSF faculty (currently 8% URM) to ensure a pool of URM candidates, we also benefit from several School of Medicine diversity initiatives (see below **Section C**, **Recruitment and Retention Plan to Enhance Diversity).** Since 2016, KL2 Scholars have been 30% URM by race/ethnicity, disability, or disadvantage (per NOT-OD-20-031). Increasing the proportion of URM faculty at UCSF (see **Core D, Aim D1.2**) and for the K Program are among our highest priorities.

Electronic application and review process. We use the Application, Review and Tracking (ART) software, developed by CTSI in 2010 to create applications, collect applications for review, securely distribute applications to reviewers, collect and collate reviews, and track Scholars. Reviewers log onto the ART website where they view applications, reviewer assignments and review criteria, and post their application reviews.

Selection process. A Selection Committee of 12 faculty, representing all four UCSF professional schools and including KL2 Program Faculty and Senior KL2 Scholars and KL2 alumni, reviews Scholar applications. Each

application is assigned to a primary, secondary, and tertiary reviewer for scoring on each of the five selection criteria. Primary and secondary reviewers interview the applicants in person, and primary reviewers prepare a 1-page written critique that is later edited based on the discussion of the Selection Committee. After the interviews are complete the Selection Committee evaluates and ranks applicants during a 5-hour meeting, following the model of the NIH peer review process. All candidates, regardless of ranking, are given 1-2 pages of written comments summarizing the strengths and weaknesses of their applications.

Selection across disciplines. One of the strengths of the KL2 selection process is that after the Selection Committee ranks applications on merit, the Director (Bauer) and Associate Directors (Walter and McCulloch) review these rankings and consider other contributing factors that would raise candidates in the rankings. The process incorporates consideration of multiple Scholar disciplines in a very intentional way. A diversity of disciplines and Scholar backgrounds is an important component of team science and we are proud that 45% of alumni Scholars surveyed reported that they have had at least one collaboration with a K Scholar from another discipline as a direct result of being in the Program.

Vignette: Interprofessional Training. *Benjamin Chaffee DDS, MPH, PhD, now an Assoc. Professor at the UCSF School of Dentistry, was awarded a KL2 in 2014. His work examines tobacco-related behaviors among adolescents, including use of new and emerging products. He is currently Project Leader within a NHLBI-funded U54 award, leading a cohort study of rural youth that incorporates epidemiology, qualitative research, and biomarker studies.* ***"The K Scholars Program provided in-depth, hands-on experience in how excellent research is achieved - from refining an idea to hiring staff, to communicating with the public. Even after the KL2, I still apply lessons learned from Mentors and fellow Scholars I otherwise would not have known and whose insight draws from diverse career paths and research methodologies."***

Review of Scholar progress and criteria for reappointment. The K Scholars Program uses subjective evaluations and milestones to assess Scholar progress during the Program. We expect all K Scholars to submit two peer-reviewed publications each year and expect KL2 and K12 Scholars to submit an independent NIH K grant by the end of the second year or, if appropriate, an R grant or the equivalent by end of the third year (**Table I.15**). All Scholars meet at least annually with their K Scholar Program Advisor to discuss their Career Development Plan. At that meeting, progress toward meeting Program milestones with respect to publications and grants are discussed, and goals for the next period are established. These reviews are the main opportunities to discuss ways to enhance the Scholar's career development infrastructure, and to identify actions the Scholar needs to take to ensure continuation in the Program. Each academic year, several monthly Faculty meetings are devoted to individual Scholar assessment, where Program Advisors summarize and critique the progress of each assigned Scholar. Our shared goal is for Scholars to become independently funded academics by the end of their K award period (or earlier); most departments share our general guidelines or milestones for publications and grant submissions. As noted above, since 2006, 59 (55%) of all KL2-funded Scholars converted their KL2s to individual Ks and 45 (42%) alumni were awarded R grants.

B.7. Institutional Environment and Commitment to Training.

B.7.a. Training environment. UCSF has four prominent health professional schools in Dentistry, Medicine, Nursing, and Pharmacy, as well as a Graduate Division. Overall, the UCSF School of Medicine has ranked in the U.S. News & World Report Best Medical Schools top five for the last ten consecutive years. In the 2020 rankings, the School of Medicine ranked fifth in research and third in primary care — the only school in the country to rank in the top five in both categories. The School of Dentistry is recognized nationally for its innovative approach to dental education, including combined DDS-PhD and DDS-MBA programs, and a 1-year training course designed to help disadvantaged students gain admission to US dental schools. The School of Nursing ranks eighteenth in U.S. News & World Report's 2020 survey for national nursing programs with Master's degrees. The School of Nursing provides education and research training in the social, behavioral, and biological sciences, with a focus on health care. The School of Pharmacy is ranked number three in the nation for its Doctor of Pharmacy program in U.S. News & World Report's 2016 survey, the latest available. In addition to conducting groundbreaking pharmaceutical research, the School pioneered the role of clinical pharmacists, which positions pharmacists as a key part of the health care team.

B.7.b. Institutional environment in support of the K Scholars Program. UCSF has a longstanding commitment to training junior faculty to develop independent clinical research careers. Institutional commitment to the comprehensive K Scholars Program, which includes the KL2 Scholars as well as Scholars supported by institutional NIH K12 awards, individual K awards, VA career development awards, and NIH diversity supplements, is demonstrated by leadership support across all four professional schools. It has safeguarded the development, sustenance, and growth of the K Scholars Program despite the decline in NCATS funding since

2016. The K Scholars Program receives significant financial support from the Deans of all four professional schools (see LOS). The School of Medicine has provided approximately $480,000 annually for the K Scholars Program, and each of the three smaller schools (Dentistry, Nursing, and Pharmacy) provides $25,000 per Scholar per year for their School's Scholars. These institutional resources support Program administration, additional K Program Faculty, and other expenses including the annual Scholar retreat. This commitment from the highest levels of leadership reflects the clear value that the K Scholars Program provides to the UCSF campus in career mentorship, methodological training, peer support, and advanced manuscript and grant writing skills development. All of these enhance the transition to career independence for our junior faculty clinical and translational research workforce. The broad and sustained participation of so many junior faculty in the K Scholars Program further demonstrates the commitment by senior leadership, departments, and schools to protect the time required for research and skills development. It also shows a significant financial commitment on the part of departments to fund the gap in salary between the $100,000/year that will be provided by the KL2 award, and the total salary of the KL2 Scholar required to protect 75% effort for research and career development activities.

B.8. Qualifications of KL2 Scholar Candidates and Admissions and Completion Records. Applicants and Selected Scholars. From 2016-19, the K Scholars Program received 76 applications and appointed 20 KL2 Scholars. **Table I.17** includes the sex, race/ethnicity, prior degree, and department of the applicants and KL2 Scholars from 2016-present. Overall, **68% of KL2 applicants and selected Scholars are women and 30% of applicants and selected Scholars are URM**. We have had KL2 Scholars from all four UCSF professional schools, although 86% of applicants and 80% of selected Scholars are from the School of Medicine. KL2 applicants were from 15 different departments at UCSF; the largest numbers of applicants are from the Departments of Medicine (42%), Pediatrics (16%), and Neurology (8%). Within the Department of Medicine, there are Scholars from 14 different divisions/specialties.

Completion of Training. Our goal is to train and help KL2 Scholars sustain long-term careers in academic research. Of the 108 KL2 since 2006 to date**, 67% have attained the rank of Associate Professor or higher and 72% devote >60% of their professional effort to research**. **Data Table 8C** shows the track record of KL2 Scholars who have been funded from 2016 onwards. We show the date of completion of their doctoral degree, dates, and focus of research interest during their KL2 training period and their subsequent position and grants. During the current grant period, we have awarded 20 new KL2 awards and supported another ten Scholars who completed KL2 training. Of these 30 Scholars (**Data Table 8C**), **27 have remained in faculty positions at UCSF or elsewhere, one is in a research position at the NIH/NHLBI, one is in a leadership role in a biopharmaceutical company, and one is primarily working as a clinician**.

C. RECRUITMENT AND RETENTION PLAN TO ENHANCE DIVERSITY

UCSF Priority Statement: *"UCSF will champion diversity, equity, and inclusion as core to our mission and will nurture and grow a culture in which everyone from all backgrounds is welcomed, supported, respected and valued."*

The UCSF School of Medicine has designed a multi-year, multi-faceted initiative called *Differences Matter,* to make UCSF the most diverse, equitable, and inclusive academic medical system in the country. San Francisco is diverse racially, ethnically, and socio-economically. It is vital that UCSF prepare learners to work in diverse settings to provide culturally appropriate care and, ultimately, reduce health disparities. The *Differences Matter* project has instituted several programs to foster inclusion on campus, and the K Scholar Program has benefited in multiple ways, as described below.

K Scholar diversity. The K Program tracks numbers of URM and women applicants and Scholars. The distribution of sex and race/ethnicity of applicants is similar to that of selected Scholars (**Table I.17**), and our Scholars broadly represent the diversity of the Bay Area. Overall, 30% of KL2 Scholars supported since 2016 are URM, including Diversity Groups A (race/ethnicity), B (disability), and C (disadvantaged background).

KL2 Scholars Program participation in campus and regional diversity initiatives. We continue to engage with "pipeline" programs on campus, including the Pre-health Undergraduate (PUP) and the U54 SF BUILD programs for URM undergraduates to come to UCSF for summer research opportunities (see **Core D**, Translational Workforce Development). Many of our K Scholars serve as mentors to these trainees and as small group leaders for the Designing Clinical Research course that all PUPs and SF BUILD students take.

NIH diversity supplements. In the past, there was no central repository of information for learners interested in diversity supplements. The Research Action Group for Equity (RAGE) worked with the campus Research Development Office to create a website with information and campus contacts. The group hosted campus events

with speakers from the NIH, the UCSF Office of Diversity and Outreach, and faculty who were awarded diversity supplements. The group is now working to create a "matchmaking" service to match principal investigators with learners at all levels who want to apply for diversity supplements. The K Program supports these efforts. Madeline Mann, our Administrative Director, is a member of the RAGE workgroup.

Enhanced diversity and inclusion training. UCSF has undertaken a broad campus initiative to foster a culture of inclusion.[34] All K Program Faculty and Scholars are encouraged to take the Diversity, Inclusion, and Equity Champion Training. This full-day training includes education on implicit biases and microaggressions, coaching in skills for addressing these issues, and training in applying thoughtful, active listening and empathy to support a more diverse, equitable, and inclusive environment. The K Program has innovative trainings to supplement campus activities. In October 2019, the Program hosted an Allyship in the Workplace for Men and White People, a 2-hour deep-dive into understanding how men, white people, and those who want to engage potential allies can deepen self-awareness to support inclusion and equity in the workplace and beyond.

Recruitment. The Program will continue to increase the scope of our recruitment to target specific URM communities on campus by working with the UCSF Office of Diversity and Outreach, by increasing the number of women and people of color on selection committees, and by working with the School of Medicine's Watson Scholars program, the RISE program, and the new HRSA Latino Center of Excellence Workforce Development program to increase the number of URM applicants.

Watson Scholars. In 2015, the School of Medicine created the Watson Scholars, a program to support the recruitment and retention of faculty who are underrepresented in medicine (URM). Each year eight faculty members are selected. In 2017, K Scholar Maria Garcia (see Vignette) became a Watson Scholar. In 2019, we invited research-focused Watson Scholars to participate in the K Scholars Program, an opportunity taken by Christopher Bartley, MD, PhD, Assistant Professor of Psychiatry, an African American faculty member and K23 awardee who studies autoantibodies in neuropsychiatric behavioral syndromes. We plan to continue to engage Watson Scholars and will begin targeted recruitment in February 2020 by inviting prospective Scholars to attend one or more didactic and WIP sessions.

Vignette: Maria Garcia, MD, MPH, MAS, RISE to IMPACT to K Scholar. As a clinician investigator, Dr. Garcia focuses on co-morbid mental health and chronic diseases and their disproportionate impact on marginalized populations, and she conducts research on mental health integration in primary care focusing on racially, ethnically, and linguistically diverse populations. Following residency and a primary care research fellowship at UCSF, Dr. Garcia became a Watson Scholar in 2017, then a RISE Scholar from 2017-18, and was awarded the IMPACT K12 career development award in July 2018; she subsequently joined the K Scholars Program. In 2020, Dr. Garcia assumed co-leadership of the Pre-health Undergraduate Program, a CTST summer clinical research training opportunity for URM undergraduates.

Sponsorship. Sponsors, as opposed to mentors, are advocates rather than advisors to Scholars and are invested in their career success.[35] **We are increasingly aware of the importance of sponsorship and will link sponsorship of our URM Scholars to our recruitment efforts described above**.

Community. We will continue to invest in programs that target prospective URM Scholars early in their careers at UCSF, and foster community. For example, we will organize interest groups for URM professional and graduate students aiming to become independent investigators. Monthly professional development seminars will address topics such as the mentor-mentee relationship, applying for diversity supplement grants, and discussions of issues that can affect the career advancement of URM students, such as stereotype threat and implicit bias.[36]

CORE J. NATIONAL RESEARCH SERVICE AWARD (NRSA) TRAINING PROGRAM (TL1)

A. BACKGROUND

A.1. Overview, Rationale, and Objectives for the TL1 Pre- and Postdoctoral Training Programs. The overarching goal of the UCSF Clinical and Translational Science Institute (CTSI) NRSA Training Program (TL1) is to train succeeding generations of diverse junior investigators in the use of cutting-edge methodologies, sophisticated analytic techniques, and effective leadership practices to expand scientific knowledge and improve health. With these foundational skills, TL1 trainees will be positioned to conduct transformative clinical and translational research with real-world impact. The TL1 training program is composed of two separate programs: the established and highly successful predoctoral **Yearlong Inquiry Program (YIP)** for health professional students and a newly focused **Clinical Research Informatics Postdoctoral (CRISP)** program for clinical fellows. The primary goals of the YIP are to train and inspire exceptional and diverse young investigators to embark on a life-long journey conducting a broad range of transformative clinical and translational research while enrolled in UCSF's health professional schools. The primary goal of the CRISP program is to address the urgent demand for in-depth training in clinical research informatics required to build a robust workforce with the necessary expertise to address health system challenges and become future leaders in this area.

During the next five years, the YIP and CRISP programs will introduce learners to new methods of conducting clinical research, including epidemiologic methods, biostatistical analysis, clinical informatics, data science, and responsible conduct of research. Both predoctoral (YIP) students and postdoctoral (CRISP) fellows will conduct mentored research projects that impact clinical practice, positioning them to successfully compete for future NIH fellowship or research career development grants and building the expertise and enthusiasm necessary to pursue and sustain academic careers as independent investigators.

The Aims of the UCSF TL1 training programs are to:

Aim J1. Expand and enhance the UCSF predoctoral Yearlong Inquiry Program (YIP), enrolling and training up to 11 students per year.

J1.1. Mentor and support a diverse group of health professional students to complete a Master's degree in clinical research and a research project and acquire lifelong research career development skills.

J1.2. In partnership with other CTSI programs, provide YIP students with exposure to: 1) Clinical Research Informatics and Data Science; and 2) Academic career development and leadership.

Aim J2. Establish a Clinical Research Informatics Postdoctoral (CRISP) Program to train clinical fellows in state-of-the-art clinical research informatics methods and provide mentorship in the design and completion of clinical research informatics projects.

J2.1. Empower a diverse group of clinical (MD, DMD, DDS, DNSc, DO, DPT, PharmD, clinically licensed PhD) postdoctoral fellows to complete coursework in clinical research and a mentored clinical research informatics project.

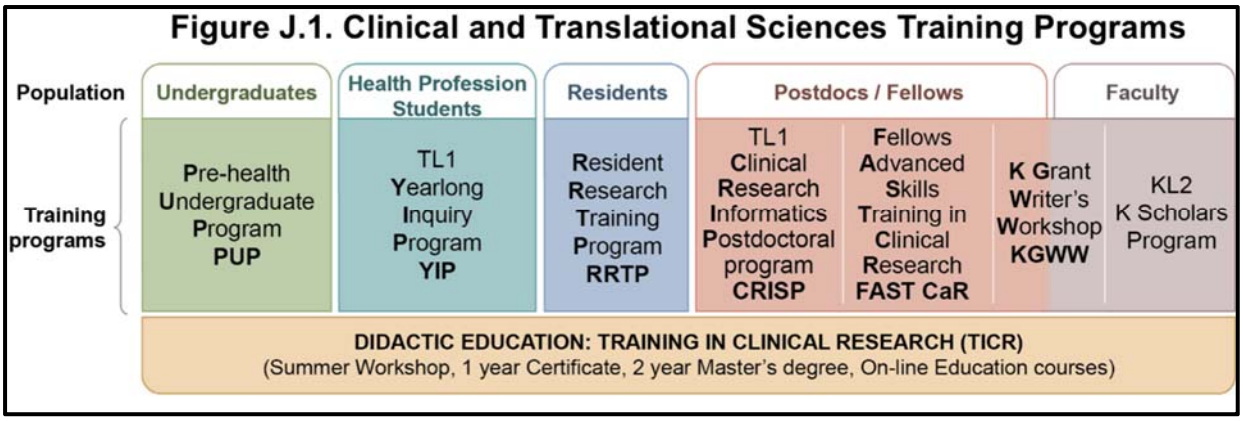
J2.2. In partnership with other CTSI programs, provide CRISP fellows with training in: 1) Clinical Research Informatics and Data Science; and 2) Academic career development and leadership.

Abbreviations used in Core J

ATCR = Advanced Training in Clinical Research
CRISP = Clinical Research Informatics Postdoctoral Fellowship Program (postdoctoral fellows)
IDP = Individual Development Plan
SFVA = San Francisco VA Health Care System
SOM = School of Medicine (UCSF)
TICR = Training in Clinical Research
UCSF = University of California, San Francisco
YIP = Yearlong Inquiry Program (predoctoral students)
ZSFG = Zuckerberg San Francisco General Hospital and Trauma Center

A.2. Integration of the TL1 programs with CTSI training programs. Over the past five years, CTSI has continued to build a comprehensive and integrated set of training programs for clinical and translational research careers. The level-specific programs have been improved and consolidated, thus extending research services and infrastructure overall. **Figure J1** displays the seven different CTSI training programs by level of learner, from undergraduate students through junior faculty. The **TL1 predoctoral YIP** is the only CTSI program serving health professional students, allowing them to gain a deeper understanding of clinical/translational research and providing a unique opportunity for them to conduct a mentored clinical research project. The **TL1 postdoctoral CRISP** program fills a unique gap in training for postdoctoral clinical research fellows at UCSF. This new program will offer a comprehensive 1- or 2-year didactic clinical research and data science curriculum, experience conducting a mentored clinical informatics research project, and career development skills. The other five CTSI training programs, including the KL2-funded K Scholars Program, are described in **Section B.1.b**.

Figure J.1. Clinical and Translational Sciences Training Programs



A.3. History and achievements of the YIP program.

History. Nathan[1] and later Nathan and Varmus[2] anticipated an acute shortage of researchers who would be able to rapidly translate findings from the basic sciences to clinical benefit for patients and the overall population. One potential intervention to address this labor shortage was the development of a pipeline of health professions students early in their careers. However, there were no organized institution-based programs to train predoctoral students in clinical and translational research. In 2001, the Doris Duke Charitable Foundation (DDCF) established the first program of its kind to fill this gap and UCSF was one of the first six institutions awarded a DDCF grant to develop a clinical research fellowship for medical students. In 2006, the CTSI TL1 was funded by the NIH to support predoctoral training for UCSF health professional students.

Since 2006, YIP has trained and inspired eight to ten predoctoral students per year in clinical and translational research from all four UCSF professional schools (Medicine, Dentistry, Nursing, and Pharmacy). The CTSI developed and refined an extensive infrastructure to select, educate, train, mentor, track, and assess outcomes for YIP students with collaboration with the schools. We have a well-honed outreach program that takes advantage of UCSF-wide efforts to engage learners in research, an online portal for submission of letters of intent and applications, and a robust NIH-style application review process, including study sections. Selected students receive in-person and web-based mentoring, didactic, and experiential training, supported by a robust program evaluation process and outreach to program graduates to assess career outcomes.

YIP students take a year off from their health professions curricula (typically between years three and four of their training). All students produce a “legacy product” based on their YIP-mentored research, frequently a published, first-authored publication to graduate with the “MD with Distinction” designation on their diplomas. After completing our year of didactic courses and mentored research, they return to finish their health professions degree in a fifth year, completing the required Master’s courses and training during this final year.

Although only eight to ten predoctoral students are directly supported by the CTSI TL1 grant, the YIP program infrastructure supports the didactic training, works-in-progress (WIP) sessions, and mentoring of a cohort of up to 20 predoctoral students annually. Each year, the four professional schools at UCSF provide YIP Faculty leaders with a list of students doing yearlong research at UCSF. (In the past this has included, Doris Duke Clinical Research and Howard Hughes fellows, as well as mentor-funded or unfunded students.) Once these students express interest in participating as external scholars, they must commit to attending all the YIP sessions. This demonstrates our role in supporting the future of scientific research beyond our TL1-funded scholars to *all* students and schools at UCSF, regardless of funding source.

Vignette: A YIP Student's Mentored Project was a Pathway to Faculty Appointment. *Dr. Allison Webel entered the YIP while a predoctoral nursing student at UCSF. She worked under the mentorship of Dr. William Holzemer, Professor of Nursing, to investigate strategies to improve symptom management in adults living with HIV. This collaboration resulted in 5 publications, and Dr. Webel was awarded a KL2 grant. Dr. Webel is currently an Associate Professor of Nursing at Case Western Reserve where her research focuses on understanding how to help adults living with HIV age well. She has published over 85 peer-reviewed manuscripts and multiple engaging lay articles (in the Huffington Post, San Francisco Chronicle, PRI, and others). Dr. Webel says, "The strong foundation for interdisciplinary work developed during my YIP predoctoral training was pivotal in helping me advance this important research program that is currently supported by a multisite R01 from NINR, a U01 from NHLBI, and several foundation and industry grants."*

Achievements. Since 2016, the YIP has trained a total of 62 students, including 40 TL1-funded predoctoral students. Of the total number of YIP students, 28 (45%) are women and 26 (42%) are underrepresented in medicine (URM) individuals. Since 2006, our grant-funded YIP alumni have published 229 manuscripts since completing the program. Outcomes for YIP are impressive (**Data Table 8**), demonstrating that early research training provides an excellent return on investment. We track outcomes for all graduates, including number of publications, H-index, and ability to match in highly competitive residency training programs across the US.

For YIP graduates who have been out of the program for more than five years and have completed residencies and clinical fellowships, we also track academic positions, proportion performing clinical and translational research, and proportion obtaining grant funding (**Table J1; Data Table 5**). Our most recent YIP graduate survey (2017) from all four UCSF health profession schools demonstrates that for graduates who completed the program more than five years ago, 81% now occupy academic positions and 62% have been awarded at least one research grant. A high proportion of YIP graduates reported that the program was a "very worthwhile experience" and that the YIP increased the likelihood that research would be a substantial part of their career. For graduates who completed the program within the past five years, there was similar impact and productivity.

Table J1. Outcomes for YIP Predoctoral Students (Short-term and Long-term) from all UCSF Schools

Post-Program Assessment	Students <5 years after YIP (N=17)	Students >5 years after YIP (N=26)*
Occupy academic position	NA	81%
Have had 1 or more research grant	NA	62%
N publications related to YIP project	34	98
N publications overall	85	346
YIP increased likelihood that research would be a substantial part of career	93%	100%
YIP program was a worthwhile experience	94%	100%
**Excludes those who are currently residents or clinical fellows*		

In addition to the alumni survey from all four UCSF schools reported above, we conducted a retrospective cohort study of 1,626 graduates from just the SOM between 2008-2019. We compared outcomes in students who had no research experience during medical school (controls) with those who had limited research experience (just a summer or an elective) and with those who participated in YIP, with its substantial mentored experience (**Table J2**). Across all metrics, YIP alumni from the SOM had more publications and achieved a higher H-Index. For those > 5 years from med school graduation, YIP alumni were more likely to be employed in academic medicine (OR 4.0, 95% C.I. 2.2-7.3, p<0.001).

Table J2. Outcomes for YIP Students Compared with Students with Less Research Training (UCSF SOM only)

Time since medical school graduation	Research training exposure	Publications during medical school	Publications after medical school	Total number of Publications	H-index	Employed in academic medicine
>5 years (N=827)	None	1.6	5.0	6.1	2.5	41%
	Limited	1.5	6.1	7.6	2.8	45%
	YIP	3.1	9.0	12.1	4.7	74%
≤5 years (N=799)	None	2.8	1.2	4.0	2.0	N/A
	Limited	3.2	1.3	4.4	2.2	N/A
	YIP	5.8	3.6	9.3	3.7	N/A

Vignette: A YIP student finds his path with mentorship. Dr. Lennox Byer is the first person in his family to pursue a career in medicine. As an undergraduate at Wesleyan University, he sought research mentors in the behavioral sciences, but struggled to find a role model for integrating a clinical career with clinical research. As a first-year UCSF medical student, he met Dr. Sabine Mueller (former K Scholar), Associate Professor in Pediatric Neurology, with whom he worked during the summer before the second year of medical school producing a publication.[3] Dr. Mueller encouraged Lennox to apply to YIP to obtain additional training in clinical research. During the YIP, he completed the Advanced Training in Clinical Research (ATCR) certificate and a mentored project to show the interconnectedness of genetic predisposition, cerebral microbleeds, and neurocognitive function in survivors of pediatric brain tumors. His work in YIP contributed to multiple conference presentations and another publication.[4] Now a resident in Neurology at UCSF, Dr. Byer plans to continue his training in clinical research and has additional UCSF mentors who model the role of academic clinician-researcher.

A.4. History and achievements of the TL1 postdoctoral program and development of its new focus.

History. In 2016, we began a TL1 postdoctoral program with the goal of providing one year of clinical research training and career mentorship to early translational postdoctoral fellows. This program included both MD and PhD clinical and translational junior scientists who received one year of support for a mentored project, the opportunity to take additional clinical research and biostatistics courses, bimonthly faculty-led career development seminars, and fellow-led WIP sessions. We developed this program in response to a need at UCSF to better bridge CTSI to the basic science faculty and to serve the needs of early translational postdoctoral scholars trained in the basic sciences by enhancing their translational skills.

Achievements. During the current grant period, we appointed approximately 10 postdoctoral fellows per year, with some electing to continue for a second year. To date, we have trained a total of 36 fellows, including 23 (64%) women and 5 (14%) URM individuals; all 36 (100%) have completed the program. Our alumni have obtained nine NIH grants and published 496 papers in total. **Table J3** and **Data Tables 5 and 8** present outcomes for the Program's 36 alumni, with 83% employed in academic positions. **Data Tables 6 and 7** show the applicant and accepted student/fellow characteristics in the current grant period.

Table J3. Outcomes for TL1 Postdoctoral Fellows, 2016-2019 (N=36)

Outcome	
Occupy academic position	30 (83%)
Devote 40% or more time to research	35 (97%)
Have received 1 or more research grants	9 (25%)
N publications related to TL1 project	12
N publications overall	496
N publications since completing the TL1 fellowship	226
Reported "I would recommend the program to other trainees"	34 (94%)

Change in focus from translational science to clinical research informatics. Based on the success of our TL1 postdoctoral program, UCSF has recently developed several new programs that provide training and career development support for early-to-late translational fellows, including the new Chan-Zuckerberg Biohub Physician-Scientist Fellowship program, the Pre-independent Bench Scientist group, and the Department of Medicine PRE-Proposal Application REview (PREPARE) grant writing assistance program. We have also recognized an increasingly compelling need for postdoctoral training in clinical research informatics. To optimize synergy and collaboration with the CTSI core infrastructure and the KL2/K Scholars Program, address the growing need for training in clinical research informatics, and comply with new NCATS budgetary constraints, we now propose a more intensive and focused postdoctoral training program in clinical research informatics.

A.5. Rationale and background for new Clinical Research Informatics Postdoctoral (CRISP) Program.

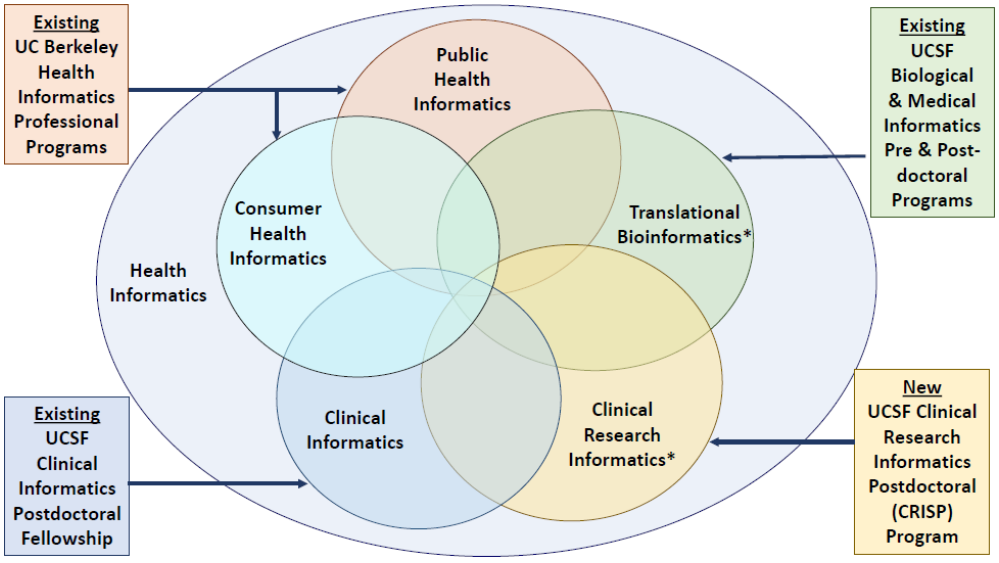
Just as Nathan and Varmus anticipated a shortage of clinical researchers two decades ago,[2] healthcare is now confronting an urgent unmet need for a skilled workforce in health informatics. Within health informatics, the emerging field of **clinical research informatics** provides the opportunity to innovate, inform, improve, and evaluate quality-based processes, new technologies, data standards, EHR implementation, and other key informatics-related efforts in healthcare. According to the American Medical Informatics Association, clinical research informatics is one of the five core domains of health informatics that are required for information and knowledge management across all of biomedical research, clinical care, and public health **(Table J4)**. Scientists working in clinical research informatics (*informaticians*) develop, apply, and evaluate new methods for data standardization, interoperability, machine learning, natural language processing, decision support, and EHR-based data analytics. Their work is inherently interdisciplinary, drawing on (and contributing to) many other component fields, including computer science, decision science, information science, management science, cognitive science, implementation science, and organizational theory.

Table J4. American Medical Informatics Association Health Informatics Core Domains

Informatics Domains	American Medical Informatics Association Definition [5]
Public Health Informatics	Focused on application of informatics to areas of public health, including population health, surveillance, prevention, preparedness, and health promotion.
Consumer Health Informatics	Focused on information structures and processes that empower consumers to manage their own health (e.g., health information literacy, consumer-friendly language, accessibility of personal health records, and Internet-based tools and resources for patients).
Translational Bioinformatics*	Focused on application of data storage, analytic, and interpretive methods to optimize the transformation of voluminous biomedical and genomic data into proactive, predictive, preventive, and participatory health.
Clinical (including medical, nursing, pharmacy, and dental) Informatics	Focused on application of informatics and information technology to the delivery of health care services. Concerned with information use in health care by clinicians (e.g., clinical decision support, visual imaging, clinical documentation, order entry, EHR implementation).[6]
Clinical Research Informatics*	Focused on the use of informatics in the discovery and management of new knowledge relating to health and disease. This includes management of information related to clinical trials and secondary research use of clinical data.
*Clinical research informatics and translational bioinformatics are the primary informatics domains supporting translational research.	

Currently, UCSF offers robust training in all of the above areas *except for* clinical research informatics (Figure J2).

Figure J2. UC Programs Addressing the Core Domains of Health Informatics.



Translational bioinformatics at UCSF. The UCSF Graduate Division hosts existing state-of-the-art pre- and postdoctoral training programs, funded in part by a T32 (in its 18th year) from the National Institute for General Medical Sciences. This "Biological & Medical Informatics Graduate Program" provides a robust bioinformatics curriculum pathway, with an optional emphasis in computational biology, that prepares PhD scientists to use tools from mathematics to physics and from chemistry to biology to gather, store, analyze, predict, and disseminate information about biology, with application to quantitative genetics and genomics. Without quantitative analysis of the massive and growing amounts of biological data, genomics, proteomics, and metabolomics, scientific progress cannot be made. Thus, this T32 program focuses on training **non-clinical PhD scientists** who can serve as leaders in research at the interface between computation and biology.

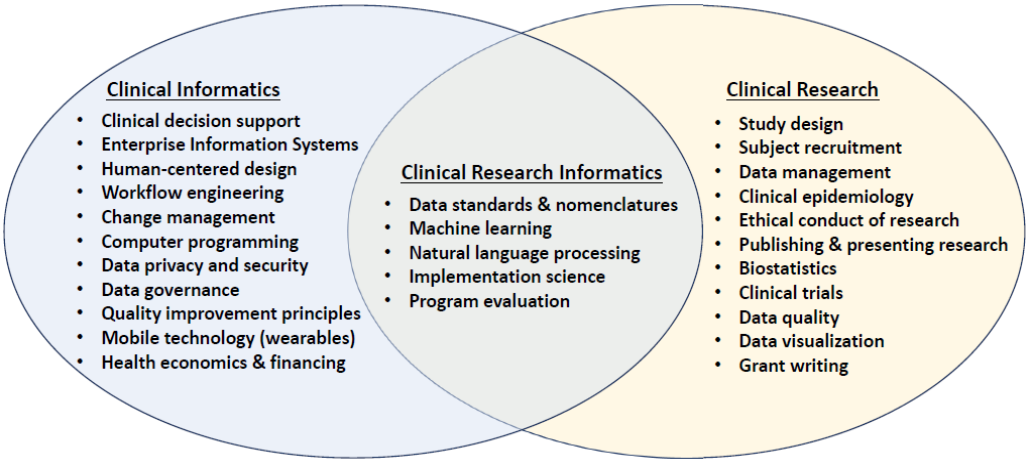
Clinical informatics at UCSF. As a leading health sciences campus, UCSF is keenly aware of the critical importance of clinical informatics in support of its tri-part mission (clinical care, education, and discovery). Clinical informatics is the application of computer and information science principles to healthcare delivery. Given the exploding demand for such expertise, few medical specialties have seen their domains change as rapidly as clinical informatics during the past decade. Within its first seven years, the clinical informatics field advanced from formal recognition (2011) to having 26 accredited clinical fellowship programs.

In 2016, UCSF received accreditation from the Accreditation Council for Graduate Medical Education (ACGME) to establish a new fellowship in Clinical Informatics. Clinical Informatics fellows develop proficiency in programming fundamentals, clinical decision science, application of artificial intelligence-based analytics, data and database structures, IT infrastructure, risk mitigation for health care, standards for data exchange, privacy, and security. Additionally, they develop skills in quality improvement methodology, negotiation, organizational leadership, and change management. Subspecialty board certification in Clinical Informatics is awarded (by the American Board of Preventive Medicine or the American Board of Pathology) based on

practical and examination-based mastery of these competencies. However, certification is currently limited to physicians who are board-eligible in Anesthesiology, Emergency Medicine, Family Medicine, Internal Medicine, Medical Genetics, Radiology, Pathology, Pediatrics, or Preventive Medicine.

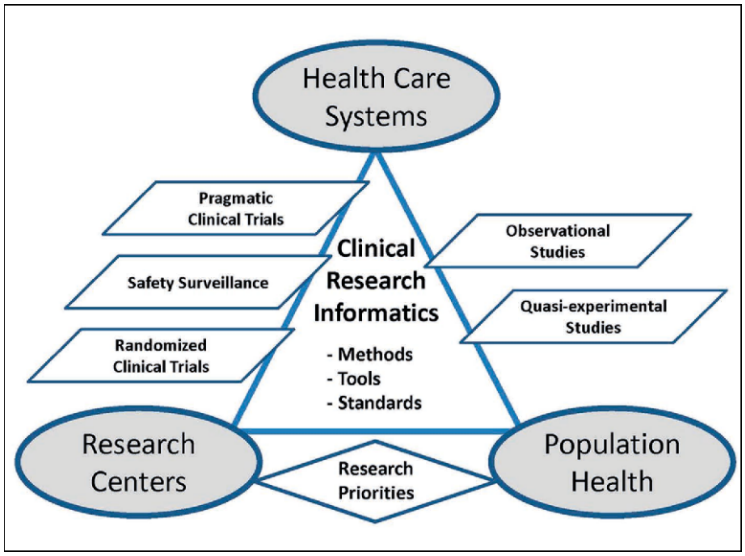
What remains conspicuously absent from the curricular offerings at UCSF is a training program in clinical research informatics (**Figure J3**). **To address this critical gap, we propose to establish the Clinical Research Informatics Postdoctoral (CRISP) Program to train postdoctoral clinician investigators who seek to advance the science of clinical research informatics, and in doing so, improve the efficiency and effectiveness of health care.** As the NIH's 2018 Strategic Plan declares: *NIH considers it essential to equip the biomedical research workforce with the tools to enhance data science understanding and expertise*. Existing technological capabilities continue to far outstrip our ability to organize and harness them into effective solutions, and many informatics interventions (such as clinical decision support tools) are rolled out without any evidence that they improve care. With increasing digitization of data entering health care organizations from an expanding number of sources, skills in the management of big data and application of data analytics are absolutely essential to ensuring the effective and efficient functioning of health care organizations.[7,8] Knowledge of clinical research informatics is critical for the rigorous application of data standards to nomenclatures, ontologies, documentation, storage, and interoperability.

Figure J3. Clinical research informatics combines the practice of clinical informatics with the rigor of clinical research and draws on expertise in both areas



The field of clinical research informatics, first described in 2007,[10] can be defined simply as the intersection of clinical research and clinical informatics.[11] Clinical research informatics focuses on developing new methods, theories, tools, and solutions to accelerate progress across the full translational continuum: basic research to clinical trials (T1), clinical trials to academic health center practice (T2), diffusion and implementation to community practice (T3), and 'real world' outcomes (T4).[12] Embi[13] has specifically categorized clinical research informatics activities into six domains: (1) data and knowledge management, discovery, and standards; (2) using EHR and insurance claims data for research; (3) researcher support and resources; (4) participant recruitment; (5) patient and consumer interfaces; and (6) policy, regulatory and fiscal matters. **Figure J4** illustrates a conceptual framework for the field.

Figure J4. Clinical research informatics applies rigorous research methods to population health and healthcare systems[9]



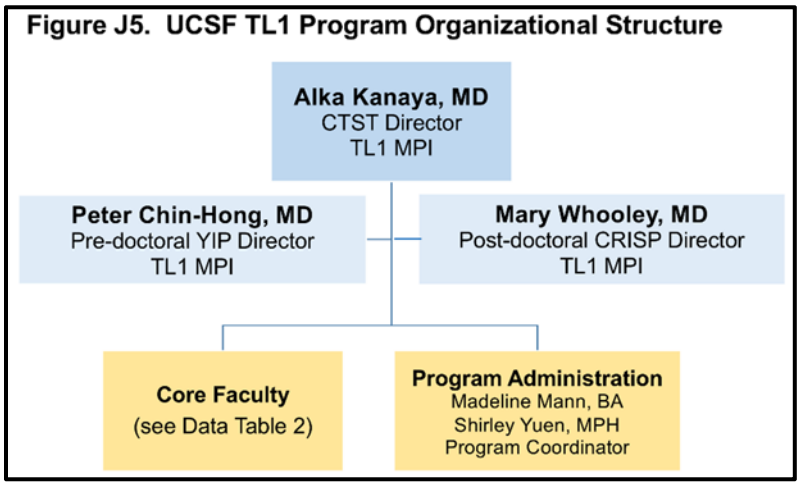
Clinical research informatics investigators often work in academic environments where they, like other biomedical researchers, pursue scientific projects while also teaching and, in some cases, practicing in one of the health professions. The presence of embedded clinicians who can develop and rigorously evaluate effective interventions and implement changes that improve the quality of health care is a key component of Learning Healthcare systems. Such faculty members can serve as mentors in graduate training programs that lead to Master's or doctoral degrees where students carry out research projects alongside their clinical training.

B. PROGRAM PLAN

B.1. Program Administration.

B.1.a. Leadership

TL1 Program Structure and Multiple Principal Investigators (MPI)s.
The TL1 will be led by **Drs. Peter Chin-Hong, Mary Whooley, and Alka Kanaya** (**Figure J5**).



Dr. Chin-Hong is a Professor of Medicine and has served as Associate Director of the YIP Program since 2006, and as Program Director/MPI since 2016. Dr. Chin-Hong specializes in infectious disease and his research focuses on donor-derived infections in transplant recipients and molecular diagnostics of infectious diseases in patients with suppressed immune systems. Dr. Chin-Hong is a medical education leader at UCSF. He was the inaugural holder of the Academy Endowed Chair for Innovation in Teaching. He was elected to Alpha Omega Alpha by the UCSF medical students and has received several teaching awards, including the UCSF Henry J. Kaiser Award for Excellence in Teaching in 2009, Essential Core teaching awards from the classes of 2009, 2011, 2013, and 2014, and a Bridges Curriculum Foundations teaching award for the class of 2020. Dr. Chin-Hong will provide leadership and direction for the predoctoral program, give guidance and attend educational meetings, supervise student selection, evaluation, and follow-up, oversee the YIP Core Mentor Faculty (**Data Table 2**), and ensure that the YIP program aligns with the goals of CTSI and NCATS.

Dr. Whooley is a Professor of Medicine; she will serve as the inaugural Program Director of the postdoctoral CRISP program and will be a TL1 MPI. She is a practicing primary care physician, with board certification in clinical informatics, who directs the Center for Healthcare Improvement and Medical Effectiveness at the SFVA Health Care System and UCSF. Her work focuses on applying health services research methods (including data science, implementation science, and program evaluation) to accelerate the adoption of evidence-based therapies into practice. Dr. Whooley was the UCSF site PI for the PCORnet®-funded Patient-Oriented Scalable Network for Effectiveness Research and currently serves as the SFVA site PI for the Million Veteran Program. She has mentored numerous junior investigators (primary mentor for five K awardees) and received mentorship awards from the UCSF Department of Medicine (2006), the San Francisco Bay Area Clinical Research Symposium (2009), the UCSF Department of Epidemiology & Biostatistics (2015), and the Academy of Consultation Liaison Psychiatry (2018). Importantly, Dr. Whooley currently serves as SFVA site director for the UCSF Clinical Informatics Fellowship and, in this capacity, is already involved in curriculum planning and training. Dr. Whooley will provide leadership and direction for the CRISP program, attend CTSA educational meetings, supervise fellow selection, manage WIP sessions, conduct evaluation of fellows, oversee the CRISP Program Core Mentor Faculty (**Data Table 2**), and ensure that the CRISP aligns with the goals of CTSI and NCATS.

Dr. Kanaya is the CTSI's Clinical and Translational Science Training (CTST) Director and will serve as TL1 MPI. Together with Drs. Chin-Hong and Whooley, she will chart the strategic direction of the TL1 programs. As the Director of CTSI training programs, she will ensure integration of the TL1 programs with the other CTSI training components to promote smooth coordination among all CTST training activities, including the K Scholars Program, and the Training in Clinical Research (TICR) didactic programs (**Figure J1**). Dr. Kanaya has been at UCSF since 1990, developed and led the K Grant Writer's Workshop (2010-2017), and was Director of the CTSI consultation services program (**Core E**) (2014-2019). She is an internationally recognized expert in diabetes and cardiovascular epidemiology, with continuous NIH funding since 2006, including K23, R21, R01, and K24 awards. With K24 and CTST experience, she has devoted significant effort to mentoring learners at all levels on clinical research methods, scientific writing, and career development. Dr. Kanaya is a member of the CTSI Senior Leadership Group and will ensure close coordination with all CTSI activities. She will be the NIH administrative contact for the TL1 programs.

Succession plan. In the event that one of the TL1 Program Directors steps down or becomes unable to sustain his/her responsibilities, a search for a qualified candidate will be undertaken with the oversight from the CTST

Director and the TL1 Executive Committee (**Table J5**). The CTST Director will assume responsibility of that Director's TL1 program until a replacement is identified.

Administrative leadership. Ms. Madeline Mann will continue to be the Program Manager for both the YIP and CRISP programs. She will work directly with TL1 leadership to plan and execute program activities, assist in budgeting, oversee program evaluation and tracking, and manage the preparation of the NIH progress reports and continuation applications. She will supervise a program coordinator who will help with student/fellow recruitment, selection, logistics for each group session, evaluation, and follow-up. Ms. Shirley Yuen will continue to be the Financial Analyst for the TL1 programs.

B.1.b. Integration with CTSI and the Clinical and Translational Science Training (CTST) Program. The TL1 grant funds two of the seven CTSI-funded integrated training programs, which are supervised by Dr. Kanaya. **Figure J1** displays the seven programs by learner level, including the 2 TL1 programs, the K Scholars program (KL2 grant), and four other training programs for undergraduates, residents, postdoctoral fellows, and junior faculty that are supported by the U54 CTSA grant (**Core D Translational Workforce Development**) and UCSF. Each of these training programs draws on the educational offerings of the Department of Epidemiology & Biostatistics Training in Clinical Research (TICR), which includes 40 accredited courses ranging from a summer Clinical Research Workshop (4 courses), a 1-year Advanced Training in Clinical Research Certificate program, and a 2-year Master's in Clinical Research (MAS). Dr. Kanaya chairs the CTST Steering Committee, composed of all the CTST Program Directors, which meets quarterly, as well as a monthly meeting of the KL2 and TL1 program directors. This organizational structure ensures that Program Directors are aware of and contribute to all CTST activities, and fosters synergy, collaboration, and cross-cutting endeavors across all educational and training programs. Dr. Kanaya reports to the CTSI MPIs, Drs. Bibbins-Domingo, Collard, and Criswell and serves on the CTSI Senior Leadership Group. The TL1 program is directly accountable to the CTSI and fully integrated into CTSI programs and activities. CTSI leadership reviews all CTST program goals, milestones, and budgets semi-annually and provides guidance on program direction.

B.2. Oversight of the TL1 Program. An Executive Committee (EC) chaired by CTSI MPI Hal Collard, MD will advise Drs. Kanaya, Chin-Hong, and Whooley in oversight of the TL1 programs. The EC consists of a group of senior academic faculty, highly committed and experienced with research training at UCSF (**Table J5**). Each was chosen to reflect a key element of the program, including clinical research informatics, quality of science, mentoring, applicant and faculty diversity, and representation from diverse healthcare disciplines. The EC will be responsible for advice on the overall direction of the program; final approval of the applicants chosen for training; annual budgets; proposed changes to the program; changes in the Core Faculty for each program (**Data Table 2**); and evaluation of TL1 students, fellows, faculty, and leadership.

Table J5. TL1 Executive Committee

Name	Position	Department
Alka Kanaya, MD	CTST Director, MPI TL1 Program	Medicine & Epidemiology/Biostatistics
Peter Chin-Hong, MD	YIP Director, MPI TL1 Program	Medicine
Mary Whooley, MD	CRISP Director, MPI TL1 Program	Medicine & Epidemiology/Biostatistics
Harold Collard, MD (Chair)	MPI UCSF CTSI, Associate Vice Chancellor for Clinical Research	Medicine
Kirsten Bibbins-Domingo, MD, PhD	MPI UCSF CTSI, Chair of Epidemiology & Biostatistics	Epidemiology/Biostatistics & Medicine
Atul Butte, MD	Director, Bakar Computational Health Sciences Institute, Chief Data Scientist UCSF	Pediatrics, Bioengineering & Therapeutic Science, Epidemiology/Biostatistics
Catherine Lucey, MD	Vice Dean for Education	Medicine
Renee Navarro, MD	Vice Chancellor, Diversity and Outreach	Anesthesiology

B.3. Program Core Faculty. The Program Core Faculty (**Table J6**) will be responsible for directing the YIP and CRISP Programs, selecting the students and fellows, providing career mentorship to the students/fellows, facilitating faculty-led seminars for their respective programs, and conducting student/fellow evaluations. In addition to the TL1 leadership (MPI Kanaya, Chin-Hong, Whooley), Dr. Hannah Glass is Associate Director of the YIP program, and will help with student selection, seminar facilitation, career mentorship, and evaluation.

Table J6. TL1 Programs Core Faculty

Faculty	Expertise
Alka Kanaya, MD	Diabetes and cardiovascular disease epidemiology and clinical behavioral trials
Peter Chin-Hong, MD	Infectious disease in transplant and immunocompromised populations, molecular diagnostics
Mary Whooley, MD	Health behaviors and cardiovascular outcomes research; use of EHR data to improve health
Hannah Glass, MD	Neonatal seizures and strokes and brain injury after pre-term birth

B.4. Didactic Courses Required for both YIP Predoctoral Students and CRISP Postdoctoral Fellows. All YIP students and CRISP fellows will take CTSI's Training in Clinical Research (TICR) summer Clinical Research Workshop (four courses) plus the 1-year ATCR or 2-year Master's degree in Clinical Research.

The TICR Program. The TICR Program was established in 1999 with a NIH K30 Clinical Research Curriculum Award to provide high quality and comprehensive research training to investigators who are focused on human subjects research. Instruction is provided across the spectrum of research methods including clinical research design, biostatistics, experimental design for interventions, genetic/molecular epidemiology, data science, decision and cost-effectiveness analysis, qualitative research, scientific communication, and implementation science. TICR is directed by Dr. Jeffrey Martin, Professor of Epidemiology & Biostatistics and Medicine and administratively housed in the Department of Epidemiology & Biostatistics. The program is guided by policies from the UCSF Graduate Division, informed by an internal advisory committee, and accredited by the Western Association of Schools and Colleges. TICR is comprised of three major educational programs (**Clinical Research Workshop, ATCR, and Master's of Clinical Research**) that provide a progressively greater depth of education depending on the needs of the learner (**Table J7**).

Table J7. TICR Program's Three Major Educational Programs

Clinical Research Workshop (CRW)
- Eight weeks (summer quarter)
- Didactic: 4 courses (6 units)
- ➢ **Deliverable:** clinical research protocol

Advanced Training in Clinical Research Certificate (ATCR)
- 1 year (4 quarters, including CRW)
- Didactic: 15 courses (27 units)
- Mentoring: one or more home unit mentors
- ➢ **Deliverables:**
- Implementation of a clinical research project
- Analysis and presentation of data

Master's Degree in Clinical Research
- Two years (7 quarters, including CRW)
- Didactic: 17 required courses plus electives (36 units)
- Mentoring: 3-member Master's Committee
- Tracks: Implementation Science *or* Data Science
- ➢ **Deliverables:**
- ▪ Comprehensive literature review
- ▪ Present research findings at a national meeting
- ▪ Submission of a first-authored peer-reviewed paper
- ▪ Instructional experience in clinical research methods

Clinical Research Workshop (CRW). The CRW consists of four courses (six units) over eight weeks during the summer and is the starting point for all clinical research training at UCSF; it is the prerequisite for the more intensive ATCR Certificate (**Table J8**) and Master's in Clinical Research degree programs. The objectives of the CRW are to understand the principles of clinical research; to plan a clinical research study; to recognize and resolve ethical dilemmas in clinical research; to understand data management; and to learn to use statistical computing tools. The CRW provides methodological instruction with a focus on hands-on application. Each course features weekly small group interactions between students and faculty where student-generated projects (e.g., NIH-style research protocol, PHS 398 Human Subjects Section) are progressively assembled. Rigor and reproducibility are emphasized in the study design, statistical methods, and ethical conduct of projects.

Table J8. ATCR Certificate Program Courses

Year 1: Summer (Clinical Research Workshop)
Designing Clinical Research (EPI 202)
Responsible Conduct of Research (EPI 201)
Introduction to Statistical Computing (BIOSTAT 212)
Database Management Systems (EPI 218)
Year 1: Fall
Epidemiologic Methods (EPI 203)
Clinical Epidemiology (EPI 204)
Biostatistical Methods for Clinical Research I (BIOSTAT 200)
ATCR Seminar (EPI 230) *or* Master's Seminar (EPI 220)
Year 1: Winter
Clinical Trials (EPI 205)
Biostatistical Methods for Clinical Research II (BIOSTAT 208)
ATCR Seminar (EPI 230) *or* Master's Seminar (EPI 220)
Year 1: Spring
Systematic Reviews/Meta-Analysis (EPI 214)
Biostatistical Methods for Clinical Research III (BIOSTAT 209)
Publishing and Presenting Clinical Research (EPI 212)
ATCR Seminar (EPI 230) *or* Master's Seminar (EPI 220)

Advanced Training in Clinical Research (ATCR) Certificate Program. ATCR is a 4-quarter program for trainees who desire rigorous training in the methods of clinical research. The first quarter (summer) consists of the Clinical Research Workshop, and the fall, winter, and spring quarters provide in-depth methodologic instruction and an opportunity for students to conduct mentored research. Fifteen required courses (27 units) are combined with multiple optional elective courses that can be taken during a second year (**Table J8**). The philosophy is to ground students in the principles of clinical research methods and biostatistics and to expose them to areas such as database management and methods. The objectives of ATCR are to learn the methods required to perform both observational and experimental clinical research; to plan and implement one or more clinical research projects; and to analyze, interpret, and present a set of clinical research data. Presentation of research findings is typically

based on the protocol that students developed in CRW's "Designing Clinical Research." If that project involves primary data collection that cannot be completed in one year, students are expected to pursue a project that involves secondary analysis of previously collected data or published data. Learners present their final work in the spring "Biostatistical Methods in Clinical Research III" course.

Master's in Clinical Research. The Master's is a 2-year course of study intended for scholars who wish to master clinical research methods and pursue clinical research careers. For YIP students, the second year of the Master's program will be compressed into two quarters during the fifth year of school so that both degrees (e.g., MD and Master's) can be completed in five years (four years professional school plus the YIP).

Table J9. Advanced Courses in Data Science and Clinical Research Informatics.

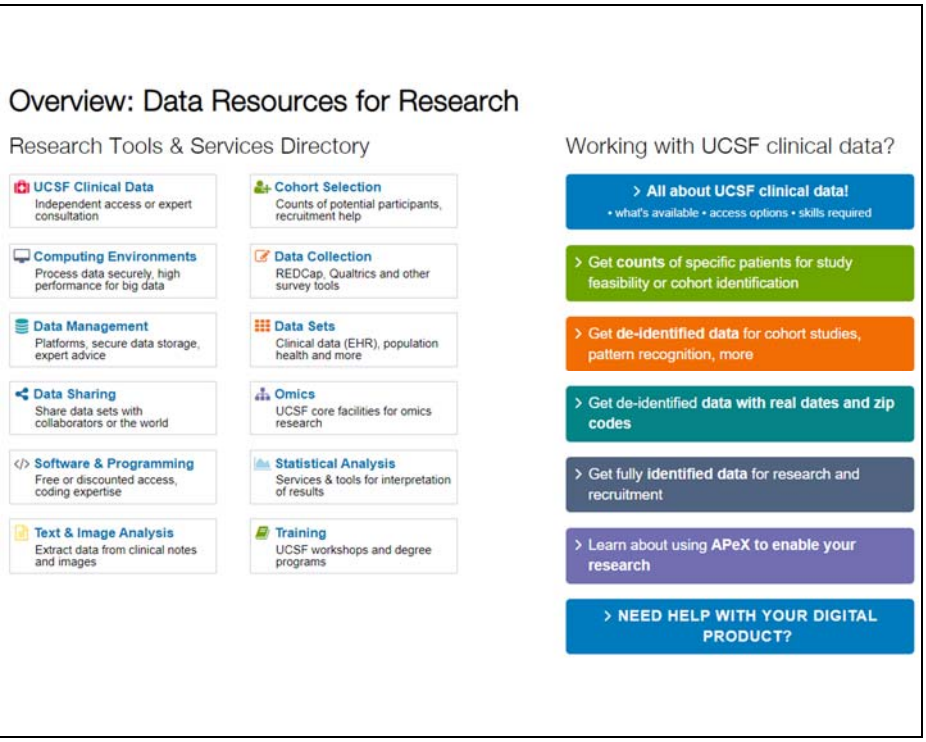
Electives in Data Science	Electives in Clinical Informatics
Introduction to the Science of "Big Data" (BIOSTAT 202)	Introduction to Clinical Informatics (Proposed, Core I)
Biostatistical Methods for Clinical Research IV (BIOSTAT 210)	Working with Electronic Health Record Data (Proposed, Core I)
Introduction to Computing in R (BIOSTAT 213)	Program Evaluation in Clinical Settings (EPI 242)
Advanced R/Data Management (BIOSTAT 214)	Human-centered Design (EPI 243)
Advanced Observational Data Analysis (BIOSTAT 215)	Translating Evidence into Policy (EPI 249)
Machine Learning in R (BIOSTAT 216)	Econometric Methods for Causal Inference (EPI 268)

During the second year, Master's candidates interested in Data Science or Clinical Research Informatics will be able to choose from several existing and two proposed electives in Clinical Informatics that will be co-funded by CTSI (**Table J9**). Although UCSF has world-class researchers and mentors in these areas, our traditional health professional school curriculum has lacked formal instruction in their specific methodologies. Deliberate exposure to these areas has been consistently cited by trainees and faculty as a critical necessity for clinical research training. The Department of Epidemiology & Biostatistics (DEB) in conjunction with CTSI has already developed several courses in Data Science within the TICR program, including courses in computing in R and machine learning. Data Science already exists as an approved track within the Master's program. In addition, several new courses are under development in both Clinical Informatics and Data Science to round out the curriculum and develop core competencies in these disciplines. **Core B** is partnering with the KL2 Program (**Core I**) to support the creation of two new Clinical Research Informatics courses: Introduction to Clinical Informatics and Working with EHR Data. These efforts will be expanded to include a partner program in Clinical Research Informatics.

For YIP students and CRISP fellows who wish to obtain exposure to some of these topics without committing to an entire course, the UCSF Library offers brief workshops and hands-on-coaching in several topics (**Box**).

Box. Data Science Workshops Offered by UCSF Library (2 to 4 times/year) and Data Resources

- Basic Statistics with R (4 hours)
- Data Acquisition with JSON & Python (2 hours)
- Data Cleaning with OpenRefine (1.5 hours)
- Intro to SQL (3 hours)
- Data Analysis with SQL and Python (2 hours)
- Introduction to Machine Learning (3 hours)
- Introduction to Python, Part 1 (3 hours)
- Introduction to Python, Part 2 (3 hours)
- Introduction to R Programming (4 hours)
- Writing R Packages (3 hours)
- Secure Research Data Management (1.5 hours)
- Records and Information Management (1.5 hours)
- Introduction to Unix (3 hours)
- DNA Variant Analysis with R Bioconductor (3 hours)
- RNA-Seq Analysis with R Bioconductor (3 hours)
- Genomic Annotations with R Bioconductor (3 hours)



B.5. Expansion and Enhancement of the Yearlong Inquiry Program for Predoctoral Students.

Aim J1. Expand and enhance the predoctoral Yearlong Inquiry Program (YIP), enrolling and training up to 11 students per year.

J1.1. Mentor and support a diverse group of health professional students to complete a Master's degree in clinical research and a research project and acquire life-long research career development skills.

B.5.a. Integration of YIP into new health professional schools' curricula. Our goal is for all of YIP students to complete one year of training, leading to completion of the Master's in Clinical Research by year five of their professional school course of study.

Inquiry curricula in the four UCSF health professions schools. Most predoctoral students who are selected to participate in YIP will come from the SOM. Historically this has occurred because the SOM has always promoted taking an additional year off ("gap year") during which their students undertake a variety of inquiry-related activities. Inquiry-based pedagogic philosophy is designed to help students recognize the limits of current knowledge and develop an appreciation for methods of discovery in a diverse set of scientific disciplines such as biomedical science, clinical science, and epidemiology and population science. We expect even more SOM students to apply in the new proposed period because the SOM was the first of the four health profession schools to facilitate a seamless incorporation of YIP training into the new SOM BRIDGES curriculum, which has a substantial focus on inquiry (see below). The UCSF School of Pharmacy has just initiated its new curriculum (starting 2019) and has explicitly integrated inquiry skills throughout, with interprofessional inquiry learning alongside medical students in calendar-aligned "Inquiry immersion" blocks. Prior to graduation, all Pharmacy students participate in a mentored "Discovery Project." The School of Dentistry offers inquiry experiences to many of its dental students through the John C. Greene Society, which is a school-based dental research organization that enrolls about one-third of the class and promotes inquiry related activities. The School of Nursing is a graduate degree only school, with robust PhD programs that traditionally participate in YIP. Like the SOM BRIDGES curriculum, we expect that curricular reform in the other schools will permit more choice and flexibility in integrating additional coursework in research methods, and the YIP will continue to welcome applicants from all schools.

The SOM BRIDGES curriculum. This recently introduced curriculum enables medical students to work within complex systems to improve health care and advance science for future generations of patients (see Letter of Support, UCSF Vice Dean for Education, Dr. Catherine Lucey). BRIDGES has two primary curricular strategies: 1) early longitudinal immersion in clinical teams with a focus on continuously improving care delivery, and 2) directly pertinent to this TL1 grant proposal, an inquiry-focused curriculum that emphasizes asking questions that push the frontiers of science and understanding of human health and disease. The inquiry element is embedded in the entire curriculum through weekly small groups, immersion blocks for skill building, and a scholarly project. Overall, the BRIDGES curriculum gives all students an introduction to and dedicated time for scholarly projects in one of the core domains of science and opportunities to customize the educational experience to address individual career goals.

Integration of YIP with BRIDGES. The YIP will be completely integrated into the activities and resources provided by the SOM BRIDGES curriculum. The YIP will benefit greatly from the medical school inquiry infrastructure and resources in the following ways: 1) Inquiry and research advising from the first year of medical school; the Bridges Inquiry Advisors will help students identify an area in which they wish to work and help them find a mentor and project in that area. Inquiry Advisors will give students preliminary feedback on the project idea, identify students who may be interested in applying for the YIP, and continue advising beyond the YIP year as needed, providing continuity with the YIP mentorship team; 2) Inquiry curriculum; all students will participate in introductory research-focused didactics, skill-building experiences, and interprofessional mini-course electives offered by preeminent UCSF faculty. Through this component, students experience the breadth of biomedical science, continue to refine skills in inquiry, connect to a community of practice, and begin forging their independent scholarship even before applying to the YIP; 3) "Deep Explore" time in the last year of medical school provides students with more protected time for ongoing research from the YIP year.

Growth of students seeking a MAS degree in YIP. We have worked with leaders of the SOM BRIDGES curriculum and TICR program to design a YIP path that allows students to achieve the MD and Master's (typically a 2-year program) in a total of five years (**Table J10**). The SOM initiated the BRIDGES program in 2016, and our current cohort of YIP students (2019-2020) was drawn from the first BRIDGES class, who will graduate in

2021. Since 2016, the YIP program has supported two students per year to graduate with a combined MD and Master's, with our first students graduating with the dual degrees in 2017. There were always many more interested students that sought to complete the dual degree curriculum, but we were historically capped to two students per year by the SOM. This was because it was challenging to fit both SOM and Master's curricula into five years and students required individual SOM administrative support to fit in all requirements. With the liberalization of curricular requirements in the BRIDGES curriculum in 2019, nine YIP students are currently conducting coursework toward the Master's degree, attesting to the demand by predoctoral students for the Master's. This provides the rationale for the Master's curricular focus in YIP. These nine YIP students will graduate with dual degrees in 2021, after completion of both the YIP year and the last year of medical school. The timing of the YIP in relation to the rest of the medical school curriculum is shown in **Table J10.** Please note that the TL1 funding will be continuous for only one year. When students complete their Master's degree during their MS-4 year, they will be supported by the health profession school tuition, which would be the same if they were only completing the MD degree.

Table J10. Timetable for Integrating Dual Degree Research Training into SOM Bridges Curriculum (MS= Medical School)

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
MS-1	Foundations 1 course	Foundations 1 course	Foundations 1 course	Research Introduction
MS-2	Foundations 1 course	Foundations 1 course	Foundations 2 courses (core clerkships)	Foundations 2 courses (core clerkships)
MS-3	Foundations 2 courses (core clerkships)	Foundations 2 courses (core clerkships)	Foundations 2 courses (core clerkships)	Career Launch (clinical focus)
	YIP	• **Master's degree courses** • **Begin mentored research project** • **Faculty seminars and student-led works-in-progress sessions**		
MS-4	Career Launch (clinical focus)	**Complete Master's and a Mentored Research Project**		Career Launch (clinical focus)

B.5.b. YIP Application and Recruitment, Eligibility and Selection. We propose to support 11 YIP predoctoral students per year, an increase of one student/year based on ongoing trends of demand for YIP and the subsequent Master's. There was a 50% increase in YIP applications from the class of 2019 (N=20, pre-BRIDGES) to the class of 2020 (N=30, first year of BRIDGES). We will support them to complete the Master's and their professional degree, in a 5-year track (**Table J10**)**.** We will explicitly recruit students from underrepresented minorities (**Section E**). Our goal is for YIP students to enter residency and postdoctoral fellowship with superb foundational training, positioning them to successfully compete for future mentored and independent research grants.

Recruitment. Because of the deliberate focus on Inquiry in the BRIDGES curriculum in the SOM, all students are made aware of YIP and the additional clinical research training available offered in the Department of Epidemiology & Biostatistics from the first day of medical school. Small group leaders during the SOM Inquiry Core Curriculum explicitly mention research opportunities available to students and the benefits of taking a year off to conduct mentored research. During Inquiry Immersion, YIP leaders, alumni, and Faculty serve on panels and present sessions to the entire class on mentorship and clinical and translational research careers. Most important for YIP recruitment is the robust system of inquiry in which each student is assigned to an Inquiry Advisor who meets with them starting in Year 1. These Inquiry Advisors demonstrate pathways to careers in clinical and translational research and describe YIP as a desirable option. In addition, Drs. Chin-Hong and YIP Core Faculty host an information session focused on research opportunities for professional students across all four UCSF professional schools for students more advanced in their health professions training. This meeting includes formal presentations by YIP leaders and former fellows. Students also learn about the program by word of mouth, and previous students serve as ambassadors for the program, which has been a very powerful recruiting tool. Through these and other efforts, YIP has always had many more applications from outstanding students than we can accommodate.

Eligibility. Prior to submission of the full YIP application, students are required to submit a letter of intent detailing their prior education and training, a brief description of their proposed research project, and identification of their lead mentor. The YIP Program Director and a representative from the SOM Inquiry Funding Office review these letters and either invite submission of a full application or advise the applicant that the project may not be suitable. Following submission and approval of the letter of intent, students are invited to apply, and work closely with the lead mentor to produce a NIH-style research proposal. In addition to submitting the research proposal, applicants are asked to submit a transcript of their professional school or other coursework performed to date, a personal statement describing their motivation to join the program, and a Dean's letter and letters of reference from two

teachers or mentors who know them well. Lead mentors are asked to submit their CV and a letter describing the role of the student in designing and describing the project, the mentorship plan for the student, resources that will be made available, and other members of the mentorship team.

To ensure that the applicant has identified a lead mentor who meets the rigorous requirements of the YIP, we ask the applicant to submit a letter of intent identifying the lead mentor before they proceed to development of a full application. The purpose of the letter of intent is to ensure that the student has identified an appropriate lead mentor who will create the right environment for future success of the student. If the YIP leaders have concerns about the experience of the proposed mentoring committee, they work with applicants to help them identify potential mentors. For School of Medicine applicants, YIP leaders also work closely with the students' assigned Inquiry Advisors (see BRIDGES Inquiry section above) to ensure that the correct mentor is selected by the student. The YIP application includes the designation of an approved lead mentor and at least one co-mentor (another subject matter or methodologic expert) and requires a letter of support from these mentors. Lead mentors are often a member of the Core Faculty (**Data Tables 2 and 4**), but other UCSF faculty may serve as mentors if they fulfill YIP mentorship qualifications.

Selection. Applicants to YIP from the SOM currently apply through the Inquiry Funding Office online application system. This very popular program centralizes applications for intramural funding from multiple sources. The Inquiry Funding Office recruits and creates a selection committee, made up of senior faculty with expertise in key research areas, which oversees the process. The YIP selection committee includes all YIP Faculty as well as additional faculty recruited from all schools at UCSF. Each application is assigned to two primary reviewers who provide preliminary scores using NIH procedures. Three components of the application are individually scored (research proposal, mentorship team, and student track record/career potential) with most of the weight assigned to the research proposal and the mentorship team. Each application is then discussed at the study section meetings, and the entire group scores all applications, similar to protocol at a NIH study section. The SOM Inquiry Funding Office has agreed to process and administer reviews for all applicants beginning in 2020, regardless of health professions school, and maintain an active interprofessional list of student proposal reviewers.

B.5.c. YIP Training Overview. All YIP students complete a program composed of seven elements: didactic clinical and translational research coursework supplemented by coursework individualized to each student as described above in **Section B.4**. Following are the other six elements: a mentored research project; student-led WIPs and monthly journal clubs; faculty presentations of research topics and skills development; participation in annual UCSF research meetings and the CTSI national research meeting; and an Individual Development Plan (**Table J11**).

Table J11. Training activities in the Yearlong Inquiry Program

1. Didactic courses for MAS (see **Section B.4**)
2. Mentored research project
3. Bi-weekly student-led WIPs and monthly journal club
4. Bi-weekly faculty presentations
5. Annual UCSF research meetings
6. Annual national research meetings
7. Individual Development Plan

Mentored research project**.** The research project forms the core of the predoctoral training activity. It is designed to provide a practicum experience and is performed under the supervision of the lead project mentor, other members of the mentoring team, including Faculty from the YIP leadership who act as career mentors. The NIH-style research program proposed in the YIP application forms the basis of the work that will be performed during the training. Disbursement of student stipends at the beginning of the year is contingent on receiving IRB approval. The amount of time spent on the project will vary during the year, depending on factors such as coursework load. The student's participation in the project is expected to justify first authorship on papers resulting from the work.

YIP program leaders have substantial experience working with students and lead mentors to help them design projects that meet the goals of being both sufficiently challenging and feasible. In end-of the-year surveys, >90% of our students indicate that their projects met these criteria and were completed on time; historically most students have multiple publications related to their YIP project by graduation. Progress on the project will be monitored through evaluations by the lead mentor, by one-on-one meetings with YIP leaders, and through evaluation of the student's WIP presentations.

WIPs and faculty-delivered research seminars. The foundation of the YIP is a core set of biweekly, 2-hour WIPs and faculty presentations. These face-to-face meetings promote the creation of a community of practice, which provides a supportive mentorship environment of peers and faculty, catalyzes networking and team science

skills, and introduces new curricular elements (see **Aim J1.2**.) with targeted faculty presentations and workshops. New faculty sessions will be devoted to data science and clinical research informatics. We will encourage YIP students to consider conducting secondary projects or integrating aspects of these new topics into their existing funded projects. Fortunately, we already have a large multidisciplinary pool of investigator-mentors who are experienced in clinical research informatics and data science research. YIP students will be further supported by targeted coaching in research publication and presentation skills essential for academic environment.

In the first hour, *two students present 30-minute WIP updates on their research projects*. At each WIP, one presentation is focused on patient-based research and the other on laboratory-based research. Over the course of the year, each student presents three times. The first presentation is focused on describing their project aims and hypotheses. The second is midway through the year and discusses progress and challenges. The third is toward the end of the year and is a summation progress report prior to their final poster presentation at the UCSF Annual Inquiry Symposium, and final podium presentation at the YIP Yearlong Inquiry Oral Colloquium. Collegial feedback is provided to each student on the quality of research and presentations. Structured peer feedback is also given (see Evaluation **Section C.2**).

The second hour is composed of *research seminars* and are attended by students, mentors, YIP Core Faculty, and guests and facilitate close cooperation among students, research faculty, and staff. Once a month, a student leads a journal club selecting a new publication in their area of interest that would have broad appeal. These invited presentation/seminars cover a wide variety of topics relevant to clinical and translational research, career choices, mentorship, and academic skills. Sessions are structured as active learning sessions with instructors and teaching assistants from the Department of Epidemiology & Biostatistics faculty, and faculty and staff from **Cores B and H**, and the **K Scholars Program**. Seminars are presented by YIP Program Leaders, Core Faculty, and others from all four health professions schools, as well as faculty and staff with expertise in the new areas of exposure (see **Aim J1.2**). YIP faculty-led sessions also focus on problem solving, communication, team science, time management, and leadership skills. Once a month, a student leads a journal club selecting a new publication in their area of interest that would have broad appeal. The students all prepare to discuss methodologic aspects, including rigor and reproducibility of the study and clinical implications.

Annual Research Meetings. There are three summative research conferences that all YIP students attend. The first is the Translational Science annual conference sponsored by the Association for Clinical and Translational Science (ACTS). Students typically present accepted papers in either a poster or podium presentation, as well as participate in networking and career exploration sessions built into the conference. The second is the UCSF Annual Inquiry Symposium that is co-funded by CTSI, where YIP students present posters of their research projects to the university community. The third event is the annual YIP Yearlong Inquiry Oral Colloquium. All students present short oral presentations in a more intimate setting to their peers and mentors as well as YIP leadership. For each conference, YIP Faculty provides individual feedback to each learner prior to the event.

Individual Development Plan. Each student creates an individual development plan (IDP) with the help of their mentoring committee. IDPs are tailored to the level of training. By defining goals, objectives, activities, and products, each IDP contains a structured review of progress in achieving academic milestones and includes individual written summaries of formal and informal experiences (**Appendix 1**). Based on this plan, an individualized trajectory of coursework and other programmatic activity are developed.

B.5.d. Mentorship. Each YIP student is mentored by a committee of three faculty members: an experienced subject matter expert (lead mentor), another subject matter or methodologic expert (secondary mentor), and a mentor from the YIP Core Faculty (career mentor). The full mentoring committee will guide the student throughout their training at UCSF, with regularly scheduled meetings. The YIP Program Leaders meet with the assigned mentee at least three times per year for one-on-one mentoring sessions during which they review the progress on the IDP and monitor the mentee's mentoring relationships.

Expectation of mentors. All mentoring committee members are senior faculty (most at the Professor level) with active research programs and extensive experience mentoring students, postdoctoral fellows, and junior faculty. Lead and secondary mentors are drawn from UCSF faculty who have served as principal investigators in clinical and translational research and have had success in disseminating their research results. Developing a successful clinical and translational research career requires strong relationships with mentors and a research team. One of the selection criteria for YIP is the strength, commitment, resources, and multidisciplinary complementarity of the proposed mentors. Students are expected to approach prospective lead mentors in advance of application submission to discuss collaboration, potential research projects, and career plans.

Training of mentors. UCSF has a well-established and robust faculty Mentoring Program that resides within the Office of Academic Affairs and is available to all UCSF faculty.[14,15] With CTSI support and led by Dr. Mitch Feldman MD, MPhil, this program has created a web-based Mentor Training Program (MTP). The modules address mentorship responsibilities, mentoring models, goals and expectations, mentoring communication, and mentoring challenges. The MTP also includes modules on "Mentoring Across Differences" that focus on the specific mentoring needs of women and URM.[16] The MTP in-person workshop and online modules are supported by institutional resources. All YIP mentors will be asked to complete the MTP.

Near-peer mentoring. YIP students have opportunities to begin to acquire mentorship skills of their own. In the past 10 years the Pre-health Undergraduate Program (PUP; formerly led by Dr. Chin-Hong, **Figure J1**) has trained 173 undergraduates (108 URM or from economically disadvantaged backgrounds) from colleges and universities nationwide who come to UCSF to receive training in clinical and translational research during the summer. Since the inception of the program we have paired PUPs with YIP students, allowing the latter to begin to practice mentorship skills. At the start of the YIP program, students receive brief didactic training on becoming a mentor, setting expectations, clear communications, and managing challenges. Many of these mentorship relationships have continued beyond the summer and some have led to joint publications.

Vignettes: YIP Students' Comments about Mentoring Pre-health Undergraduate Program Students. *"Incredible working with passionate and curious first-generation undergraduate students. Working with first-generation undergraduate students also helped me adapt my mentorship style and expectations to their specific needs so that I can be a more effective mentor to underrepresented students in the future."*

"It was a great experience to be in the mentor role for the first time. It made me think more actively about what I appreciate in my current mentors and made me believe that I also have something to offer younger colleagues, even though I am still early in my career. …Being in the mentor position myself, made me think about the dynamic of a mentee/mentor relationship, and what traits I appreciate the most in my own mentors, and what kind of traits I look for in future mentors as well."

J1.2. In partnership with other CTSI programs, provide YIP students with exposure to: 1) Clinical research informatics and data science; and 2) Academic career development and leadership.

We propose to introduce two new curricular elements in YIP – clinical research informatics and data science. These are new CTSI programs that are being developed that will provide infrastructure, training, and support for these areas at the institutional level (see **Core B Informatics and Core I Institutional Career Development (KL2) Program**). Although there are rich resources at UCSF for mentorship and research in these areas, world-class instruction in methodologies in these areas have been lacking until this point, and absent in the health professions schools' curricula. Moreover, exposure to and training in these areas have been consistently cited by students and faculty as key skills for the future of clinical research, and deliberate exposure early in training is critical as covered in **Section A.5**.

Plan to integrate these new curricular elements into the YIP predoctoral training program. YIP will provide a critical introduction to these two new topics for the students. Four faculty sessions during the year will cover these topics. Sessions will be structured as active learning sessions with instructors and teaching assistants from the Department of Epidemiology & Biostatistics faculty, and faculty and staff from **Core B** and the **K Scholars Program (Core I)**. YIP students who wish to pursue additional training will be able to take elective courses as Master's candidates or complete the entire Master's track in Data Science if they desire deep proficiency in these skills **(Table J9 and Box).**

Mentoring for YIP students interested in clinical informatics and data science. We will encourage YIP students to consider conducting secondary projects or integrating aspects of these new topics into their existing funded projects. Fortunately, we already have a large multidisciplinary pool of investigators who are experienced in clinical informatics and data science research and in mentoring students **(Data Tables 2 and 4).**

B.6. Training for Clinical Research Informatics Postdoctoral (CRISP) Fellows.

Aim J2. Establish the Clinical Research Informatics Postdoctoral (CRISP) Program to train clinical fellows in state-of-the-art clinical research informatics methods and provide mentorship in the design and completion of clinical research informatics projects.

J2.1. Empower a diverse group of clinical (MD, DMD, DDS, DNSc, DO, DPT, PharmD, PhD) postdoctoral fellows to complete coursework in clinical research and a mentored clinical research informatics project.

J2.2. In partnership with other CTSI programs, provide CRISP postdoctoral fellows with training in: 1) Clinical research informatics and data science; and 2) Academic career development and leadership.

B.6.a. CRISP Application and Recruitment, Eligibility, and Selection of Fellows. CRISP will fund three postdoctoral fellows (three 2-year postdoctoral fellows every other year, or three 1-year postdoctoral fellows every year, or a combination of 1- and 2-year postdoctoral fellows, depending on the interests of the applicants). Eligible fellows must be doctoral-level (MD, DMD, DNSc, DO, DPT, PharmD, clinically licensed PhD) clinicians who have completed US residency (or similar clinical) training in a medical specialty, nursing, dentistry, pharmaceutical sciences, physical therapy, or psychology.

The CRISP Program is unique in that it will be focused on practicing clinicians who wish to pursue academic careers that combine the rigor of clinical research with the practice of clinical informatics. These fellows will undertake one to two years of didactic coursework in Clinical Research Informatics and Data Science, while working under the mentorship of skilled faculty with ongoing projects in the field. Fellows will be strategically positioned to apply for K grants (e.g., UCSF institutional KL2, UCSF K12 Learning Health Systems, or an independent NIH K grant) that use the methods of clinical research informatics to improve clinical care and population health. **The goal will be to generate a pipeline of clinical research informaticians who are poised for a successful transition to academic faculty positions.**

Recruitment. To attract motivated candidates who are committed to using the methods of clinical research informatics to generate knowledge that improves the delivery of health care, we will advertise CRISP to current UCSF residents and fellows, program directors, researchers, and operational leaders. We are aware that there is a growing demand for formal training in clinical research informatics, and particularly for online learning that allows for flexibility. Thus, we will create a new website dedicated specifically to CRISP that will include a description of the program, links to websites for all program Faculty, and application materials.

Eligibility. We anticipate a wide range of applicants who are seeking a variety of fellowship training experiences, including clinical research informatics alone, in combination with ACGME training in the subspecialty of clinical informatics, or in combination with ACGME training in a clinical subspecialty (e.g., cardiology). We will coordinate recruitment with the UCSF ACGME-accredited Clinical Informatics Fellowship so that fellows can obtain additional clinical research informatics training and complete a mentored project while simultaneously completing the requirements for board eligibility in Clinical Informatics (**Table J12**). Dr. Raman Khanna, director of the UCSF Clinical Informatics Fellowship, is extremely enthusiastic about the proposed Clinical Research Informatics Fellowship, and Dr. Whooley, who serves as SFVA site director for the existing Clinical Informatics Fellowship, will be in an ideal position to coordinate coursework and activities across these two groups. The overlap between these fellowships will also provide a highly synergistic opportunity to create a larger group of fellows with the critical mass necessary for lively group discussions and feedback. The first year of the Clinical Informatics Fellowship already includes some of the didactic courses mentioned in **Section B.4**, and the second year is focused on mentored informatics projects related to the fellow's area of clinical expertise. Most graduates of the UCSF Clinical Informatics program pursue applied careers in industry, hospitals, clinical practice, government, or other settings. The option of adding Clinical Research Informatics training and earning a Master's degree in Clinical Research will expand these career options to include academic careers as clinician investigators who can apply rigorous clinical research methods to the practice of Clinical Informatics.

Table J12. Training Pathways in CRISP

Training Pathway	# Years Training	Clinical Informatics Board Eligibility
CRISP with ATCR	1	No
CRISP with Master's	2	No
CRISP with ATCR + ACGME fellowship	2	Yes
CRISP with Master's + ACGME fellowship	3	Yes

ATCR = Advanced Training in Clinical Research; Master's in Applied Science (Clinical Research); ACGME = Accreditation Council for Graduate Medical Education

Application process. Applicants to the CRISP postdoctoral program will apply through a purpose-built application portal created by CTSI. Applicants will be asked to submit a CV and a brief statement describing their area of interest, prior training/experience, potential project ideas, three letters of reference, and a letter from a mentor or UCSF division chief describing the clinical experience planned for that fellow. No prior experience in Clinical Research Informatics will be required; however, this program will be most effective for those who have identified a potential project or at least an area of clinical need for improvement. Applicants from the ACGME Clinical Informatics Fellowship who wish to pursue academic careers will be given priority.

Selection. A CRISP-specific selection committee will be assembled that includes members of the TL1 Executive Committee (**Table J5**) along with senior faculty who have expertise in key research areas represented in the applicant pool. Applicants will be interviewed by members of the selection committee with the goal of selecting participants from multiple disciplines and backgrounds. Interviewers will complete an online evaluation describing their impressions from the interview. Once the interviews are complete, each application packet will be assigned to three reviewers who will provide preliminary scores. In a group meeting, the primary reviewer will present the applicant, Dr. Kanaya will lead a discussion, and each member of the committee will score the applicant privately (similar to an NIH study section). After applicants are ranked by score, the committee will discuss the application again, with attention to gender balance and the recruitment of underrepresented minorities.

Selection criteria. Among eligible applicants, selection criteria will focus on the strengths and potential of the candidate to become a productive clinical investigator as evaluated across five domains:

1. **Track Record:** Creativity of the candidate and potential to conduct innovative research based on prior training, areas of expertise, demonstrated interests, publications, grants, and collaborations
2. **Research Plan:** Scientific strength, potential clinical importance, and feasibility of the proposed research plan
3. **Training Plan:** Strength, appropriateness, and multidisciplinary complementarity of the proposed mentors as well as plan for didactic education and training
4. **Resources:** Tangible commitment and resources provided by the mentor (e.g., workstation, computer, data analytic support, pre- and post-award grant assistance) and suitability of available infrastructure
5. **Career Potential:** Assessment of the likelihood that the candidate will develop a career as an outstanding investigator whose work will have an important impact on health care

B.6.b. Overview of novel training program that will be used to meet objectives. All CRISP fellows will complete a program comprised of five central elements **(Table J13)**: (1) mentored research project; (2) WIP sessions alternating with career development seminars; (3) longitudinal clinical activity; (4) individualized development plan including presentation at a national meeting; and (5) ATCR certificate or Master's degree.

Table J13. Five Core Training Components of CRISP

1. Mentored research project
2. Works-in-progress and career development seminars
3. Longitudinal clinical activity (20% time)
4. Individualized Development Plan including presentation of research findings at a national meeting
5. Completion of ATCR Certificate or Master's in Clinical Research supplemented by didactic coursework individually tailored to specific interests (see **Section B.4**.)

1. Mentored research project. CRISP will provide postdoctoral education in the methods of clinical research informatics within a unique environment where fellows will learn from nationally recognized faculty, seasoned investigators, and innovators. CRISP fellows will be expected to complete at least one research project (leading to a publication and presentation) during their training. Because both Zuckerberg San Francisco General (ZSFG) and SFVA are closely affiliated with UCSF, and clinical trainees are accustomed to working across all sites, CRISP fellows will have a wide range of opportunities to work with electronic health record (EHR) data from UCSF's (EPIC-based) data warehouse, ZSFG's (Epic-based) EHR, and the VA's national standardized repository that includes EHR data from over 20 million patients who have been followed for 20 years (2000-2020). Available data fields include (but are not limited to) age, gender, race, ethnicity, zip code, dates of outpatient and inpatient encounters, conditions, procedures, lab results, vital signs, medications, prescription refills, radiology reports, costs, durable medical equipment, skilled nursing care, vital status, location of care, and national provider identification number. Claims data from the Center for Medicare and Medicaid Services, including the US Renal Data System, are also available at no cost. Fellows will be able to access EHR and/or Claims data for approved clinical research projects, obtain consultation regarding the data elements available,

and get help identifying, extracting, and merging variables of interest. In addition to these three health care systems and the many talented faculty who are eager to mentor fellows, UCSF is home to a wealth of informatics resources (**Table J14**). Fellows will have the opportunity to work with faculty in any of these programs that match their area of interest.

Table J14. Selected Informatics Resources at UCSF

UCSF Program Name	Description
Bakar Institute for Computational Health Sciences	Institute devoted to building a foundation of knowledge in computational health sciences and bringing together a community of thinkers who are interested in this emerging field
Biological and Medical Informatics Graduate Program	Program that readies scientists to master and interpret, using sophisticated tools and computational models, increasing amounts of information about human biology
Center for Clinical Informatics and Improvement Research	Center that uses electronic health data to serve as a learning lab for academic researchers who are interested in using digital tools to improve the quality and value of health care
Center for Digital Health Innovation	Group that works to develop, incubate, test, validate, and iterate on transformative technologies in real clinical environments
Center for Healthcare Improvement and Medical Effectiveness	Collaboration and training hub where investigators leverage data from the VA's national electronic health record to conduct patient-oriented research that improves health.
Center for Intelligent Imaging	Institutional resource focused on applying artificial intelligence and image analysis tools to medical imaging
CTSI Informatics and Research Innovation (Core B)	Multidisciplinary program focused on making electronic health data more accessible and usable for research, enabling digital interventions, and developing research curricula in data science
Information Commons	Computing environment where a diversity of data and tools are made available to investigators for research
MyChart	Recruitment service that allows researchers to send targeted messages to patients who may be eligible for studies
Population Health Data Initiative	Initiative supporting efforts to provide data and resources for population health, health equity, and health services research
OnCore Shared Resource Partnership (O-ShaRP) Program	Infrastructure providing centralized clinical research informatics tools and services for clinical trials across the UCSF enterprise

In addition to the above EHR data resources, the UCSF Population Health Data Initiative, funded by the SOM and Executive Vice Chancellor's Office, provides access to an enormous offering of Population Health and Health Services Research Datasets. It provides a searchable catalog of more than 100 public and private, citywide, statewide, nationwide, and global datasets for population health, health services, and health equity research. The datasets are categorized by geography, type, and cost. Finally, UCSF has built a high-capacity computing infrastructure, the Information Commons, on Amazon Web Services that enables the analysis of complex clinical data at scale with the necessary speed required for high-throughput analyses. This high-performance computer cluster provides an environment suited to pattern recognition and machine learning.

2. Works-in-Progress sessions and Career Development Seminars. CRISP WIP sessions will be held twice monthly for one hour. The group will discuss one or more works-in-progress being conducted by fellows or other local investigators who are using secondary analysis of EHR, registry, public health, administrative, or claims data to answer clinical research questions. These seminars will highlight the challenges of using big data for research, including the lack of standardized methods for ensuring that data quality, completeness, and provenance are sufficient to assess the appropriateness of its use for research. Discussion will include methods for linking with and integrating data from heterogeneous sources, natural language processing, use of computable phenotypes for both pragmatic clinical trials and observational investigations, strong data governance to better understand and control quality of enterprise data, and promotion of national standards for representing and using clinical data.[9] Project mentors will be invited to attend the sessions.

Career Development Seminars. CRISP career development seminars will be held twice monthly, on weeks alternating with WIP sessions. A faculty member will lead a discussion based on one of the 22 chapters in the recently published second edition of "Clinical Research Informatics"[17] or invite senior faculty to discuss a career development topic such as finding a mentor, managing time, setting priorities, balancing work-life demands, writing manuscripts, conducting peer review of manuscripts, responding to reviews, choosing a journal, deciding on authorship order, grant writing, negotiating for resources, or securing a job.

In addition to attending CRISP seminars, fellows will attend bimonthly seminars in applied clinical informatics that are currently provided in UCSF's existing ACGME-accredited Clinical Informatics Fellowship. Because Dr. Whooley also serves as the VA site director for UCSF's ACGME-accredited CIF, activities will be highly

coordinated. Fellows will also be invited to the monthly “Health Informatics Grand Rounds,” facilitated by Russ Cucina, MD, MS, Vice President for Health Informatics and Chief Health Information Officer for UCSF Health.

Finally, CRISP fellows will join the Fellows in Advanced Skills Training in Clinical Research (FAST CaR) seminars. FAST CaR is one of the seven CTSI Training Programs (**Figure J1**) that ensures that clinical fellows pursuing a career in clinical research have foundational skills in scientific writing, evidence presentation, research dissemination, professional networking, and readiness to compete for research faculty positions. Clinical fellows from many other UCSF T32 programs participate in FAST CaR, which helps to promote a workforce development community and interdisciplinary collaboration (see **Core D1, Translational Workforce Development**).

3. Clinical Experience. A key distinguishing feature of CRISP will be embedding clinicians (physicians, nurses, dentists, physical therapists, pharmacists) within the health system (UCSF, SFVA, or ZSFG) that they are working to improve. Forrest et al. have emphasized that researchers who merely use data collected within health systems, without clear links to the priorities and operations of the system, have less potential to generate impactful research. *Ideally, the researcher must be part of the system when conducting the research and address questions of interest to the stakeholders of the health system.*[18] Clinicians focused on clinical research informatics can leverage our knowledge of medicine, data systems, and analytics to generate better quality clinical research than ever before. For this reason, CRISP postdoctoral fellows must apply from within a clinical department that specifies how the fellow will be involved in clinical care. The goal will be for the fellow to devote 20% effort to patient care so that s/he can link the research project with the care being delivered to those patients.

4. Individual development plan. Under the guidance of the mentor, each CRISP fellow will create an IDP tailored to their level of training. By defining goals, objectives, activities, and products, each IDP contains a structured review of progress in achieving academic milestones and includes individual written summaries of formal and informal experiences (**Appendix 1**). Based on this plan, an individualized trajectory of coursework and other programmatic activity will be developed that includes submission of an abstract and presentation of research findings at a national meeting.

5. Completion of ATCR Certificate or Master’s degree supplemented by individually tailored didactic coursework (see **Section B.4.**).

B.6.c. Mentorship. Structured mentoring by faculty members experienced in the fellow's chosen subject matter is an essential element of becoming an accomplished clinical researcher. While the course curriculum will provide the methodologic guidance to enable the fellow to plan and implement clinical research, it will not substitute for the benefits derived from a relationship with mentors who work primarily in the fellow's content area. Hence, we require that each fellow receive guidance from a lead mentor who is an established scientist who meets regularly with the fellow, reviews progress, endorses the individual development plan, and provides ongoing scholarly guidance. Potential mentors are listed in **Data Table 2**. Mentors will be matched to fellows based on topic area and specific training goals. Mentors will meet with fellows on a weekly or bi-weekly basis to review research project plans and progress. Mentors will be expected to complete the Mentor Training Program as described in **Section B.5.d.** above. Mentors will be continually evaluated based on the depth, breadth, and quality of their clinical informatics research, their track records in interdisciplinary work, and their success in mentoring fellows (see **Section C.2.b)**. Fellows will provide formal evaluations of mentors, and these will be used to determine whether a mentor successfully fulfills the goals of the CRISP program. Feedback will be provided to the mentors and corrective action taken if needed.

C. TRAINING PROGRAM EVALUATION FOR YIP STUDENTS AND CRISP FELLOWS

C.1. Program Evaluation. We will build on the successful TL1 program evaluation and tracking procedures to align with the Aims of each of the programs, and incorporate the Common Metrics developed by NCATS. We will work with the CTSI administrative team to develop scorecards and dashboards to document our progress. We will examine the processes used to achieve these metrics, given the relatively short duration of YIP and CRISP to achieve outcomes such as publications.

In **Table J15** we describe the metrics to be tracked and the processes employed for evaluation of the programs and tracking of trainees. We will characterize the outcomes using the popular Kirkpatrick Framework.[19] Metrics for each of the Aims will be evaluated at least semi-annually by the TL1 Program in the context of the CTSI’s overall program evaluation. Measures of satisfaction and engagement (level 1) with the program components inform our ongoing efforts to improve the program. Level 2 outcomes will include evidence of trainees’ learning as they participate in the program. The metrics for outcomes at level 3 (behavior) and level 4 (results) are tracked

after trainees have completed the programs. Level 3 metrics include the number of trainees who pursue research training up to five years after graduation, who present at UCSF or national research meetings, and publications. Other metrics, especially after year 5, will focus on Level 4 outcomes that support the results from the program that include: honors, current job position, training positions after completion of TL1 training, all grants or contracts, and percent time spent on research. Other measures of Level 4 success include trainees in academic positions with sustained publication and funding.

Table J15. YIP and CRISP Metrics

Aim 1. Expand and enhance the predoctoral YIP with 11 students/year. Aim 1.1 Mentor and support a diverse group of trainees to complete a Masters' degree in Clinical Research and a research project and acquire research career skills.		**Responsible Person/Data Sources**
Process measures	• Implementation of an outreach effort within UCSF with coordinated efforts with key contacts in each school • Matching all URM learners with mentors aligned with their preferences as indicated in meetings with leadership • Develop new sessions employing curriculum development methods and ensuring active learning and reflection by participants as indicated by review of syllabus materials • Learner's completion of an individualized development plan	Directors • Documented reports
Level 1 Level 2 Level 3 Student diversity Student progress Level 4	• Learner satisfaction and engagement measured by attendance in sessions, interactions with mentors and responses to annual survey of program elements and focus group • Demonstration of skill development • #/% of URM applicants and selected trainees accepted into MD-MAS track • #/% of UCSF schools/departments represented by trainees in MD-MAS track; #/% of trainees who complete the MAS degree • #/% of trainees with R01 or equivalent grants 5 years or more after program completion; # of publications as first or last author 5 years after program completion	Directors • Report from each session, annual survey Evaluation services • Focus group Directors • Review of IDPs, course assignment • Report from annual survey
Aim 1.2. Expand the predoctoral student exposure to include clinical informatics and data science.		**Responsible Person/Data Sources**
Level 1 Level 2 Level 3 Level 4	• Student perceptions of informatics and data science offerings and of their engagement with the content • Course assignments • Use of data in scholarly projects • # dissemination products using clinical informatics and/large datasets	Directors • Course evaluations • Course products • Summary of project
Aim 2. Establish a CRISP fellowship program to train clinical fellows in clinical research informatics methods and provide mentorship in the design and completion of clinical research informatics projects.		**Responsible Person/Data Sources**
Level 1 Fellow diversity Level 2 Fellow progress Level 3 Fellow achievements Level 4	• Perceptions of engagement and quality of the program • #/% of URM applicants and selected fellows • #/% of UCSF schools/departments represented by fellows; # of publications as first or last author during program • #/% of fellows in academic medicine or other research career 5 years after program completion • #/% of fellows active in clinical informatics and data science research 5 years after program completion • #/% of fellows with R01 or equivalent grants 5 yrs or more after program completion; # of publications as first or last author 5 years after program completion	Evaluation services • Interviews Directors • Annual summary reports 5-year follow-up survey

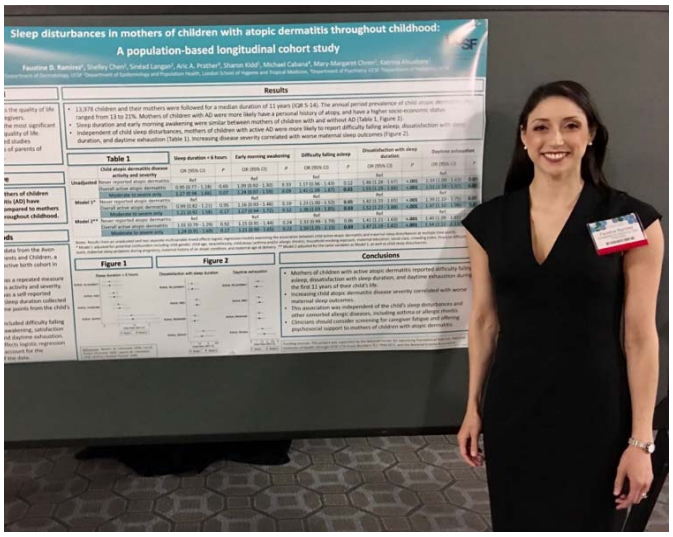
The YIP and CRISP programs will submit their Aims, metrics, initiatives, and budgets to CTSI, which are maintained in a web-based balanced scorecard system called "Process Based Leadership." TL1 program staff will update the scorecard twice a year with actual achievements. Process Based Leadership also provides an efficient platform for incorporating NCATS common metrics. The TL1 Directors and CTST Director (Drs. Chin-Hong, Whooley, and Kanaya) will attend formal meetings with the CTSI Executive Committee at mid-year and

end-of-year to conduct reviews of TL1 performance. The CTSI Executive Committee will offer semi-annual strategic, operational, and tactical guidance in writing to the TL1 Directors and TL1 Executive Committee.

The TL1 Programs will administer a year-end survey to obtain trainees' satisfaction with the programs (**Appendix 2**). The survey includes assessment of TL1 Program Leadership, value of each of the Program activities, satisfaction with Program curricula, and satisfaction with the primary research project. Additional metrics relate to recruitment of URM trainees and minority faculty to the program. Faculty will also complete program evaluation forms to measure their assessment of the program and where it could be improved. Trainees and mentors are asked to evaluate these elements as to their value to their career development on a scale of 1 to 5. We also conduct confidential focus groups at the end of the year to solicit feedback as to what went well during the year, what they would like to do differently, and what types of activities they would like to see in the coming year. For this activity, we will call on the research and evaluation members of the Center for Faculty Educators at UCSF.

The TL1 has extensive experience following trainees longitudinally and obtaining permanent contact information from each trainee/fellow, such as a phone number of parents or other family members. We require trainees to sign a statement confirming that they will cooperate with our request to obtain long-term outcome information and that they will be contacted annually for an indefinite period. Social networking tools such as Facebook and LinkedIn are also good ways to stay in touch with program graduates.

Vignette: A YIP Student's Mentored Project as a Medical Student led to a Long-Term Collaboration with her Mentor During Residency. As a YIP student, Faustine Ramirez took the ATCR Certificate Program. Under the guidance of Dr. Katrina Abuabara (former K scholar), YIP enabled her to conduct multiple studies using a longitudinal birth cohort of >10,000 mother-child pairs. Dr. Ramirez found that children with atopic dermatitis experienced worse sleep quality compared to those without dermatitis, and that their mothers also suffered more from poor sleep. Her YIP traineeship resulted in 3 oral presentations, 2 poster presentations, 2 first-author manuscripts, and several awards including the UCSF Pathways to Discover Prize in Clinical and Translational Research and the Academic Pediatric Association Research Award for Best Abstract by a Student. As a pediatrics resident at UCSF, Dr. Ramirez has combined her passion for children's health and research to examine the effects of prenatal and childhood tobacco smoke exposure on pediatric sleep-disordered breathing. As an aspiring academic general pediatrician, she continues to collaborate with Dr. Abuabara on numerous projects relating to children's health with several manuscripts underway.



C.2. Evaluation of Students/Fellows and Mentors for YIP and CRISP.

C.2.a. Evaluation of Students/Fellows. Evaluation of TL1 trainees will be conducted midway and at the end of the programs by the lead mentor using the web-based MedHub platform, in a standardized format that includes open-ended questions. These cover the student/fellow's strengths and weaknesses as they relate to their career stage and career goals and to their scientific productivity. In addition to the open-ended questions, students/fellows will be rated on specific skills (0 [cannot rate] - 5 [superior] scale). Items range from specific research skills (e.g., writing, proficiency in statistics) to level of individual responsibility and personal qualities (e.g., ability to cooperate with team members, communication and presentation skills). All forms and evaluation documents are kept in a confidential file. In addition to evaluation by the lead mentor, TL1 leaders will meet with trainees at least three times a year for one-on-one feedback sessions. One TL1 leader will be assigned to each fellow for the duration of their training. These sessions are designed to obtain additional feedback and create solutions in situations where the student/fellow is experiencing a problem.

C.2.b. Evaluation of Mentors. A key role of the TL1 Program Leaders is to monitor the mentoring relationships between students/fellows and their mentors. If a TL1 Program Leader has concerns about the quality of a mentoring relationship, he/she will take one of several courses of action: discuss the issue directly with the lead and/or secondary mentor if appropriate and, if applicable, bring the problem to the attention of the student/fellow's Inquiry Advisor for SOM students (these advisors help advance students' scholarly endeavors during Career Launch). TL1 program leaders may then intervene to help the mentor improve; or help the student/fellow to select a new mentor. In addition to Inquiry Advisors, the SOM has a robust system of coaches (clinician educators who provide advice, assistance, and encouragement in all aspects of our students' education and professional development) who remain engaged with learners until graduation. TL1 leaders will also communicate with

students' coaches as needed. Under certain circumstances, they may bring the problem to the attention of the division chief, department chair, or the Vice Dean for Education of the appropriate professional school (Dr. Catherine Lucey for MD trainees). TL1 program leaders will coordinate with the appropriate institutional official to intervene to help the mentor improve, or to help the TL1 trainee select a new mentor. In our experience, with advice from TL1 leaders, trainees have been able to resolve mentorship issues, and very rarely have changed mentors except in cases where the mentor has left UCSF.

Assessment of lead mentors and co-mentors by the students/fellows also occurs every 4 months and at the end of the training period. We use a standardized format that includes open-ended questions on the mentor's assets and liabilities. We will also collect standardized ratings on specific skills (on a 0 [cannot rate] to 5 [superior] scale). Skills evaluated range from teaching skills in specific areas (e.g., methodology and statistics, manuscript preparation) to personal qualities (e.g., quality of support, availability, enthusiasm, and timeliness of feedback). In addition, we have also begun to conduct a formal mentor evaluation using a 14-item electronic mentor evaluation instrument developed by the CTSI Comprehensive Mentoring Program. Results of these surveys are reviewed by the student/fellow's program leader. After mentee and mentor evaluations are completed, TL1 leaders discusses any identified problems with the mentors. Mentors who do not demonstrate adequate expertise or commitment and support for mentees may be asked to step down and will not be asked to act as mentors for future fellows. All forms are kept in a confidential file.

Vignettes: YIP Students' Comments about their Experience as Mentees. *"My mentor first inspired me as a 3rd-year medical student on the wards when her compassion and dedication to serving vulnerable populations shone through her clinical care. Now, as her research mentee, I have had the distinct honor to see how this same compassion and dedication drives her research. She creates a welcoming, rigorous, and stimulating environment for mentees and who inspires students with her passion and commitment to mission-driven research aims and selfless teaching."*

"Dr. E is a phenomenal mentor because she treats me as a true colleague. She rearranges her schedule for us to meet in person several times per week. Whenever I send her anything-- a Stata question, a manuscript for revision--she provides feedback quickly and thoughtfully, always highlighting what I've done well and what could be improved. In every interaction, I feel that she prioritizes our partnership, and is invested in my success. I often think to myself, "I want to be a mentor like that one day". Without a doubt, Dr. E is the single most important source of mentorship in my training thus far."

"I am in awe of Dr. C's vision, organization, and execution and feel absolutely blessed to have worked with her this past year. Not only was I able to expand my research skills into survey and qualitative research, something I have never tried before, but I was also able to take a project from start to finish all in under a year. I am extremely proud to call her my mentor."

C.2.c. Evaluation of Core Mentor Faculty. The roster of TL1 Program Core Mentor Faculty (**Data Table 2**) will be reviewed annually by the leaders of the TL1 programs, including Dr. Kanaya and members of the Executive Committee (**Table J5**). New faculty will be invited to join the TL1 Program Core Faculty once their success in mentoring TL1 students/fellows and their commitment to the program has been demonstrated. This will commonly occur when TL1 students/fellows have successful mentoring experiences with UCSF faculty who are not currently members of our Program Core Mentor Faculty. Success in mentoring will be evaluated as described above. Commitment to the program will be judged according to the quality and level of participation. When TL1 Program Faculty serve as mentors, we will implement formal evaluations using the 14-item electronic mentor evaluation instrument described above. Results of this survey will be reviewed by TL1 leaders semi-annually. Faculty who do not demonstrate continued commitment to mentoring will be removed from the Core Mentor Faculty list.

D. INSTITUTIONAL ENVIRONMENT AND COMMITMENT TO TRAINING

D.1. Training environment. UCSF has been the top public recipient of NIH funds annually since 2006. In the 2020 rankings of the best medical schools by U.S. News & World Report, the SOM ranked fifth in research and third in primary care — the only school in the country to rank in the top five in both categories, and has ranked in the top five for the last 10 consecutive year. The SOM has topped the list for NIH funding for medical schools since 2012. The School of Dentistry has had the highest NIH funding of any U.S. dental school for the past 29 consecutive years and is recognized nationally for its innovative approach to dental education. Unique curricula include a combined DDS-PhD and DDS-MBA program and a 1-year training course designed to help disadvantaged students gain admission to U.S. dental schools. The School of Nursing ranks highest in the nation for NIH funding for the past 16 consecutive years, and 18th in U.S. News & World Report's 2020 survey for national nursing Master's degrees. The School provides education and research training in the social, behavioral, and biological sciences, with a focus on health care. The School of Pharmacy is ranked top in the nation for NIH funding for the past 40 years, and in U.S. News & World Report's 2016 survey, the latest available, was number three in the nation for its Doctor of Pharmacy (PharmD) program. In addition to conducting groundbreaking

pharmaceutical research, the School pioneered the role of clinical pharmacists, which positions pharmacists as a key part of a patient's care team. Most of the TL1 predoctoral fellows will come from the SOM and will have completed residency programs in diverse departments and disciplines. **Data Table 1** shows the census of students in all the participating departments, and **Data Table 3** shows all the institutional training grants. Recruitment is described in **Section B.5.b.**, and plans to enhance diversity are described in **Section E**.

D.2. Institutional environment in support of Inquiry and Clinical Research Informatics.

Inquiry. As set forth in **Aim J1**, the SOM has invested significant resources in inquiry in the new BRIDGES curriculum. The YIP will benefit greatly from this investment by taking advantage of the dedicated inquiry advising system, other faculty and staff resources and the pervasive culture of inquiry that is now fully embedded in the SOM curriculum. Inquiry starts with weekly half-day sessions in Year 1 and culminates in up to 20 weeks of mentored project time during Career Launch during Year 4. The YIP will take advantage of the five funded BRIDGES Inquiry Advisors, both to support recruitment to the YIP and to provide continuity in research advising before and after the YIP. Drawing inspiration from the SOM, the UCSF School of Pharmacy has already begun to integrate inquiry into their curriculum, and pharmacy students will join the medical students during portions of Inquiry Immersion. We anticipate that the curricular changes in the Schools of Dentistry and Nursing will follow in a similar fashion.

Clinical Research Informatics. The UCSF CTSI renewal has made clinical informatics a priority (see **Core B**) and is focused on developing and providing state-of-the-art clinical research informatics and data science training (see **Core I, Aim 2**). UCSF already provides a rich environment and mentorship for clinical informatics research with a deep bench of faculty who are clinical research informatics experts (**Data Table 2**). Leadership from our CTSI, the Departments of Epidemiology & Biostatistics, and Medicine are all committed to building a world-class curriculum and training in clinical research informatics.

D.3. Institutional commitment to the TL1 program. In addition to the above, UCSF provides additional resources to YIP students. When YIP students are enrolled in the TL1 program they are registered in the Graduate Division, and UCSF covers administrative costs separate from the tuition costs provided by the TL1 grant to cover the required ATCR and Master's coursework. For all YIP students, UCSF also covers interest accrued on loans during the additional year if part of the student's financial aid package on matriculation to health professions school. In addition to the TL1 stipend, postdoctoral CRISP fellows will receive supplemental support from their primary mentor and/or their clinical program directors.

E. RECRUITMENT PLAN TO ENHANCE DIVERSITY

UCSF strongly supports recruitment, training, and retention of students from underrepresented minorities. The YIP has had strong representation from URM students from 2006 to the present (**Table J16**). Of the 92 URM predoctoral students who have completed the yearlong training, the TL1 program enrolled 52, representing 39% of the total YIP population. We have presented vignettes of three different TL1 fellows in this proposal.

Table J16. Underrepresented in Medicine (URM) yearlong predoctoral students supported by TL1 YIP and other programs.

From 2006-present	YIP	Other*	Total
Total N of Yearlong Inquiry Fellows	133	118	251
Hispanic/Latino	22	28	50
Black/African American	12	6	18
Am Indian/Hawaiian/Pacific Islander	4	0	4
Individuals with a disability	6	3	9
Individuals from a disadvantaged background	8	3	11
Total URM	52 (39%)	40 (34%)	92 (37%)
*Individuals with yearlong fellowships supported by School of Medicine and other funding sources			

Probably the biggest factor in helping the TL1 to enhance its diversity efforts is the broader and deliberate efforts undertaken by UCSF to increase diversity in its postdocs and students, who then become the applicant pool for the TL1. For example, the SOM increased the proportion of URM medical students from 31% for the 2015 entering class to 40% in the 2018 entering class. In addition, CTSI has supported a range of activities intended to help URM students/fellows enter the pipeline and progress to the next level of training. These initiatives have been strengthened over time and will help us in our continued efforts in the TL1 to recruit, train, and promote URM students into academic career paths.

Vignette: ***A YIP Student's Mentored Project and Community led to Persistence in Research****. Dr. Joel Ramirez, the first in his family to pursue a career in health care, struggled to identify mentors in medicine and science. Although Dr. Ramirez demonstrated a clear interest in research, he had not initially had an opportunity to formally present or publish any research. As a UCSF medical student and YIP trainee, he worked under the mentorship of Dr. Marlene Grenon (former K Scholar), Associate Professor of Surgery in the Division of Vascular and Endovascular Surgery. Using a cross-sectional cohort and serum biobank based on multiple large data sets, he demonstrated the importance of mental health and depression on vascular function and outcomes in patients with peripheral artery disease. His year working with Dr. Grenon resulted in 20 conference podium and poster presentations, 10 research-related awards, and 15 publications. He is now a vascular surgery resident with two required research years built into the program, which he plans to fund via a NIH F32 grant. Since starting residency, he has continued to utilize numerous skills that he acquired during his YIP and continues to present and publish novel research.*

The initiatives we describe below include ones that directly increase enrollments of URM trainees in YIP and CRISP, those that further training opportunities for URM trainees within YIP or CRISP, and those that generally reflect CTSI training programs' commitment to diversifying the biomedical workforce. These initiatives include:

UCSF Promoting Research Opportunities Fully Prospective Academics Transforming Health (PROF-PATH). This is a research and academic career development program for URM health professions students interested in research. Originally funded by the National Institute of Minority Health and Health Disparities, the UCSF SOM and the UCSF LatinX Center of Excellence now fully support this important program. PROF-PATH provides community and resources for UCSF students from URM backgrounds regardless of research area focus, and students interested in health disparities research regardless of background. PROF-PATH provides funding for summer research, classes, mentorship, community, and opportunities for training for students from all four UCSF professional schools. PROF-PATH and YIP share infrastructure and training goals for URM. First, PROF-PATH provides a potential pipeline to the YIP for URM students who participate in its funded 6-week summer program and who seek additional funded research experiences and training in epidemiology and biostatistics. Additionally, PROF-PATH provides important community and mentorship to all URM students accepted as YIP students. At the time when all URM students are first awarded YIP positions, they are simultaneously invited to participate in PROF-PATH during the year.

NIH diversity supplements. In the past, there was no central repository of information for learners interested in diversity supplements. The UCSF Research Action Group for Equity (RAGE) worked with the campus Research Development Office to create a website with information and campus contacts. The group hosted an annual campus event with speakers from the NIH, the UCSF Office of Diversity and Outreach, and faculty who were successfully awarded diversity supplements. The group has already created a "match-making" service to match principal investigators with learners at all levels who want to apply for diversity supplements. Madeline Mann, Administrative Director of the TL1 Program, is a member of the RAGE workgroup. This robust effort could enhance URM TL1 learners' research experiences by providing additional funding beyond the supported time in the TL1 as needed and if consistent with the student's career goals.

The Pre-health Undergraduate Program (PUP). In the past 10 years we have trained 173 undergraduates (108 URM or disadvantaged) from colleges and universities nationwide who come to UCSF to receive training in clinical and translational research during the summer. This program began in 2009 and is supported by institutional funds. Demand for the program has grown, with typically over 150 applications for 15-20 slots from undergraduate students across the country. The outcomes from the program have been excellent to date, with 96% of PUP alumni gaining admittance to graduate or health professions schools at five years post-PUP, 43% published in a peer-reviewed journals, and 57% presented at national conferences. Of PUP graduates, 85% reported that they are likely to pursue a research career, and 94% stated that PUP had a positive influence on their overall career goals. Dr. Chin-Hong, YIP Director, led the program since 2009. In the next funding period, PUP will be led by Drs. Maria Garcia (K Scholar) and Kala Mehta. PUP has specifically enhanced YIP in two ways. First, the YIP students learn valuable mentorship skills by near-peer mentoring of PUP undergraduates. Second, PUP is one of few pipeline programs at UCSF focusing solely on broad clinical and translational research exposure, and we hope these students will become future YIP students themselves.

SF Building Infrastructure Leading to Diversity (SF BUILD). In 2014, the San Francisco State University (SFSU) was awarded $17 million with UCSF as its research partner to promote training opportunities and career

development for minority students and faculty in the biomedical sciences. Dr. Bibbins-Domingo, MPI of the U54, former CTST Director and TL1 Co-Director, is MPI of SF BUILD. The first cohort of 12 URM undergraduate students at SFSU began in 2015. The student training core of SF BUILD is directed by Peter Chin-Hong, MD, Director of the YIP program. SF BUILD students come to UCSF during the summer for training in clinical and translational research and are included in many of the same activities as PUP students; the programs are synergistic, and the students receive mentorship from senior researchers at UCSF, attend orientation, take classes together in Designing Clinical Research and Responsible Conduct of Research, and participate in WIPs and faculty-led seminars. They also engage in separate activities and retain their own program identity. SF BUILD was recently awarded a renewal for an additional five years.

The UCSF Department of Medicine Clinical Fellowship Directors (FD). This group meets monthly to coordinate issues related to fellowships, including efforts to improve recruitment of racial/ethnic populations that are underrepresented in medicine. This FD group has developed and distributes informational materials with specific strategies to improve URM recruitment **(Figure J6).** The group also hosts two clinical fellowship (evening) information sessions each year where interested residents have an opportunity to meet with program directors, learn about existing programs, and ask questions. All members of the FD group proactively reach out to and encourage URM residents to attend these sessions. In addition, the Clinical Informatics Fellowship hosts an informational dinner and evening at a faculty member's home in the spring of each year to which prospective fellows from across all four health professional schools are invited. Dr. Khanna (Director, Clinical Informatics Fellowship), Dr. Whooley (VA Site Director) and other leaders of the Clinical Informatics Fellowship proactively recruit URM residents to attend this dinner.

Figure J6. Example Infographic to Enhance Recruitment of Populations Underrepresented in Medicine (URM)