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An Overdose Forecasting Dashboard for Local Harm-Reduction Response

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Abstract

As the United States grapples with an ongoing overdose crisis, states and jurisdictions are adopting novel approaches to reduce overdose mortality. In one novel approach, public health researchers and leaders in Rhode Island leveraged the state's robust surveillance data and collaborations between government, academic, and community-based organizations (CBOs) to launch the PROVIDENT (PREventing OVERdose using Information and Data from the EnvironmeNT) project, a population-based randomized controlled research trial ([NCT05096429](#)) in December 2019. The PROVIDENT trial utilizes machine learning (ML) methods to identify neighborhoods at risk of future overdose deaths at the census-block-group level to inform community-level overdose prevention resource distribution. To disseminate the ML model predictions, our research team developed an interactive, online mapping dashboard in close collaboration with three statewide CBOs. We measured whether these organizations utilized the PROVIDENT dashboard to allocate harm-reduction services based on ML model predictions and collected information about their data-driven decision-making processes. This case study describes how we assembled and piloted this overdose forecasting dashboard for use by CBOs between November 2021 and August 2024. By measuring dashboard logins, completed surveys, and engagement with ongoing training, we illustrate how organizations utilized ML and surveillance data to inform their outreach efforts and generate valuable insights at a neighborhood level.

Keywords

overdose prevention; machine learning; forecasting; predictive analytics; data dashboard; data visualization; GIS; neighborhood; community organizations

BACKGROUND

The overdose crisis in the United States claimed over 100,000 lives in 2023, driven by synthetic opioids such as fentanyl (Ahmad et al., 2024). Many public health practitioners have utilized surveillance data to inform their overdose response. Data dashboards often house overdose surveillance data, but little is known about what data are most informative for overdose prevention efforts. In addition, data may not be available at local geographic resolution, presenting limitations to informing local responses.

Machine learning (ML) can be used to gain insights into patterns in data and has aided in predicting public health outcomes related to disease and mortality risk, crime, and clinical prognosis (Mhasawade et al., 2021; Xia et al., 2021). ML methods have also been developed to identify specific subpopulations or neighborhoods with elevated future overdose risk (Neill & Herlands, 2018). Recent literature offers promising examples of how ML can predict overdoses at the community level, presenting new avenues to inform overdose prevention services and maximize the effectiveness of life-saving resources (Allen et al., 2023, 2024; Schell et al., 2022). Effective integration of ML predictions into prevention requires presenting results to public health practitioners in straightforward and accessible ways so that they can readily be leveraged to inform overdose prevention resource allocation. Few examples exist of efforts to combine ML methods with a community-focused tool to engage overdose prevention organizations in using predictions in service allocation.

In Rhode Island (a state with a historically high overdose burden), government, academic, and community-based organizations (CBOs) have collaborated over the last decade to develop accessible overdose prevention data dashboards and decision-making tools (J. Yedinak et al., 2024). The PROVIDENT (PReventing Overdose using Information and Data from the EnvironmeNT) project, a statewide community-based randomized controlled trial launched in 2019, brought ML and a community engagement process together to promote the use of ML predictions for overdose prevention (Marshall et al., 2022). The ML model for PROVIDENT forecasts overdose from the state's multicomponent overdose surveillance system, including overdoses, emergency medical services, substance use disorder treatment, and publicly available data including American Community Survey (ACS) data at the census-block-group level (Allen et al., 2023; Schell et al., 2022). The primary aim of the PROVIDENT trial was to test whether providing CBOs with predictions of neighborhood-level future overdose risk could lead to reductions in overdose mortality compared to traditional surveillance data.

In this paper, we describe the development of an online, interactive, community-focused web tool that displayed the PROVIDENT overdose forecasting results (provident.preventoverdoseri.org). The dashboard was designed to inform service provision for harm-reduction organizations in Rhode Island to support the main aim of the PROVIDENT trial. By providing a web tool and ongoing technical assistance, we hypothesized that CBO staff would access the PROVIDENT dashboard to utilize ML model results and inform their allocation of harm-reduction services.

METHODS

The PROVIDENT project began in December 2019 with the creation of an ML model, described previously (Allen et al., 2024; Marshall et al., 2022). In brief, the census block group-level (i.e., neighborhood) model projections identify the top 20% of neighborhoods in towns across Rhode Island by future predicted overdose risk with the goal that those neighborhoods will include at least 40% of statewide overdose deaths. Projections were updated semi-annually and displayed in the web tool, with the last update in July 2024. To distribute model results and inform statewide overdose prevention efforts, we developed an implementation plan to (1) create an online interactive dashboard to visualize model results, (2) partner with and train CBOs to access the results and utilize the dashboard, and (3) engage with organizations throughout the study to train new staff and improve the dashboard.

We partnered with harm-reduction organizations identified by the Rhode Island Department of Health as responsible for distributing a majority of overdose prevention supplies and materials across the state (e.g., naloxone, fentanyl test strips, education) and having the staffing capacity to utilize our dashboard. These organizations had previously collaborated with the research team to inform the development of existing statewide data dashboards (J. L. Yedinak et al., 2021; J. Yedinak et al., 2024). Partnering organizations received compensation (i.e., \$10,000 annually) for attending training sessions, accessing an online dashboard, completing surveys after the model updates, and providing feedback to inform dashboard development. Partnering organizations were also provided iPads to access the dashboard in the field or office.

The PROVIDENT dashboard was launched in November 2021 with an 8-hour training delivered by research staff to participating organizations. The training was designed to orient organizations to the project and enhance their understanding of data, numeracy, and public health concepts to improve overall data literacy and capacity. Ad hoc 1- to 2-hour engagement activities (e.g., peer check-ins, training, technical assistance, and focus groups) were provided throughout the trial as new cohorts of staff joined and model predictions were released. During the first two years of implementation, the study team met monthly with dashboard users to facilitate discussions about surveillance data trends and organizational activities to increase the use of the PROVIDENT dashboard. Technical assistance sessions were offered to organizations to help troubleshoot dashboard issues and support individuals needing further training. Asynchronous training resources were hosted on the dashboard, including onboarding videos and training guides created by study staff (provident.preventoverdoseri.org/resources). Finally, we engaged with organizations through focus group sessions, discussing how they integrated the dashboard into their work (Gray et al., 2025). In response to organizational challenges related to the unprecedented COVID-19 pandemic, we offered additional CBOs within the state access to the dashboard in the summer of 2023.

We adapted frameworks from existing Rhode Island platforms the study team had developed to rapidly deploy the dashboard (J. Yedinak et al., 2024) and hosted the dashboard as a subdomain of a statewide overdose data dashboard maintained by the study team

(preventover-doseri.org) to enhance familiarity and buy-in among participating organizations (Figure 1). Participants could access two types of surveys embedded in the dashboard (see Supplement). The first survey, the neighborhood assessment, was designed for organizational staff to capture their knowledge and perceptions about a neighborhood, including service and resource accessibility in a neighborhood (e.g., naloxone, needles, and fentanyl test strips) and outreach perceptions (e.g., police activity, barriers to outreach, availability of basic services). The second survey, the neighborhood plan, was designed to capture staff activity (e.g., initiating or increasing a service, building local relationships), and assign details such as tasks and due dates. Additional follow-up planning surveys were automatically generated based on due dates as another opportunity for staff to capture progress and outcomes. Organizational staff could access completed surveys, via the dashboard and by printing them out, to guide weekly outreach efforts.

As part of the PROVIDENT trial, half of Rhode Island's 39 towns were randomized to receive ML predictions. Neighborhoods prioritized by the ML model as being at the highest risk of fatal overdose were given a designation (e.g., "prioritized by the PROVIDENT model") and displayed as shaded areas on the dashboard map (Figure 1). We provided additional ACS and US Census data to ensure all neighborhoods, regardless of designation, contained information that could aid decision-making. In addition, we developed symbology indicating whether a selected neighborhood had more, less, or similar resources (e.g., economic, housing, transportation) compared to neighborhoods in the city and across the state. We also used cellular telephone data from SafeGraph as a proxy to indicate locations with high foot traffic. Users could zoom into neighborhoods to view the top five visited locations (snapped to the nearest place of interest) to help guide outreach efforts, especially in unfamiliar or more rural areas.

The PROVIDENT online dashboard utilized Google Firestore, a cloud database, to store modeling results, neighborhood information (e.g., model predictions, ACS data, points of interest), user-entered surveys, user activity logs, and secure login information. We chose Firestore, in part, because it was free to use based on our anticipated dashboard activity and provided robust security features. We used Vue, a JavaScript framework, to create responsive navigation and display elements and for accessibility on desktop, tablet, and mobile devices. Code development was managed on GitHub, a developer platform, where the dashboard framework is freely adaptable under a GPL 3.0 license: <https://github.com/pph-collective/provident-app>.

RESULTS

Between November 2021 and August 2024, 36 unique users registered to use the PROVIDENT dashboard and logged in 562 times (Figure 2). Users included outreach workers responsible for distributing harm-reduction supplies as well as program directors, agency leaders, and data coordinators. Of the 809 census block groups included in the dashboard, users clicked on 631 (78%) at least once, zoomed into 356 (44%), and completed surveys in 84 (10%); users were more likely to create surveys in towns with neighborhoods prioritized by the ML model for PROVIDENT (83% vs. 27%) and were more likely to select or zoom into neighborhoods prioritized by the model (68% vs. 32%). A total of 37

engagement activities (e.g., peer check-ins, training, technical assistance, and focus groups) were held throughout the PROVIDENT Trial, totaling more than 50 hours of engagement time (about 1.5 hours per week). Our results indicate that, while use of the dashboard decreased somewhat over time, engagement trends demonstrated upticks following training opportunities, technical assistance sessions, and other supports, which may have helped sustain levels of user registrations, logins, and survey completions.

A total of 184 neighborhood assessment surveys and 49 resource plan surveys were completed throughout the study period. Organizations used assessments and plans to guide their work by choosing neighborhoods in the dashboard, assessing them, and then printing out completed plans to guide where to focus outreach efforts. Surveys captured a wide range of organizational services and planned activities at the neighborhood level (see Supplement). Assessment surveys captured services offered within neighborhoods and barriers to outreach, including police presence or logistics. Assessment surveys were also used to capture baseline knowledge and perceptions of a neighborhood before organizations began activities. Neighborhood plans captured organizational activities, including installation of harm-reduction vending machines, targeted relationship building (at libraries, town halls, businesses), outreach planning (scoping out parks, finding homeless encampments, meeting with members of the community), and harm-reduction awareness and supply distribution (door hangers, informational flyers, naloxone).

DISCUSSION

ML methods present new opportunities to leverage data in the public health decision-making process. It is increasingly important to understand the best ways to communicate ML findings across a wide range of audiences. Our results indicate that integrating ML results into an accessible, interactive, online data dashboard for community-based harm-reduction service providers can generate valuable neighborhood-level assessments and plans when paired with engagement and training opportunities. Organizations that accessed the PROVIDENT dashboard used ML predictions to guide their outreach efforts, including distributing harm-reduction supplies, building new relationships with businesses and community members, and increasing overdose awareness. Users were also more likely to investigate neighborhoods prioritized by the ML model, as indicated by a discrete shading on a map. This suggests visual methods to describe neighborhoods at increased risk of future overdose can be effective in influencing resource allocation. While we do not report quantitative findings from the assessment and planning surveys in this article, our qualitative findings indicate how organizational staff used them for targeted local response, including recording their neighborhood perceptions and tracking their progress. By the end of the trial, the repository of survey data tied to neighborhoods provided a rich tapestry of community-led insights. Future research should investigate how web-based decision tools can maximize the impact of ML methods on reducing overdose rates.

LIMITATIONS

Rhode Island's unique collaborative environment was built on years-long coordination between multiple state, research, and community organizations and may not apply to other jurisdictions.

IMPLICATIONS FOR PRACTICE

This case study offers promising insight into how ML methods can be integrated into overdose prevention decision-making at a community level. By pairing ongoing training and engagement activities with an accessible dashboard, CBOs could utilize ML and surveillance data to inform their outreach efforts and generate valuable insights at a neighborhood level. This case study can be valuable to CBOs or health departments looking to increase transparency around data and planning activities. Such a framework could be adapted to allow multiple organizations to see and contribute to statewide planning activities to give an evolving, community-led snapshot.

IMPLICATIONS FOR RESEARCH

ML applications should be regionally tailored to their intended users, and future research should explore the best methods to deliver this information for optimized uptake, use, and sustainability. Dashboard designers looking to integrate ML should consider whether the audience has the training bandwidth to utilize such results and whether staffing capacity exists to actively engage with dashboard users.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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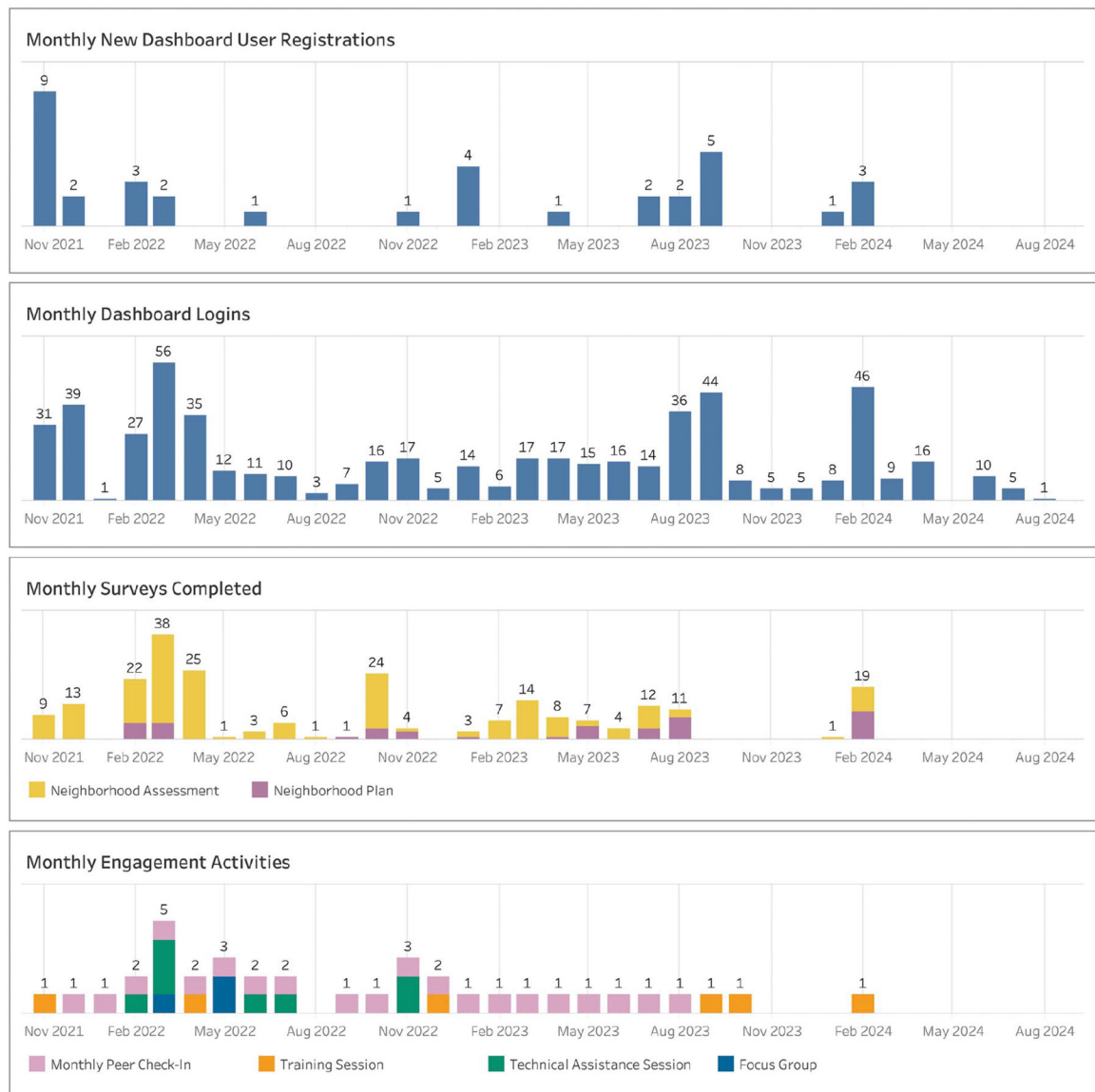


FIGURE 2.
PROVIDENT Dashboard User Activity (November 2021 to August 2024)