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Bridging health equity and technology: Integrating social determinants of health into real-time surveillance systems

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Abstract

Bridging this gap between health equity and technological tools by integrating Social Determinants of Health (SDOH) into real-time population health surveillance methods is becoming essential to managing the population's health responsively and inclusively.. This conceptual overview dwells on the theoretical backgrounds, existing practices, and prospects of how SDOH can be embedded in dynamic surveillance systems in public health. Based on important frameworks, such as the WHO SDOH model, the Dahlgren and Whitehead model, syndemic theory, systems thinking, and equity-oriented surveillance, this study emphasizes how health outcomes are determined by what is captured concerning the socio-economic and environmental contexts. Although the introduction of real-time surveillance tools like electronic health records (EHRs), mobile health applications and instruments, geospatial information systems (GIS), and artificial intelligence (AI) have enhanced the speed and scope of data capture, these technologies have mostly been clinically oriented. The review also outlines key obstacles to SDOH integration. Data fragmentation, insufficient standardized indicators, privacy issues, and the inability to deal with real-time data are the key obstacles to SDOH integration. It also points at potential initiatives like cross-sector collaborations of data-sharing, implementing health equity impact indicators, and predictive analytics that can be used to detect vulnerable populations. The paper's conclusion will propose creating standardized data models, ethical data governance frameworks, more investment in public health informatics, and pilot projects to demonstrate the practicability of various models. Finally, this paper argues in favor of a paradigm shift in how surveillance is conducted in public health surveillance, which is not just about monitoring the incidence of disease but also about questioning and dealing with the social determinants of health. This form of integration can be transformative in terms of more inclusive, equitable, and proactive public health systems.

Keywords: Social Determinants of Health (SDOH); Real-Time Surveillance; Public Health Informatics; Health Equity; Syndemic Theory; Data Integration

1. Introduction

This paper examines how digital innovations could bridge the connection between technology and health equity by real-time incorporating Social Determinants of Health into public health surveillance. Social Determinants of Health (SDOH) are describing a broad population of social, economic, and environmental social determinants, affecting individual and population health outcomes. These factors are income level, level of education, employment status, housing and ability to access medical services (World Health Organization [WHO], 2023). They all together determine the environment in which individuals are born, grown, live, work and age and are currently well-studied to be the most important determinants of health inequality among various communities (Braveman & Gottlieb, 2014). Real-time public health surveillance systems entail the regular, systematic gathering, assessment, and interpretation of health-related data to be used in decision-making and the act of intervention at the moment (Centers for Disease Control and Prevention [CDC], 2021). Being historically centred on monitoring the infectious diseases and health events, such systems are

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getting more tech-savvy and are now able to integrate more complicated data streams, such as behavioural and environmental (Lazarus et al., 2022). Nevertheless, the inclusion of SDOH in these systems is not high, though the effect of the social context on health patterns and results is clear. In this review, exploration happened on both conceptual basis and practice regarding the integration of SDOH into real-time surveillance systems within public health. It is an attempt to synthesise the current theoretical frameworks, outline the weaknesses of current surveillance practices, and suggest the strategic directions in relation to all-inclusive and equity-based monitoring practices. Instead of offering empirical evidence, the review takes a conceptual stance with the aim of offering a multi-disciplinary posture on how surveillance can be carried out in a more holistic way to represent reality as experienced by the populations, and more importantly, vulnerable groups. Since the landscape of 3 digital health technologies is constantly changing as well as our perception of SDOH, the conceptual review is most relevant. It allows testing various models and approaches, which are not limited by the available data sets or results in a particular case. This way, it provides a basis to future empirical research studies and system design, which integrate equity their central premise of the health intelligence.

2. Theoretical Frameworks and Concepts

An analysis of how Social Determinants of Health (SDOH) could be used in real-time public health monitoring involves contact with the primary theoretical frameworks that expound how social factors impact on the population health. These constructs can also curb to provide a conceptual basis in the design of surveillance systems beyond the clinical indicators to structural and societal forces (Solar & Irwin, 2010). Still one principle model is the Commission on Social Determinants of Health (CSDH) developed by the World Health Organization that separates health determinants into structural (e.g., socioeconomic policies, governance) and intermediary (e.g., living conditions, psychosocial factors) categories (WHO, 2008). This model emphasizes the demand to solve inequity and frames health disparities as outcomes of the unequal access to power, resources as well as opportunities. To provide surveillance, the framework is conducive to the inclusion of both upstream indicators (education and income) and downstream factors (housing and quality and social stressors) (Braveman & Gottlieb, 2014). In complement, there can also be found Dahlgren and Whitehead model, a view of health determinants of concentric circles around the individual, as proximal aspects of personal lifestyle to distal socioeconomic, cultural and environmental determinants (Dahlgren & Whitehead, 1991). This model in specific is beneficial in the area of conceptualising the various levels at which data must be captured into surveillance systems as well as stressing the importance of conducting a multi-level analysis of health determinants. The conceptual framework is further enhanced by the syndemic theory, which demonstrates that social inequities add to the tendency of several health problems to cluster and afflict each other (Singer et al., 2017). Syndemic theory was initially designed to comprehend the interaction between HIV, violence, and substance abuse among the marginalised groups; in particular, it emphasised the necessity of combined surveillance of the social and health factors. It is particularly applicable to complex emergencies, such as pandemics, since, in that case, race, housing, and income all contribute to health simultaneously (Mendenhall, 2017).

The second valuable perspective that systems thinking provides is the perception of health as an emergent of the many overlapping social, economic, and biological systems (Peters, 2014). Choosing this method would model non-linearity, feedback loops and adaptivity of systems- aspects that are important to efficient real- time surveillance in the dynamic environment. To take an extreme case, the mutual dependency between unemployment and mental health in the period of economic slowdown needs coordinated representation of shifts in the job markets, accessibility of services and overall psychological health (Luke & Stamatakis, 2012). Equity-oriented surveillance is becoming a well-known conceptual resolution with a strong emphasis on the deliberate enrolment of marginalised groups and systematic stratification of information on the basis of race, gender, and disability, and income (Ford & Airhihenbuwa, 2018). This tool questions the traditional practice of epidemiology because they reveal that aggregate data may hide the inequality and inform actions inaccurately (Pauly et al., 2019). It seeks to educate not only the description studies but also the interventions related to policy measures to respond directly to inequity in health (Baciu et al., 2017). In order to implement these structures, the technologies needed are the public health informatics and digital surveillance systems that support the requirements. PHI is based on the concepts of computer science and information management aimed at promoting health outcomes by enhancing data systems (Yasnoff et al., 2000; Magnuson & Fu, 2014). Electronic health records (EHRs), mobile health applications, machine learning models, and geographic information systems (GIS) can capture, process and spatially analyze SDOH information in near real-time. An example is the use of GIS to visualise differences in health in neighbourhoods using overlapping of health outcomes on social-economic indicators.

Furthermore, the sources of monitored data are broadened to sources of social media, internet search, and wearable devices which provide novel opportunities to track social conditions and behaviours as they change with time (Salath 2012). In spite of the ethical implications of these innovations that concern consent and privacy of individuals (Vayena et al., 2015), they present promising ways of incorporating SDOH and adaptive, responsive mental health surveillance. In tandem, these frameworks help focus on a more holistic, equity-centred, and system-based approach to how an

effective, and an impactful surveillance solution should be designed, so that it is not only rigorously analytically but also responsive to social realities (Garg et al., 2022).

2.1. Social Determinants of Health: Key Dimensions

Social Determinants of Health (SDOH) are those factors that are not related to medication, but have the greatest influence on health status and balance the inequalities in different populations (WHO, 2023). Such dimensions are education, income, housing, employment, and social cohesion, which all have an impact on the environment under which individuals work, live, and socialize (Braveman & Gottlieb, 2014). The education impacts the health literacy, employment opportunities and earnings. The better an education level, the healthier behaviours and the easier the access to care (Cutler & Lleras-Muney, 2010). Conversely, the less educated a group is the more likely they are to have chronic disease and have a shorter life expectancy. Earnings are the key to access to basic resources such as healthy food, secure housing, and medical services (Phelan et al., 2010); poverty increases stress and health hazards (Adler & Rehkopf, 2008). The quality of housing determines the exposure to the dangers, and insecurity or homelessness contribute to the development of a disease and mental illness (Fazel et al., 2014). Working helps to give people financial security and social roles, but job loss, insecurity, and bad working environment may contribute to a lower level of health (Benach et al., 2014). Resilience and wellbeing are caused by social cohesion whereas disparities are aggravated by isolation and discrimination (Kawachi & Berkman, 2000). Nevertheless, it is hard to incorporate SDOH within real-time surveillance. Information is usually obsolete, non-harmonised, or accumulated in non-health areas (Diez Roux, 2011; Magnuson & Fu, 2016). The sharing of data is also hampered by privacy issues and concerns of ethics (Vayena et al., 2015). In order to conduct information-thorough, timely, granular, and cross-sector data-driven, the development of systems with the possibility of collecting this information is a necessity (Garg et al., 2022).

2.2. Current State of Real-Time Public Health Surveillance

Real-time surveillance in the field of public health implies the real-time gathering and processing of health-associated information that ensures immediate actions in the sphere of public health (Chiolero et al., 2021). It is unlike the traditional methods because it allows quick reaction to new threats with the aid of systems like the syndromic surveillance that includes tracking of the pre-diagnostic symptoms (Henning, 2004) and digital detecting of diseases by using online sources of information, i.e., search queries and social media. The technologies behind this would be Electronic Health Records (EHRs) that offer real-time clinical data (Adler-Milstein & Jha, 2017); mobile health (mHealth) skills, which monitor behavioral and physiological data and Geographic Information Systems (GIS), which visually depict health trends. To a greater extent, anomaly detection and predictive modeling based on large data sets become better realized with artificial intelligence (AI) and machine learning (Rajkomar et al., 2019). It has been boosted by the health emergencies worldwide, especially the COVID-19 one (Oliver et al., 2020). The cases count and vaccine coverage were monitored with the help of dashboards and similar systems, such as the U.S. FluView (CDC, 2022), opioid surveillance platforms (Dasgupta et al., 2018), etc. Nonetheless, the majority of systems are mainly concentrated on biomedical data. Social Determinants of Health (SDOH) must be incorporated into the provision of health to ensure a broader more responsive approach to health the goal of which is to eliminate health inequities.

2.3. Gaps and Challenges in Integrating SDOH

Incorporating the Social Determinants of Health (SDOH) in real-time surveillance systems of public health has a number of multilateral dilemmas. Fragmentation of data and insufficient interoperability is a crucial problem because SDOH information is distributed across systems and are stored in disparate platforms and with disparate standards in different domains, including housing, education, and employment (Magnuson & Fu, 2016). It does not facilitate the integration of data in a seamless process and restricts the ability to achieve real-time and comprehensive perspective of population health (Dixon et al., 2020). The other problem is the absence of standardized indicators and policy guiding (Braveman et al., 2011). In contrast to clinical data, SDOH do not have standard metrics that are accepted by everyone, which means that measures like housing insecurity or social isolation can hardly be tracked and compared across custodies (NASEM, 2019). Ethical, legal and privacy issues are a hindrance also given that SDOH data tend to entail sensitive personal data (Vayena et al., 2015). To ensure the trust of the people, the key issues of informed consent, possession of data, and stigmatization need to be addressed (Ienca et al., 2018). Technically, most of the surveillance systems have a problem with the timeliness, quality, and granularity of data and usually depend on the old sources or limited sources (Diez Roux, 2011). To clinch such gaps, policy amendments, ethical governance, and intensive investment in the interoperable data infrastructure will be needed (Garg et al., 2022).

2.4. Opportunities and Strategies for Integration

Nevertheless, it is becoming a possibility in real-time public health surveillance with the usage of such technologies as big data, AI, machine learning, and geospatial tools to implement SDOH. Information sharing across sectors is also

possible, which helps to see indicators of vulnerabilities early and allows prompt visibility at a higher level, but it needs good governance and interoperability frameworks. Health Equity Impact Assessment is a framework that focuses on the prioritisation of equity. Potential scale-up efforts such as the integration of housing data to asthma monitoring have potential, but requires political desire, capital in the form of investment, and human resources.

Recommendations

To improve the real-time integration of Social Determinants of Health (SDOH) as indicators, increasing interoperability to meet the requirement of standardised indicators or enhancing policy response through coordination is needed. Data investment and intelligent, multidisciplinary teams are also crucial to analysing and capturing real-time socioeconomic data. The legal and ethical systems should protect privacy and establish the population's confidence. At the same time, facilitating and assessing the pilot projects, especially with the collaboration of different sectors, can demonstrate the scale models and emphasise the feasibility of SDOH-informed surveillance. The combination of these strategies will not only increase responsiveness and equity of public health because it is based on social determinants of health.

3. Conclusion

Incorporating social determinants of health into real-time surveillance is a breakthrough in the equitable and responsiveness of people's health systems. Issues, including data fragmentation and ethical considerations notwithstanding, the current frameworks, such as the WHO SDOH model or the syndemic theory, are solid. The breakthroughs in science and inter-sector partnership provide new opportunities to capture and put into practice the social drivers of health. This includes surveillance to transcend disease monitoring so that systems can focus on health disparity causes. Putting people first by adopting equitable data management would make it clear that effective universal interventions in health are not just in time but treated socially fairly, as well. Finally, combining technology and equity with the help of SDOH-informed real-time surveillance will help evolve public health systems into more open, anticipative, and socially aware constructs.

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