The Role Of Laboratory Surveillance Systems In Early Detection And Prevention Of Outbreaks

Gabal Ghosun Mashan Alotaibi , Abdullah Omar Mohammed Omair , Abdulsalam Saud Said Alshallali , Adel Faleh Aljohani , Muteb Sulaiman Hamdan Albalawi , Muhanna Safar Musleh Almutari , Alya Awadh Alazmi , Hassan Mohammed Wadani , Ali Mohmmed Ali Khobrani , Ibrahim Saleh Alnafisah , Idris Hamoud Arar Zaeri , Jameel Abdulrahman Alnemari , Talal Jubayr Alharthi, Sayfullah Atiah Bakri

Abstract

The occurrence of worldwide pandemics has escalated in frequency during the last ten years as a result of inadequate operation of surveillance systems that manage data on human health. An examination was undertaken of alternative infectious disease Early Warning Systems (EWSs) through the lens of surveillance data collection methods and their applicability in various contexts, as part of a systematic review. 68 publications were selected for inclusion in the final sample out of 1669. Chief complaints extracted from emergency department data are effective EWSs, but require standardized formats across institutions, according to the study. EWSs based on centralized public health records facilitate the exchange of information but are dependent on clinicians' case reporting. Web-based EWSs provide several benefits, including expedited alarm transmission and simplified reporting. Laboratory results and pharmaceutical sales did not establish solo effectiveness. The integration of surveillance data from staff and health records into the EWS design yielded positive results, with the most effective augmentation strategy being the daily notification of surveillance data during mass gatherings. Enhancing and refining pre-existing systems held greater significance in Low Middle Income Countries compared to the implementation of novel syndromic surveillance approaches. The research assessed the efficacy of EWSs across various resource settings and contexts.

Keywords: laboratory surveillance systems, early detection, prevention, COVID-19 pandemic, outbreaks.

1. Introduction

The worldwide COVID-19 pandemic had an enormous impact on the economies and public health of every nation. Over the past decade, the frequency of global pandemics has increased, but there has been a failure to capitalize on opportunities to allocate resources towards preparedness and surveillance. By developing monitoring and early warning systems and enhancing the international exchange of information, the impact of global infectious diseases can be diminished [1]. In light of the COVID-19 pandemic and its emergent variants, the efficacy of Early Warning Systems (EWSs) in detecting infectious disease outbreaks has been called into doubt. Despite the emergency warning issued by Chinese ophthalmologist Dr. Li Wenliang in December 2019 regarding anomalous pneumonia cases, numerous countries, including the United States, failed to adequately respond [2]. Recently, The Economist developed a machine-learning model to estimate the number of additional fatalities in 223 countries attributable to the pandemic [3]. According to the model's estimation, the true number of fatalities exceeds the confirmed fatalities by a factor of 2–4 [3]. Global estimates place the number of additional fatalities attributable to COVID-19 between 20 and 25 million [3]. These losses are caused by the direct impact of the virus as well as the indirect repercussions on the already overburdened capacity of health systems in both developed and developing nations [4].

The recent transmission of the monkeypox virus serves as a poignant reminder of the criticality of diligently monitoring surveillance data in order to effectively contain outbreaks and promptly initiate response strategies, in light of the uncertainties and worldwide apprehension regarding a recurrence of the catastrophic pandemic that befell COVID-19 [5]. Despite this, the majority of governments worldwide continue to disregard investments in public health pandemic data systems within the health sector [4], despite the existence of substantial evidence to the contrary. As an illustration, Stefan Schweinfest, the director of the Statistics Division at the United Nations Department of Economic and Social Affairs (UN DESA), stated that accurate estimation of the consequences of

atypical health occurrences is hindered by the absence of data [4].

Recent research conducted in China has identified the accumulation, integration, and analysis of data sources as fundamental elements of a successful infectious disease EWS [6]. For instance, databases sourced from Emergency Departments (EDs), hospitals, public health organizations, pharmacies, and laboratories are being utilized as methods for monitoring infectious diseases surveillance. These databases would produce alerts that would prompt public health investigations and responses. Notwithstanding the extensive range of contemporary surveillance techniques, the efficacy of these systems and indicators fluctuates due to a multitude of factors, such as the availability of resources, the context of the diseases or symptoms being monitored, and additional population health and social considerations.

The susceptibility of global human health to established or emergent infectious diseases is widely acknowledged to be attributable to the suboptimal operation of surveillance systems that manage health informatics data [4]. To collect population data, these health informatics systems utilize a variety of mechanisms, including paper-based and digital systems; they are not restricted to technology alone, contrary to popular belief [7]. Thus, EWSs permit early detection of the apex of symptom levels surpassing the threshold prior to a surge in cases, as well as prompt identification of small clusters of cases prior to health systems becoming overwhelmed by the prevalent illness.

Nevertheless, an optimal and efficacious surveillance system has not yet been developed. The identification of atypical health occurrences that are indicative of early epidemics continues to be a formidable task. In this article, we present a systematic evaluation of the efficacy of various EWS designs with regard to the data acquisition methodologies they employ, taking into account their applicability in various resource settings.

As far as we are aware, this systematic review represents the initial attempt to assess the efficacy of surveillance systems. By synthesizing the peer-reviewed literature on the strategies and effectiveness of EWSs according to the methods of data acquisition, we bridge this divide. By observing patients' symptoms and confirmed diseases, respectively, we

conducted a systematic review and narrative synthesis of published studies on syndromic and sentinel surveillance for infectious diseases.

2. Surveillance

Surveillance is defined as "the continuous and methodical gathering, examination, and interpretation of health-related data that is crucial for the development, execution, and assessment of public health strategies. This process is intricately linked with the prompt distribution of this information to relevant parties" [8-10]. Early Warning Systems (EWS) consist of data-driven detection systems that employ health informatics data and infectious disease surveillance methodologies.

Surveillance methods include the monitoring of sales of over-the-counter (OTC) medications and diagnostic laboratory-based testing, through which early warning systems extract patient data from paramedical sources. It was not demonstrated that any of the three EWSs in the designated category operated independently [11-13].

3. Clinical correlation and laboratory compliance

Clinical correlation and laboratory compliance are the primary obstacles for lab-based EWSs. As an illustration, the Infectious Diseases Surveillance Information System (ISIS) of the Netherlands exhibited inadequate coverage, as solely 18 out of the 85 labs that were incorporated were linked to the central medical microbiology laboratories (MML). Therefore, the routine integration of positive and negative microbiological results into laboratory information management systems did not accurately reflect the situation in the Netherlands [14]. In addition, influenza specimens obtained in the laboratory do not represent the entire viral load. For example, respiratory pathogens, including respiratory syncytial virus (RSV), exhibit comparable symptoms to influenza and would therefore have a limited correlation with positive laboratory results for ILI [15]. However, it is not advisable to terminate the aforementioned ineffective systems in situations where laboratory EWSs offer current trends in the incidence of microorganisms and their suspension would result in the loss of critical epidemiological data [14].

However, the lack of traceability of cases poses a significant challenge when drug prescription sales are utilized

as a surveillance method. The ineffectiveness of the drug sales EWS in Tianjin as a supplement to the pre-existing influenza lab surveillance was hindered, for instance, by the lack of information regarding over-the-counter purchasers [16]. However, in spite of the New York City OTC-EWS data collection on prescription sales and information on medical visits beyond over-the-counter (OTC) drugs, Das et al. noted that the designated New York system served only as a supplement to surveillance in areas where ED diarrheal visits were more significant than gastrointestinal drug sales, and its effectiveness was limited to monitoring patients' levels [17].

Moreover, the dynamic OTC market and changes in consumer behavior pose distinct obstacles for pharmaceutical sales-EWSs. For example, if members of the public were to accumulate over-the-counter medications, this would obscure the true amount consumed due to acute illness [17]. In addition, the variation in drug formulations and the introduction of new drugs to the market present obstacles to the classification of syndromes based on over-the-counter sales-based EWS [17].

The assessment of the advantages of improving current systems as opposed to syndromic surveillance is a contentious topic, considering the difficulty of maintaining daily data transmission in settings with limited resources [18]. An example of this can be seen in the retrospective evaluation of the complete implementation of a web-based tool from Suite for Automated Global Electronic bioSurveillance Open ESSENCE (SAGES OE) for data storage in the Federated States of Micronesia and Samoa, during the 8th Micronesian Games and the third United Nations Conference on Small Island Developing States (SIDS), which were hindered by connectivity problems, insufficient computers, and a shortage of trained personnel [19].

Additionally, in SIDS, a spreadsheet-based substitute was implemented as a result of technical constraints with SAGES OE [18]. However, the authors emphasized that the designated enhanced surveillance system facilitated decision-making and served as a health security assurance system; it also improved communication channels between clinical, laboratory, and public health departments and had the potential to be fully integrated into routine surveillance [19,20]. The primary obstacles to lab-based EWSs are clinical correlation and laboratory compliance; laboratories' results may not reflect

the total viral activity due to their limited coverage [14]. However, it is not advised to cease operation of the aforementioned ineffective systems [15]. Moreover, the lack of traceability of cases constitutes a significant drawback when drug prescription sales are utilized as a means of surveillance. In addition, the dynamic OTC market and changes in consumer behavior present unique obstacles for pharmaceutical sales-EWSs [16].

4. Conclusion

Our research successfully assessed the efficacy of Early Warning Systems (EWSs) across various resource settings and contexts by analyzing the data collection methodology employed by EWSs. Consistent evidence suggests that EWSs that compile pre-diagnosis data detect outbreaks in a more proactive manner. Chief complaint data from emergency departments (EDs) is an effective EWS; however, it necessitates the implementation of standardized formats across all hospital EDs. The assets of telephone triaging systems include their simplicity, acceptability by health personnel, and national representativeness. Over time, inpatient systems may enable local epidemiologists to manually examine the daily surveillance data of hospitals.

EWSs based on centralized public health records facilitate the exchange of information; nevertheless, they are dependent on the case reporting of clinicians. It is noteworthy that human resources-based systems are more prevalent in least developed countries (LMICs), where none of the EWSs analyzed in this category were deemed ineffective.

Rapid alarm transmission and facilitated reporting through remote health settings are two of the most significant benefits of Web-based EWSs. Email-based systems present distinct challenges with respect to the integrity of data and the necessity for critical informants. Furthermore, EWSs associated with social trends operated effectively; however, they gave rise to apprehensions regarding their ability to accurately represent and conduct unethical, biased data collection.

Pharmacological sales and laboratory results failed to establish the efficacy of the drugs in isolation. The integration of surveillance data from staff and health records into the EWS design proved to be highly effective. Furthermore, daily notification of surveillance data was the most effective and

widely accepted enhancement strategy, particularly in the context of large-scale gatherings.

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