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* Technology reports follow the same structure as full papers. However, instead of methods and results, there should be Development and Application sections (IDAD – Introduction, Development, Application, Discussion). They should not exceed 2,000 words and six diagrams or illustrations. The abstract is limited to 250 words.
* The development section should describe the generic type of technology, i.e. how it was developed and the barriers/technical challenges that had to be overcome to develop it.
* The application of the technology section should describe the context in which the pilot application or other technology should be used and give any early feedback about its use. Even limited real world data is useful in this section. Wherever possible, a link to a demonstration website should be provided.

Using Cloud-Based, Opensource Technology to Evaluate, Improve, and Rapidly Disseminate Community-Based Intervention Data.

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**Abstract (250 words)**

**Introduction:** The Building Uplifted Families (BUF) Intervention is a multi-sector community effort to address social and economic disparities in Charlotte, North Carolina. Formative evaluation strategies, enhanced with health information technology, were used to support iterative process improvement and collaborative engagement. To address challenges in electronic data collection, we developed the BUF Rapid Dissemination Model (BUF RD Model), a structured, multi-stage data governance system supplemented by opensource technologies.

**Development:** Our model organized the collection and integration of data from disparate sources, and the dissemination of key results through an interactive dashboard. The system design requirements were identified using key informant interviews and regular meetings with users. Data were collected using REDCap Cloud and Google Driveand imported into RStudio for data cleaning and processing. An RShiny Dashboard was developed and housed using the RShiny Server. The dashboard user interface reflected the program’s logic model and displayed progress toward key program goals.

**Application:** The BUF RD Model was successfully deployed in a 6-month beta test to reduce the time lapse between data collection and dissemination from 3-months to 2-weeks. The dashboard became a tool that was used at leadership team meetings to review progress and stimulate discussion around project implementation barriers and potential solutions.

**Discussion:** Implementation challenges included: i) major changes in the evaluation structure; ii) frequent staff and leadership turnover; iii) reduced efficiency from co-occurring activities; and iv) partnership trust and buy-in challenges. Recommended solutions includeformative evaluation strategies to adapt work and regular self-evaluation for resource and personnel coverage.

**Background**

Health and economic disparities are a function of structural and social inequalities described by the World Health Organization as social determinants of health (SDoH); the conditions in which people are born, grow, live, work, and age that are shaped by the distribution of money, power and resources at global, national, and local levels1. These disparities have alarming consequences- over one-third of the annual total deaths in the U.S. are attributable to social and economic factors including income inequality and low educational attainment, according to a meta-analysis of almost 50 studies2. The Charlotte-Mecklenburg county of North Carolina (NC) is a community with recognized health and economic disparities. A national study by Chetty and colleagues ranked the Charlotte-Mecklenburg county 50th out of 50 major metropolitan cities for economic mobility (i.e. moving from low- to high-income)3. This community is the focus of an innovative collaborative effort to address SDoH, in part through improving access to community resources4.

The Building Uplifted Families (BUF) initiative is a local community transformation effort to reduce health disparities and improve economic mobility in one of the county’s most distressed neighborhoods. Led by the Renaissance West Community Initiative (RWCI), a residential non-profit organization, BUF involves an unprecedented cross-sector community partnership among local healthcare systems, non-profit health and human service organizations, a local academic institution, and the county’s public health department. BUF was funded as part of the national BUILD Health Challenge which focuses on strengthening cross-sector community partnerships to advance equity (https://buildhealthchallenge.org/communities/2-building-uplifted-families). The BUF intervention is delivered through a team of Life Navigators that work one-on-one with RWCI residents to address SDoH factors of healthcare access, employment, and education through the development and implementation of individualized goals, and the targeted referral of residents to community resources.

Effective communication and maintenance of a shared vision among a diverse team of cross-sector partners are critical barriers to success in in complex community improvement efforts such as BUF5. Formative evaluation strategies can be used to overcome these barriers by using preliminary results to support iterative process improvement and collaborative engagement6–8. Technology and electronic data collection can enhance formative evaluation methods9,10. The BUF Intervention used health information technology (HIT) to collect data electronically through REDCap Cloud11, a third-party, cloud-based system built on an opensource database created by Vanderbilt University and supported by the National Institute of Health. Cloud-based data systems can address many logistical and security barriers for complex cross-sector data collection; and third-party facilitation of cloud storage (e.g., outsourcing to REDCap) is endorsed by experts in the field of data security12–14. Additionally, cloud-based data systems can be enhanced with other technology and computing solutions using system automation15 and decision support from artificial intelligence (AI) algorithms16.

Our application of REDCap Cloud was challenging due to the number of involved stakeholders and concurrent intervention activities, as well as the dynamic and pilot nature of program implementation. To address these challenges, we developed the BUF Rapid Dissemination Model (hereafter BUF RD Model), a structured, multi-stage data governance system supplemented by advanced and opensource technologies. This manuscript will describe the development of the BUF RD Model and results from our pilot deployment.

**Development**

The BUF RD Model was designed to manage the collection and integration of data from disparate sources, monitor implementation and program progress, and to visually represent key findings using an interactive dashboard. Dashboards have been used in healthcare settings to improve patient care and safety by giving providers access to tailored information to support decision making17–20. In community settings, dashboards can be used as part of formative evaluation process to monitor intervention activities and shape adaptive interventions21. The following sections describe our development process.

**Engineering Methods**

**BUF RD Model.** To anchor thedesign process, we identified a key model function goal of reducing the time lapse between data collection and dissemination through the dashboard. A detailed assessment of system requirements and current infrastructure limitations was conducted using key informant interviews and regular meetings with service providers and the program manager. The methods for achieving our model function goal were identified as: i) automating data cleaning and integration protocols to reduce manual labor; ii) standardizing the access and exchange of key programmatic data with the program manager; and iii) creating a flexible and adaptable system to incorporate new data sources and allow for rapid iteration of the model.

**BUF Community Dashboard.** The results of our work culminated in the BUF Community Dashboard as a dissemination tool to rapidly communicate progress towards key program goals. The BUF Intervention was structured using a logic model to plan program activities that were tied to project goals with measurable outcomes22,23. Linking program measures to a strategic and responsive planning process is a key ingredient for successful community development measurement systems24. The BUF logic model was developed by all of the project stakeholders who were engaged through a Partnership Advisory Board (PAB). The prototype dashboard user interface was organized using the BUF logic model framework and then reviewed by the PAB with feedback incorporated as it was received.

The system architecture, dashboard user interface, and all associated data integration, cleaning, analysis processes were designed and led by the lead author, Carlene A. Mayfield. The REDCap Cloud system design and development was led by Jainmary Jones, Leslie Snapper, and Margaret Gigler, with initial research and support from Saugat Karki.

**System Requirements**

The existing structure of the BUF Intervention presented specific design challenges. A set of system requirements were identified in response to these challenges, summarized and presented in Table 1. Our work supported an ongoing community intervention effort with evolving evaluation planning and implementation methods. This required a level of flexibility and customization that was not possible with the standard REDCap Cloud dashboard functionality and made other off the shelf software products unusable. The BUF Intervention also had extremely limited resources relying on graduate students and volunteers to build the technology and therefore required free solutions with support from the opensource community. Any additional software and technology solutions had to be compatible with REDCap Cloud and not introduce interoperability challenges with data integration. The user-base for model outputs (e.g., dashboard) required an easy, barrier-free access to account for limited time and attention from users. For this reason, the use of login and password protected access was ultimately rejected, resulting in additional considerations for data analysis to account for reduced security through removal of any identifiable client information from the dashboard. Lastly, the system design needed to be scalable beyond the current application and able to incorporate additional layers of optimization as project goals, funding, and support changed over time.

[Table 1]

**Technology**

**Data Collection.** The BUF Intervention was originally designed to collect identified, individual-level participant data electronically using REDCap Cloud11, a third-party, cloud-based data collection system in compliance with current federal privacy and security laws (HIPAA 1996 and HITECH 2009). The REDCap Cloud application programming interface (API) is compatible with opensource programming language, allowing for easy integration with other technology solutions. Our design process identified the need for program-level data collection and an opportunity to respond to the specific reporting needs of the program manager. Therefore, we expanded the data collection methods to include Google Sheets, a shared cloud-based spreadsheet available through Google Drive. This method allowed the analyst to record and subsequently share de-identified, aggregate counts of participants with the project manager in exchange for program-level data recorded in the same folder (e.g., frequency of community events and stakeholder attendance at PAB meetings).

**Data Integration, Analysis, & Dissemination.** The degree of data manipulation that was required for usability prioritized an integrated software platform with combined functionality for data management, analysis, and dissemination. We selected RStudio25, a free opensource statistical software solution to develop semi-automated scripts for data integration, cleaning and analysis. In addition, RStudio has a dashboard function, RShiny Dashboard26, with a built-in server application available through: [www.shinyapps.io](http://www.shinyapps.io) to house dashboard applications. This server space is available for free at the base level, with additional space and services available by subscription. In addition, applications run in individual protected environments with SSL encryption that complied with the project’s security needs for protecting patient health information (PHI).

**Application**

**Implementation.** The system design for the BUF RD Model is presented in Figure 1. Data were collected by multiple sources including the Life Navigators that work one-on-one with participants as well as the project manager (Figure 1: Source). Multiple levels of data were collected including the individual participant-level, as well as the program, environment, (e.g., RWCI), and leadership-levels using both identified and de-identified methods (Figure 1: Population). Different types of data were collected including both self-report and objective assessments (Figure 1: Types). Individual-level, identified data were collected using REDCap Cloud, while other aggregate-level, de-identified data were collected using Google Sheets or by other report forms (Figure 1: Technology and Dissemination). Data were manually downloaded from REDCap and other sources (e.g., Google Drive) and imported into RStudio using an import script. Data were cleaned and processed in RStudio, including the user interface and server scripts through the RShiny Dashboard package, and pushed out to the RShiny Server.

[Figure 1]

Some data were collected at multiple timepoints to allow for an assessment of changes over time (i.e., trends). The system design for select trends is presented in Figure 2. For this example, only trends for individual-level, participant data collected by Life Navigators using REDCap are depicted. Participant demographic and programmatic data were collected at enrollment (Figure 2: Enrollment & Demographics), along with baseline measures for focus areas aligned with the program’s logic model (Figure 2: Workforce & Education; Preventive Health). Follow-up data for focus areas were collected at 6- and 12-month time periods after initial enrollment.

[Figure 2]

**Beta Results.**  The BUF RD Model was deployed for a 6-month beta test to support the BUF Intervention. During this period, the time lapse between data collection and dissemination was reduced from 3-months to 2-weeks. In addition, the BUF Community Dashboard became a tool that was used at all subsequent PAB meetings and select team meetings to review progress and stimulate discussion around project implementation barriers and potential solutions. The current BUF RD Model includes some manual steps that necessitated a minimum 2-week lag between data collection and visualization in the dashboard. However, parts of this model will scale to a fully automated system with data import through API connections between RStudio and REDCap Cloud.

A prototype of the BUF Community Dashboard displaying simulated data is available using the following link: <https://carlene-mayfield.shinyapps.io/BUF_Dashboard/>.

**Discussion**

The BUF RD Model was successfully deployed in a 6-month beta test to reduce the time lapse between data collection and dissemination. This effort used opensource technology solutions to supplement a HIT, cloud-based data collection system. Throughout implementation and testing we had to overcome several specific challenges, resulting in practical lessons for the future applications of this work. Specifically our challenges included: i) major changes in the program’s evaluation structure during the first 6 months of the implementation process; ii) frequent staff turnover and changes in the overall partnership structure; iii) the co-occurrence of program implementation and data collection system development that reduced the efficiency of work; and iv) limited experience in electronic data capture among team members and community partners impacted trust and understanding of how the data could be used to enhance project implementation.

To overcome these challenges, we used formative evaluation strategies to adapt our work during major transitions and build partnership trust and buy-in. First, we included users in the design and development process through regular meetings for user feedback and observation of technology use. Second, we proactively developed example technology solutions for real-world testing that empowered our users by reducing manual labor and improving efficiency (e.g., data exchange through Google Drive). The degree and frequency of turnover among staff and leadership was a continuous challenge that impacted all areas of the program. In similar evolving community-based efforts, we recommend a regular internal evaluation of personnel, resources, and coverage of the roles and responsibilities necessary for successful implementation of the BUF RD Model (Table 2).

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**Supplemental Materials**

**Appendix A.** BUF Community Dashboard Data Cleaning

[BUF\_mock\_data\_cleaning.R]

**Appendix B**. BUF Community Dashboard UI Code:

[ui.R]

**Appendix C.** BUF Community Dashboard Server Code:

[server.R]