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Evaluating Public Health's Ability to Model Infectious Diseases: A Qualitative Investigation of State and Local Organizations

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Abstract: Tools for forecasting and modeling infectious diseases are essential for managing outbreaks. However, there is variation in state and local health departments' ability to use these technologies efficiently, which is impacted by things like financing, staffing levels, infrastructure, and data availability. The purpose of this study is to determine the state and local public health departments' present objectives, requirements, and capabilities with regard to infectious disease modeling and forecasting tools. Epidemiologists, informaticists, and leaders from state and municipal health departments in Montana, Utah, and Washington were interviewed as key informants. For thematic analysis, axial coding and thematic coding were employed. Three themes surfaced: (1) models and instruments need to be flexible according to the type of jurisdiction (state, urban, or rural); (2) Adoption is significantly preceded by the development of trust in models and tools; and (3) data availability and quality are issues. The need for flexible modeling techniques that are suited to particular public health jurisdictions is highlighted by this study. For modeling and forecasting techniques to be successfully implemented and used in a variety of public health contexts, it is imperative to solve data quality concerns and foster trust in these tools.

Keywords: Evaluating Public Health's, State and Local Organizations, Health, Infectious Diseases, Evaluating.

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Introduction:

For controlling infectious disease epidemics, modeling and forecasting technologies are becoming more and more crucial. These instruments forecast the transmissibility of pathogens, guide policy choices, evaluate the success of preventative and control actions, and distribute crucial resources in times of public health emergency. Global issues like climate change, which affects disease vectors, and growing globalization, which speeds up the transmission of viruses, have made accurate disease modeling more important. In these models, timely access to trustworthy data is essential since missing or out-of-date information might result in incorrect public health interventions. This requirement was especially clear during the COVID-19 pandemic, when containment tactics and susceptible people were protected by real-time data. Beyond infectious diseases, modeling has been crucial in tackling substance abuse and chronic disease prevention, highlighting its expanding significance in enhancing community health outcomes (Lewis, 2023; Hartsell, 2024).

During previous epidemics, public health organizations have used forecasting techniques and models in a variety of ways. For example, the World Health Organization used models to coordinate epidemic response units and determine worldwide vaccination programs influenza pandemic. The design of immunization trials was influenced by models that evaluated outbreak control characteristics. The "test-and-treat" approach to HIV prevention has been informed by models of infectious diseases. In these situations, prompt actions were made possible by models that were precise, flexible, and in line with each implementing agency's resource capabilities (Milwid et al., 2016).

Despite these achievements, there are disparities in the public health environment regarding the ability to use modeling and forecasting tools successfully. While local health departments (LHDs) operate closer to their communities and frequently have smaller budgets and staff, state health departments (SHDs) frequently have more resources, infrastructure, and data access. Many state and local health departments lack the staff, resources, equipment, and expertise needed to use sophisticated infectious disease modeling methods (Heesterbeek et al., 2015; Bertozzi, 2020).

On the other hand, while model developers at academic institutions possess the technical know-how to produce intricate models, they might not comprehend the requirements and capabilities of public health organizations. The disparities in the ability to use modeling and forecasting in the context of public health are highlighted by these structural variations as well as differing goals and resources. Models must be created with different degrees of technical competence, resource availability, and particular public health needs in mind in order to be effective (Metcalf, 2015).

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Even while modeling tools are becoming more and more important in public health, most of the research that is now available concentrates on the models themselves or the ability of healthcare systems to apply them. The ability of public health organizations, especially those at the state and municipal levels, to adopt and employ these technologies successfully has received far less attention. By offering qualitative insights into the needs, priorities, and limitations unique to each jurisdiction that influence public health involvement with infectious disease models, this study fills that gap (Kretzschmar, 2020).

Model makers must first comprehend the unique requirements of public health agencies and how they differ by jurisdiction to guarantee that public health infectious disease models are efficient and useful for state and local health departments. This study's goal was to determine the state and local public health departments' present objectives, requirements, and capabilities for infectious disease modeling and prediction tools in the US states of Montana, Washington, and Utah. The Mountain West Center for Forecasting and Surveillance of Infectious Threats and Epidemics will use the findings to inform the creation of infectious disease models. By offering qualitative information from several jurisdictions, our work seeks to close this gap.

Methods:

Study Design: To understand how infectious disease models have been used by SHDs and LHDs and to determine public health needs for future tool development, we carried out a qualitative formative evaluation using in-depth key informant interviews. To make it easier to collect potential users' viewpoints, a semi-structured interview guide was created.

Study Population: Participants required to be employed by a SHD or LHD and have some experience utilizing an infectious disease model or prediction to guide state or local public health decision-making in order to be eligible for the study. Participants were selected from state and municipal health departments via purposeful sampling, with an emphasis on those in leadership roles, epidemiologists, and informaticists. A study description and a request to find more participants within their agencies were included in the initial email correspondence. Two weeks later, follow-up emails were sent.

Data Analysis: The interview guide served as the basis for the deductive development of the codebook for thematic analysis, which covered topics like organizational capacity, data sources and availability, current infectious disease processes, priorities,

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and interventions, experience with pertinent tools, technical infrastructure, and resource availability.

Materials:

Public health departments for infectious disease modeling and prediction:

Our study's goal was to determine the state and local public health departments' present goals, requirements, and capabilities for infectious disease modeling and prediction tools in Montana, Washington, and Utah. Our results emphasize the necessity for flexible forecasting and modeling methods that take into account the various priorities and capacities of state and municipal health departments. In particular, we found notable differences between rural and urban health departments as well as between local and state health departments in terms of resources, technical infrastructure, data accessibility, and disease modeling competence. The National Association of County and City Health Officials' (NACCHO) national surveys and publications, among other public health contexts, have identified these discrepancies, which are not exclusive to our study (Corley et al., 2014; Lessler, 2016).

Smaller LHDs have many obstacles, such as a lack of informatics departments, employees that perform numerous functions, and dependence on the SHD for data administration and monitoring, even though SHDs frequently have the ability to conduct advanced modeling. When it comes to reacting to outbreaks, smaller LHDs are clearly at a disadvantage due to the lack of resources, especially in terms of staff and technical infrastructure (Knight, 2016; Hyde, 2012; Lewis, 2023).

For example, many rural LHDs rely on state agencies for data processing and storage because they lack the server infrastructure and computing capabilities necessary to host complicated models. They are forced to use reactive rather than proactive tactics because of this dependence, which restricts their capacity to produce real-time insights. Furthermore, more general systemic limits exacerbate these infrastructural limitations. A 2019 NACCHO research found that the majority of LHDs remained to rely largely on state and local funding sources and had static or declining preparedness budgets. Simultaneously, between 2008 and 2019, the local public health staff shrank by roughly 16%, with little increase in preparedness-specific positions like statisticians and epidemiologists. Building capacity and creating scalable solutions could close this gap and guarantee that smaller health departments can (Hartsell et al., 2024).

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Trust in modeling tools rebuilt:

Lack of confidence in the models is one obstacle to their implementation. During the COVID-19 pandemic, participants frequently reported receiving inconsistent or unreliable forecasts, raising questions about model fidelity. This implies that open communication regarding the model's advantages and disadvantages is necessary to restore confidence in modeling tools. However, increasing transparency alone is not enough to foster trust in models; local validation is also necessary. Public health experts may be more inclined to trust models that are created and evaluated using data unique to a certain jurisdiction. The usability and credibility of models can be improved by regular updates based on local surveillance data and the development of user-friendly interfaces that can be successfully shared with the public and policymakers, according to reports. Involving local health departments in the design phase also guarantees that models are in line with their practice requirements. By encouraging a sense of ownership over the technologies being used, this participatory approach helps reduce distrust (DeSalvo et al., 2021).

Concerns regarding the availability and quality of data also surfaced as a crucial problem. The accuracy and usability of tools are diminished by inconsistent and inadequate data. There are several reasons why these problems with data quality occur. First, data collection across data sources including at the health system level is not harmonized. This makes it difficult to include data into analysis, which restricts comparability. Second, even though health IT standards have improved dramatically over the previous 20 years, there is still content diversity due to both technical constraints and clinical practices. highlighted that prompt access to high-quality data during the COVID-19 pandemic was hampered by the scattered nature of public health information systems and the reliance on manual data entry (Arrazola, 2022; Beck A, 2017).

To assist forecasting and public health decision-making, they promote investments in analytical capabilities and interoperable infrastructure. Our research indicates that data governance and sharing protocols may present more substantial obstacles to successful model adoption than the models themselves, even as technical modeling capabilities continue to progress. Approaches like Bayesian regression and multivariate imputation by chained equations (MICE), which can lessen the impact of data restrictions, may also be useful for future modeling endeavors (Mcfarlane, 2019).

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Rural jurisdictions challenges:

Due to lower population densities, rural jurisdictions confront unique difficulties, such as insufficient case counts to safeguard patient privacy, which restricts the use of the data in modeling. Effective disease modeling and outbreak response are still severely hampered by the difficulty of data exchange, especially between jurisdictions. The information transfer between states, local health departments, tribal, and federal institutions is frequently restricted by current rules, which leads to fragmented datasets that reduce model accuracy (Hartsell et al., 2024).

Health departments' capacity to respond to public health emergencies could be greatly enhanced by the establishment of regional or nationwide data-sharing systems, such as a health information exchange, which enable the real-time interchange of information. Strong privacy safeguards should also be taken into account in these frameworks to allay worries about sensitive data in smaller jurisdictions, where a lack of cases raises the possibility of identifying specific people. Technical fixes (such guaranteeing data standards) and legislative initiatives that promote more efficient data sharing will be needed to address these issues (Wallace, 2020).

Recommendations:

Our research offers several practical suggestions that could enhance the efficiency and usability of modeling tools for various public health agencies. We advise that the following recommendations be considered as tool developers proceed with developing infectious disease models and forecasts for public health:

- **First**, local and state health departments must have different perspectives. Models must have components that can be altered at the level at which they are being utilized, as well as the flexibility to adapt to demands or concerns at the jurisdiction level.
- **Second**, building trust and making interpretation easier requires a thorough comprehension of the logic behind model generation. Involve partners in pilot or testing projects to promote trust and buy-in.
- **Third**, developers must make sure the data needed for the model is accessible at all levels and adequate for the use case (i.e., the data must have high levels of completeness and quality).
- **Finally**, when developing a model, governance must be thoroughly taken into account. Examine whether some of the governance issues are eliminated by state-level implementation.

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Conclusion:

Understanding the various needs of health departments is essential as modeling becomes an increasingly important tool in public health. The purpose of this study was to investigate the needs, goals, and difficulties public health departments now have when implementing infectious disease modeling tools. Our findings highlight a number of crucial needs: first, there are differences between rural and urban settings, as well as different capacities and priorities of LHDs and SHDs; second, models are mistrusted at all levels of jurisdiction; and third, data quality and data governance issues are of concern. We suggest several crucial steps to close these gaps. Public health stakeholders should be involved in model testing and implementation, data governance and availability concerns should be given top priority, and modeling tools should be adaptable to jurisdiction-specific requirements. Lastly, to help public health agencies handle upcoming public health problems, continuous research and development is required. A more robust public health system that is capable of responding to infectious disease risks in an increasingly interconnected world can be made possible by ensuring accessible, high-quality data and stakeholder-engaged model development.

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