BRIDGE: Bringing Precision Medicine to Clinic

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Project Team

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Collaborators

Clinic	Collaborators
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Memory and Aging Center	Kate Possin, PhD; Melanie Stephens, PhD; Michael Erkinnen, MD
Multiple Sclerosis	Bruce Cree, MD, PhD, MAS; Jeffrey Gelfand, MD; Douglas Goodin, MD; Ari Green, MD; Joanne Guo, MD; Stephen Hauser, MD; Samuel Pleasure, MD, PhD; Joseph Sabatino, MD, PhD; Amy Schwartzburg, RN, CNP; Michael Wilson, MD; Scott Zamvil, MD, PhD
Movement Disorders	Ethan Brown, MD; Jill Ostrem, MD; Carlie Tanner, MD, PhD
Neurorecovery	Cathra Halabi, MD; Geoffrey Manley, MD, PhD
Primary Care	Ida Sim, MD, PhD; Jason Satterfield, PhD; Jane Jih, MD, MPH; Tung Nguyen, MD

Overview

The vision of BRIDGE is to use targeted computation and visualization tools to decrease clinician time spent digging through the Electronic Medical Record (EMR), allow for the clinician to spend more time with the patient, help the clinician and patient to be on the same page and make shared decisions, and ultimately to improve treatment decisions and patient outcomes.

Problem

Precision medicine has the potential to revolutionize patient care, but only if the relevant information can be delivered in an actionable format to clinicians at the point of care. Technological progress has exponentially increased the volume of medically relevant data, including wearables, imaging, and genomics, while computer science has generated complex algorithms to interpret multi-modal 'big data', including artificial intelligence and quantitative medical image processing. While these data sources can improve clinical outcomes, we lack the tools to bring cutting-edge information technology to the bedside. Furthermore, the optimal data sources and algorithms vary between specialties and clinics, and change over time; thus clinical acumen is required to tailor the delivery of effective clinical informatics. However, training clinicians as programmers or adding programmers to individual clinical teams is not a feasible long-term solution.

Solution

BRIDGE is a precision medicine platform built by a team of clinicians and programmers that directly addresses these problems. It extracts the key elements relevant to a patient's clinical condition from the electronic health record (EHR) in real-time, integrates these EHR data with curated research datasets, performs analyses of the combined data to derive relevant clinical indices (e.g., clinical risk scores, normative comparisons, severity indices based on imaging data), and represents these data and indices to clinicians in a simple visual format. It solves the last-mile challenges of delivering precision medicine tools developed *in silico* to the point of care, so they can be tested in real-world settings. To account for the diverse requirements of different clinics, the modular design of BRIDGE enables rapid development and deployment of clinic-specific visualizations with customized underlying data streams. By sharing tools and data sources, BRIDGE reduces the silos across clinics to reduce the development burden, cost, and time each clinic would require to build their own tool. Central to our core clinical mission within UCSF, the BRIDGE platform puts patients and clinicians together on the same page, to jointly visualize the disease trajectory in the context of a group of similar patients to discuss treatment options.

The BRIDGE project stems from a collaboration of investigators across three clinical research groups (Autism, Memory and Aging, and Multiple Sclerosis), who had individually developed disorder-specific platforms; these were integrated to form the multidisciplinary BRIDGE (bridge.ucsf.edu) platform. BRIDGE is designed by clinicians, for clinicians. The three lead PIs are clinician scientists with expertise in their clinical specialty along with imaging analysis, genetics, cloud-computing, and informatics. This team works directly with clinicians applying a human-centered design approach in order to create usable and accessible dashboards. We have already developed BRIDGE dashboards for: Autism, Memory and Aging, Multiple Sclerosis, Movement Disorders, Neurorecovery, and Primary Care, and we are in the design phase with many other clinics.

The aims of BRIDGE are to: 1) make existing EHR data easy to find and digest in a single page 2) integrate all relevant research data 3) apply algorithms to the EHR and research data in order to make insights readily available at the point of care 4) provide a mechanism to test and evaluate visualizations and algorithms with real clinic patients and 5) accelerate the time it takes to gather approvals, develop, test and evaluate digital health tools.

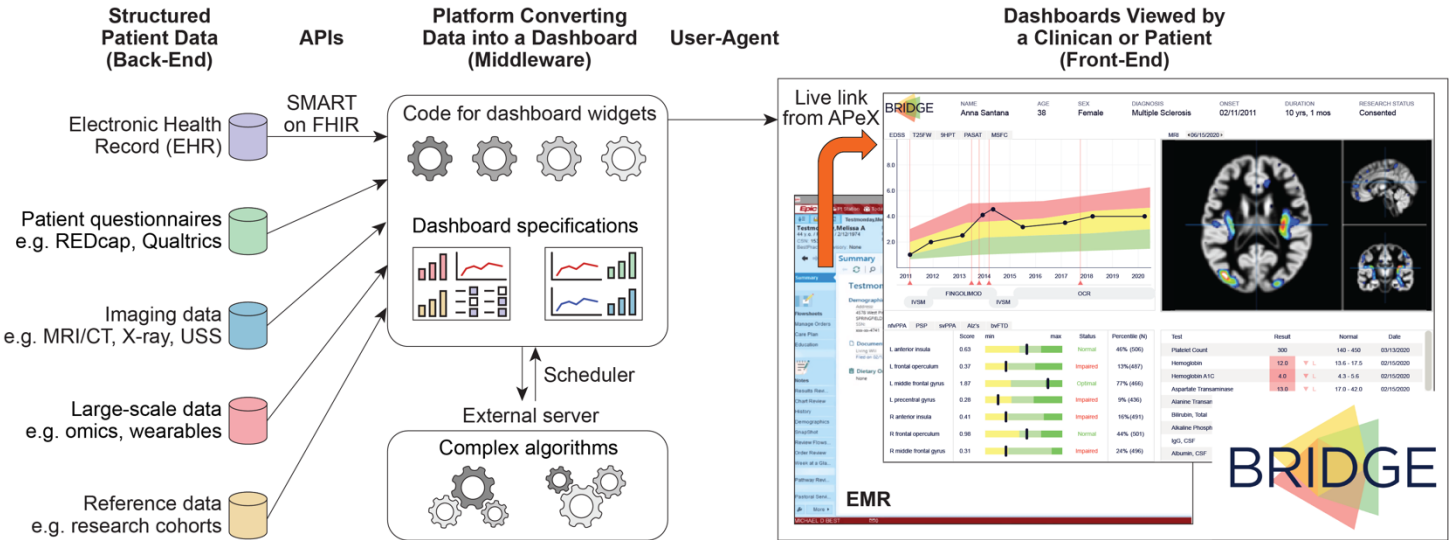

Figure 1. Overview of technological components of BRIDGE. Flow of information is depicted as it moves from back-end data sources, through the integrating middleware layer of light- and heavy-computational resources, to the multiple functionally distinct widgets shown in a user-facing front end dashboard designed to reflect the needs of a single clinic. Abbreviations. API: Application Programming Interfaces; EHR: Electronic Health Record; FHIR: Fast Healthcare Interoperability Resources; SMART: Substitutable Medical Applications and Reusable Technologies. To protect intellectual property and institutional knowledge the Epic screenshot is from the Epic website and is not the proprietary UCSF implementation.

Technical details. BRIDGE is a SMART on FHIR application that launches a browser-based clinician-facing dashboard by clicking on a link in the UCSF EHR (Epic) while viewing a patient's encounter, maintaining compliance with existing institutional security and authentication protocols. BRIDGE makes use of FHIR and non-FHIR APIs to call EHR data in real-time. In addition, BRIDGE is integrated with both widely accessible research databases (e.g., REDCap, Qualtrics), as well as more boutique data research databases (e.g., TabCAT computerized cognitive assessment, mPROVE patient-facing data). BRIDGE is a custom Python Flask application that stores configuration and normative data in a Postgres database. The front-end of BRIDGE is built using custom JavaScript, jQuery, and d3.js.

Visualization and configuration components. BRIDGE was designed to be modular so that all features can be adapted to an expanding array of clinical scenarios (**Fig. 1**). In initial implementation it included four reusable core visualizations: 1) longitudinal clinical course with treatment, 2) cross-sectional normative metrics, 3) specialty-focused laboratory data, and 4) quantitative neuroimaging. Both the cross-sectional and longitudinal widgets enable the patient's scores and metrics to be contextualized against a larger reference cohort, indicating both normal/abnormal values as well as percentile calculations, allowing the patient's clinical status to be interpreted by the clinician at a glance (**Fig. 1**). The configuration data for all viewers are stored by BRIDGE and can be quickly adapted, enabling both ongoing user engagement and rapid deployment to meet the evolving needs of specific clinics. As we expand to more clinics, new functionality (e.g., geolocation, genomics, AI-based differential diagnosis) is being developed that can be retroactively made available to prior clinics.

Accelerated and modular development timelines. Development started in March 2017 and BRIDGE went live in May 2019. Achieving this initial launch required us to collaborate across a number of key institutional committees within UCSF, such

as Privacy Legal and Risk, IT Security, Digital Devices and Technology, among others. In fact, after we launched live, we were asked to share our process with these regulatory committees so it could serve as a roadmap for others.

One of the goals of the BRIDGE platform is to decrease the development timeline for deployment with successive clinics and disease conditions (**Fig. 2**). Therefore, BRIDGE was built in a modular manner to leverage the built integrations, logic, and visualizations, and allow for rapid development of clinic-specific dashboards. We met this goal by rapidly expanding to other clinics and conditions, leveraging the institutional approvals to save additional teams years of work to set up similar processes. We continue to use this modular infrastructure to enable and accelerate collaboration with other researchers and Departments. For example, to build for Dr. Ida Sim's AHRQ-funded project in primary care, *Improving the Management of Multiple Chronic Conditions with mPROVE*, we adapted the BRIDGE longitudinal and table widgets and integrated with the mPROVE mobile application data, to allow clinicians to view EHR and patient-reported data in a single BRIDGE dashboard.

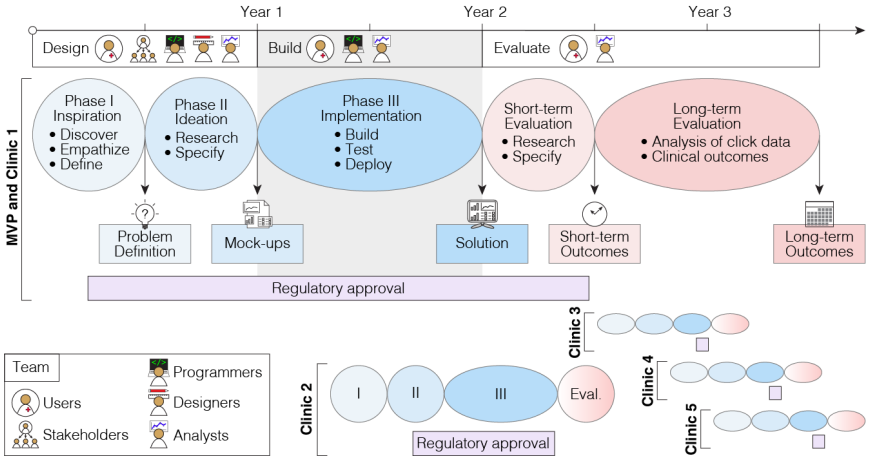

Figure 2. Example timelines and milestones of clinical application development. The design and development of BRIDGE is a multi-year. Following the principles and phases of human centered design ensures the development of a product that meets the needs of the users and the requirements of the institution. In parallel to the design and development process, institutional regulatory approval is critical and can risk becoming the rate-limiting step. Evaluation of the product initially focuses on user-experience, followed by clinical outcomes such as morbidity, mortality, or efficiency. The design and build time is dramatically reduced for clinic 2 and continues to fall as the process becomes refined and occurs in parallel. Abbreviations. MVP: Minimum viable product.

Goals and Achievements to Date

1. Development

Develop a scalable solution that integrates with the EHR and that can be adapted to other clinics, in and beyond UCSF. Our central goal is to enable clinicians in our participating clinics to access their patients' data in a visually appealing, clinically relevant and workflow-efficient format. We are achieving this goal via the following key steps: (a) Conducted an extensive human-centered design process to develop BRIDGE with the best technological approach for the overarching user interface and workflows (b) Navigated dozens of key institutional stakeholder groups with regulatory oversight at UCSF, to permit launching from the Epic (APeX) EHR (c) Iterated a focused human-centered design process for each clinical context, engaging clinicians, researchers, clinical and administrative staff, patients, and developers, to design a dashboard specific for that clinic, using existing and custom visualizations (d) Disseminating our approach within UCSF and to other institutions.

Dashboards

We have built and launched six clinic-specific dashboards after extensive user input and testing. The three clinics initially supported by BRIDGE are: Multiple Sclerosis, Memory and Aging Center, and Autism. We collaborated with clinicians in the Movement Disorders and Neurorecovery groups to define their specifications, build clinic-specific dashboards, and iterate based on feedback. Beyond the UCSF Weill Institute for the Neurosciences, we built a Primary Care dashboard that focuses on patient reported outcomes. Additional dashboards are under active development with more UCSF clinical groups.

2. Evaluation

Demonstrate the broad relevance of BRIDGE across clinical research and care. The holy grail of innovative digital technology is to improve our understanding and management of disease. We engage in short- and long-term evaluation of each new clinic's BRIDGE deployment. Our validation studies begin with simple stakeholder evaluations (user experience, patient and clinician care satisfaction, click data analysis, visit-level data analytics), and later expand to *in silico* trials evaluating the performance of novel algorithms. Our target is that eventually the application should: reduce physician time spent searching

for and collating disparate data sources, enable delivery of precision medicine to the bedside, and ultimately: enhance the function and lives of patients living with neuropsychiatric, and other, diseases.

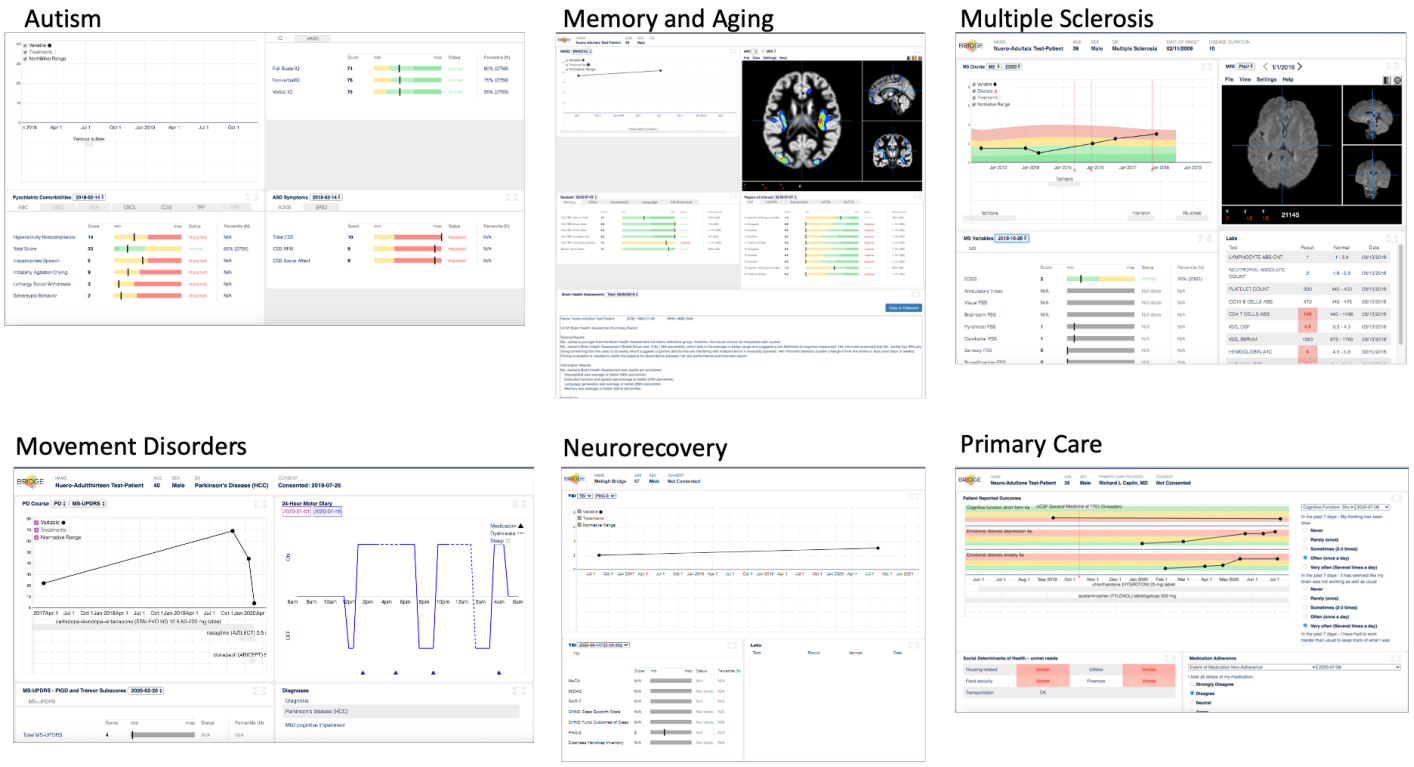

Fig 3: Screenshots of BRIDGE dashboards.

We are in the initial stages of this evaluation process, assessing usage, user experience and user satisfaction. The BRIDGE dashboard is live in six clinics and has been launched 2536 times. Larger implementation studies such as randomized controlled trials of BRIDGE dashboard use are planned in some of our clinics during the next 6 months to better demonstrate impact. We are also systematizing and modularizing the evaluation process to make it easier for different clinics to apply best practices to evaluate the effectiveness of their BRIDGE dashboards.

The following user feedback was culled from the validation studies currently underway (MS, Primary Care, Movement Disorders):

Clinician (MS):

- "It is invaluable to see a patient's reported mood right in the dashboard, with a flag for concerning values, and evidence-based resources to inform my choice of medications at my fingertips"

Collaborating PI (Primary Care, Dr. Ida Sim):

- "BRIDGE offers extensive time and costs savings for my projects by integrating and delivering my patient-facing tools right into the point of care."
- Precision Medicine Leadership: "You name a disease and I'll find a use for this"

Patient feedback:

- “Fast and easy”
- “Discussing adjustment of my medication as it relates to the wearing-off of med as revealed by BRIDGE”
- “A clearer picture of how my meds are working at different times throughout the day/night in comparison with when the dose was taken.”

3. Expansion

BRIDGE was designed for scalability. Our goal is to partner with clinicians and researchers across departments to continue expanding our library of data integrations, processing pipelines, algorithms, and visualizations. Our current data sources are EHR data, imaging, patient-reported outcomes, research data available in a number of platforms (REDCap, Qualtrics, etc.) and custom research databases. We are expanding our data sources to include genetics, biomarkers, and patient-generated wearables data. Current data analytics pipelines include disease risk and progression scores, medical image quantification algorithms, clinical decision support (CDS) tools, and the novel multimodal knowledge network SPOKE. We are collaborating with clinicians, researchers, and data scientists to create real-world monitoring and automatic alerts for clinicians, advanced imaging processing pipelines, advanced clinical decision support algorithms, treatment response predictors, and data processing to determine disease classification and prediction.

BRIDGE across the UC system. There has been substantial and broad enthusiasm for developing BRIDGE-like platforms at collaborating institutions, including other UCs (UC Irvine) as well as Neurohub partners (University of Washington).

Summary

Innovation: BRIDGE is built by clinicians for clinicians. Our small team has worked with multiple groups and departments to build a human-centered precision medicine platform.

Broad positive change: BRIDGE is a modular and scalable platform. It is built to be extended across every aspect of patient care and for all clinicians.

Collaboration: BRIDGE started through a collaboration across three clinical research groups (Autism, Memory and Aging, and Multiple Sclerosis) and the BRIDGE team continues to actively expand to collaborate with other clinical research groups including: Parkinson's, Neurorecovery, and Primary Care.

Efficiency or usability/accessibility: We built the BRIDGE platform through a human-centered design process and for each dashboard that we create with clinicians in order to refine the user experience and make BRIDGE usable for all.

Shareable, interoperable: BRIDGE was built using technical standards in order to make it readily transportable to other EHR systems.

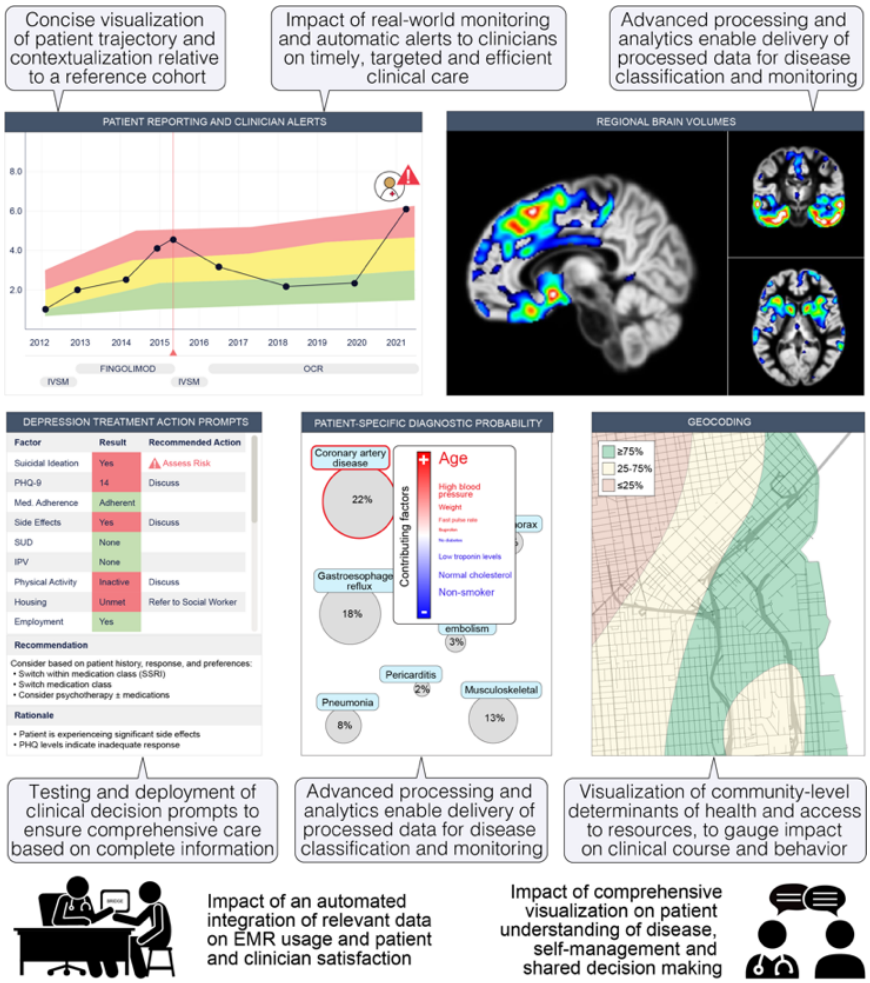

Figure 4. Examples of types of clinical research enabled by BRIDGE visualizations (actual

In conclusion: BRIDGE brings precision medicine to the clinic, giving UC a strategic advantage in delivering world class care. The current healthcare approach makes it very difficult for clinicians to find all necessary EHR data, even more difficult to find externally collected data, and almost impossible to see algorithmically generated scores and insights for their patients at the point of care. Many medical centers are reaching for the goal of precision medicine but lack the infrastructure required to efficiently build tools that meet the needs of each clinic. Through BRIDGE, we have built the infrastructure necessary to deliver precision medicine at the point of care in the UC system. In the next few years, we will see the expansion of BRIDGE across clinics and sites. Translating research into clinician-accessible platforms is critical to advancing the standards of care and healthcare delivery, and we believe that BRIDGE is the link that will allow the UC system to achieve this vision.