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Redefining syndromic surveillance

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Abstract With growing concerns about international spread of disease and expanding use of early disease detection surveillance methods, the field of syndromic surveillance has received increased attention over the last decade. The purpose of this article is to clarify the various meanings that have been assigned to the term syndromic surveillance and to propose a refined categorization of the characteristics of these systems. Existing literature and conference proceedings were examined on syndromic surveillance from 1998 to 2010, focusing on low- and middle-income settings. Based on the 36 unique definitions of syndromic surveillance found in the literature, five commonly accepted principles of syndromic surveillance systems were identified, as well as two fundamental categories: specific and non-specific disease detection. Ultimately, the proposed categorization of syndromic surveillance distinguishes between systems that focus on detecting defined syndromes or outcomes of interest and those that aim to uncover non-specific trends that suggest an outbreak may be occurring. By providing an accurate and comprehensive picture of this field's capabilities, and differentiating among system types, a unified understanding of the syndromic surveillance field can be developed, encouraging the adoption, investment in, and implementation of these systems in settings that need bolstered surveillance capacity, particularly low- and middle-income countries.

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Abbreviations: AIDS; acquired immune deficiency syndrome; CDC; Centers for Disease Control and Prevention; DOD-GEIS; Department of Defense Global Emerging Infections Surveillance and Response System; EWORS; Early Warning Outbreak Recognition System; ICD; International Classification of Diseases; IHR; International Health Regulations; ILI; influenza-like illness; ISDS; International Society for Disease Surveillance; IT; information technology; JHU/APL; Johns Hopkins University/Applied Physics Laboratory; SARS; severe acute respiratory syndrome; SBS; syndromic-based surveillance; SEARO; Regional Office for South-East Asia; SNS; syndromic-non-specific surveillance; STD; sexually transmitted disease; US; United States; USAID; United States Agency for International Development; WHO; World Health Organization.

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1. Introduction

The field of syndromic surveillance is best understood through the context of global efforts to respond and adapt to modern-day surveillance challenges and disease threats. Globalization and the ease of international spread of disease require improved global surveillance capacity in order to rapidly detect and contain public health emergencies. Recognition of this need has led to increased efforts to enhance disease surveillance and demands examination of all available tools-one of which is syndromic surveillance. Such thinking is exemplified by the World Health Organization's (WHO) decision to revise the International Health Regulations (IHR).

As part of the 10-year IHR revision process, WHO sponsored a pilot study in 22 countries from 1997 to 1999 to evaluate syndromic reporting. It was concluded that "syndromic reporting, although valuable within a national system, was not appropriate for use in the context of a regulatory framework" [1].

The final negotiated IHR (2005) regulates detection, reporting and response within a more adaptive category of "events that may constitute a public health emergency of international concern" [2]. The IHR (2005) also obligates every member state of the WHO to build national core competency for disease surveillance. However, the regulations do not prescribe exactly how nations are to meet this core capacity. Certain low- and middle-income countries-particularly those facing the need to rapidly strengthen disease surveillance and overall public health infrastructure to meet

their IHR (2005) obligations-may be looking to syndromic surveillance options and opportunities. A report from the IHR (2005) negotiations stresses this point: "Because areas with the highest needs for surveillance of communicable diseases have often the poorest surveillance systems, new surveillance approaches, such as the surveillance of syndromes, adapted to poor laboratory infrastructure should be developed to respond to the challenge of development gaps" [3].

In addition to the increased attention to syndromic surveillance in the negotiations of IHR (2005), syndromic surveillance has gained importance for national governments and has become widely used at the country level, particularly in high-income countries. Examples include a syndromic surveillance system in the United Kingdom based on data from the national telehealth system (NHS Direct) and a system in Denmark that utilizes ambulance dispatch records [4]. In the United States (US), state and local syndromic surveillance systems are widespread [5], as evidenced by a recent survey that concluded, "populations covered by health departments that reported conducting syndromic surveillance account for 72% of the US population" [6].

Spurred by a series of reports from the US Government Accountability Office [7] and other organizations [8], the US federal government has recently begun re-examining how to best ensure effective and efficient disease surveillance capacity. In this context, the Centers for Disease Control and Prevention (CDC) must re-evaluate biosurveillance for human health [9]. The United States Agency for International Development's (USAID)

PREDICT program aims to integrate human and animal disease surveillance, primarily focused on the implementation of programs in developing nations [10]. Researchers in the field of syndromic surveillance have similarly turned toward translating syndromic surveillance for use in lower resource settings [11–13].

A 2007 Disease Surveillance Workshop held in Bangkok, Thailand, sponsored by the Department of Defense Global Emerging Infections Surveillance and Response System (DOD-GEIS) and Johns Hopkins University/Applied Physics Laboratory (JHU/APL), focused on the adaptation of electronic surveillance tools to low- and middle-income settings [11]. In order to reenergize these discussions (which were begun by 13 countries and other stakeholders during the 2007 workshop), clarification of the definition, functions, and challenges of syndromic surveillance is needed. Doing so would help ensure that syndromic surveillance will be adopted in all places where it would be of benefit.

Since syndromic surveillance systems began being used in the 1990s and became widespread in early 2000, vast applications of these systems have demonstrated many capabilities and uses. There are numerous variations among syndromic surveillance system definitions, objectives, and surveillance methodologies, which is why there is a need for a comprehensive characterization of the breadth of the term “syndromic surveillance.” Common themes across the literature have emerged, suggesting general agreement among those in the field. The commonly accepted principles of syndromic surveillance include:

- *Early detection and response:* Most articles on syndromic surveillance discuss the value of these systems in signaling the presence of an abnormal trend with “sufficient probability” to warrant further investigation (without necessarily providing definitive detection) [14–20].
- *Use of “continuously acquired” pre-diagnostic information:* By focusing on data collected prior to clinical diagnosis or laboratory confirmation, syndromic surveillance uses non-traditional health indicator data [17,21,22].
- *Possible situational awareness use:* Chretien and his co-authors describe situational awareness as “monitoring the effectiveness of epidemic responses and characterizing affected populations” [12]. By providing a tool for following the course of an outbreak, syndromic surveillance has value besides merely initial detection in augmenting public health surveillance as well as outbreak response [6,11,15,23–25].

- *Providing reassurance that an outbreak is not actually occurring:* By monitoring outbreak thresholds, as well as collecting data from a variety of sources, a syndromic surveillance system can provide information to public health authorities confirming or refuting the occurrence of an outbreak [17,19,24,26].
- *Augments traditional public health surveillance:* In order to improve outbreak detection [13,17,19], several definitions of syndromic surveillance emphasize that its goal is to “enhance, rather than replace, traditional approaches to epidemic detection” [14].

Despite these points of agreement and the popularity of syndromic surveillance systems in many countries, there is still little or no consensus regarding a standard definition encompassing the full scope of the term “syndromic surveillance.” According to Mostashari and Hartman, the term syndromic surveillance is “imprecise and potentially misleading” [27]. The first point of confusion is the fact that “many of the systems under discussion do not monitor well-defined constellations of signs and symptoms (syndromes), but instead target non-specific indicators of health, such as a patient with a chief complaint of ‘cough’ or the sale of over-the-counter cold medication; conversely, many systems that do monitor syndromes (e.g., acute flaccid paralysis, Reye’s syndrome, or carpal tunnel syndrome) are not included in these discussions” [27]. Second, some refer to the term “syndrome” as a specific, clinically defined phenomenon, such as severe acute respiratory syndrome (SARS) or acquired immune deficiency syndrome (AIDS), and others use it more loosely and non-specifically as simply a group of symptoms [28].

Several researchers have proposed alternative names to differentiate the forms of syndromic surveillance; however, these suggestions for clarified terminology have not yet taken hold. Ten other names that have been proposed in the literature include: outbreak detection systems, early warning systems, health indicator surveillance, prodromal/ ic surveillance, information system-based sentinel surveillance, pre-diagnosis surveillance, nontraditional surveillance, enhanced surveillance, drop-in surveillance, and biosurveillance [12,19,27,28]. Problematically, these terms overlap, contradict, or are inconsistently applied, maintaining the terminological confusion. Further, several terms frequently applied to syndromic surveillance are not adequately descriptive to convey the type of system being referred to or do not distinguish between types of systems, and thus may not be appropriate as general, overarching terms. Given

the challenge of developing clearer terminology, the potentially confusing term “syndromic surveillance” is still being used [27].

Due to the significant increase in applications of syndromic surveillance, and the new technologies and expanded potential of the tool-demonstrated by the evolution of the proceedings of the International Society for Disease Surveillance (ISDS) conferences on syndromic surveillance [29]-it is evident that the field has expanded over the last decade. Thus, there is now an even greater need for a consensus about what syndromic surveillance means. Additionally, as plans to translate syndromic surveillance systems to lower resource settings proceed, a proper conceptualization of the systems could increase their acceptance and efficient use. The development and communication of a unified understanding of the field may encourage governments or localities to adopt, invest in, and implement syndromic surveillance, where appropriate, and thus enhance compliance with IHR (2005); this adoption in middle- and low-income nations is being explored in the ongoing work to identify exemplary case studies of successful utilization of syndromic surveillance [30]. The purpose of this article is to clarify the various meanings that have been assigned to the term syndromic surveillance and to propose a refined categorization of the characteristics of the systems.

2. Materials and methods

In an effort to capture the variety of definitions and explanations of syndromic surveillance in the literature, MEDLINE, Scopus, Google Scholar, proceedings from all ISDS conferences, and previous literature reviews and reference lists related to this topic were searched from 1998 to 2010. Search terms included “syndromic surveillance” and the 10 other terms mentioned above, which are considered synonymous with syndromic surveillance. In addition to general overview articles, the set of articles pertaining to country- and region-specific systems were narrowed by including the terms “low-income” and “developing country” to fit the emphasis on the translation of these systems to lower resource settings.

Through a review of titles, abstracts, and full-length articles, 81 general articles were identified describing and evaluating syndromic surveillance systems along with several hundred articles delineating surveillance systems implemented in specific countries or regions. Within the articles collected, those that defined syndromic surveillance or provided a description of fundamental

aspects of these systems were selected and compiled for comparison. In total, 43 separate articles defined syndromic surveillance, of which 36 provided unique definitions. A majority of the unique definitions found came from overview of articles of syndromic surveillance, rather than country-specific articles. However, the country-specific articles provided distinguishing examples of systems being implemented in various settings.

3. Results

Table 1 contains the 36 unique definitions of syndromic surveillance found in the literature. The five general points of agreement among those in the field and mentioned above are frequently noted in the definitions and are designated in the set of columns on the far right. The two shaded columns indicate that there are two fundamental categories of syndromic surveillance systems conveyed by the collection of definitions. These two categories involve the same investigational approach, and may even be components of the same system, but monitor two distinct outcome types: specific and non-specific outcomes. Within the two fundamental categories of syndromic surveillance (defined further below), all five principles are relevant, with the principles of early detection and response and the use of pre-diagnostic information being the most commonly referred to across the definitions.

3.1. Previous research

The literature review yielded multiple articles that noted the distinction between specific and non-specific surveillance systems. In a foundational article introducing the field of syndromic surveillance to a wider audience, Sosin explains that indicators of a disease outbreak can either be suggestive of “highly specific syndrome[s]” or “non-specific expressions of the target diseases that occur before a diagnosis would routinely be made” [18]. The following year, an article based on recommendations from a CDC Working Group contrasted surveillance of a syndrome that “is relatively specific for the condition of interest” (such as acute flaccid paralysis as “a syndromic marker” in the detection of poliomyelitis) to surveillance with a broader purpose, such as “sexually transmitted disease detection and control” [35]. More recently, Fricker differentiates “well-defined” data that are “linked to specific types of outbreaks” to data that are “vaguely defined and perhaps only weakly linked to specific types of outbreaks, such as over-the-counter sales

Table 1 Unique definitions of syndromic surveillance found in the literature, 1998–2010.

Article	Article makes reference to						
	“Specific Disease” category	“Non-specific Disease” category	Early detection and response	Pre-diagnostic information	Situational awareness	Outbreak re-assurance	Supplement to traditional surveillance
World Health Organization [1]	X						
World Health Organization [32]	X						
Buehler et al. [14]	X	X	X	X		X	X
Centers for Disease Control and Prevention [33]	X	X		X			
Pavlin [21]		X	X	X			
Reingold [34]	X	X	X				
Smolinski et al. [28]	X	X		X			X
Sosin [18]	X	X	X	X			
Sosin [19]	X	X	X	X		X	X
Buehler [35]	X	X	X	X			
MMWR Editors [36]			X	X			
Henning [26]			X			X	
Lombardo et al. [37]			X	X			
Mandl et al. [22]		X	X	X			
Stoto et al. [16]		X	X	X			
Ang et al. [38]							
Berger et al. [17]			X	X		X	X
Stoto et al. [39]	X		X	X			
Chaves and Pascual [40]		X					
Morse [41]	X	X					
Buehler et al. [6]	X	X	X	X	X		
Centers for Disease Control and Prevention [20]			X	X			
Chretien et al. [12]	X	X	X	X	X		
Chretien et al. [11]	X			X	X		
Fearnley [42]		X		X			
Fricker [43]	X	X	X				
Fricker et al. [15]	X	X	X	X	X		
Jefferson et al. [44]		X	X	X			
Nordin et al. [39]							
Tsui et al. [46]			X				
Buehler et al. [23]			X	X	X		
Gault et al. [47]			X				
May et al. [13]				X			X
Sintchenko and Gallego [24]		X			X	X	
Zhang et al. [48]		X	X	X			
Josseran et al. [49]		X					

Table 2 Specific vs. non-specific syndromic surveillance categories.

	“Syndrome-based” surveillance (SBS): specific disease/syndrome detection	“Syndromic-non-specific” surveillance (SNS): non-specific disease detection
Under-lying purpose	“Case detection and management of diseases when the condition is infrequent and the syndrome is relatively specific for the condition of interest” [35]	To answer the question: Is there anything unusual or unexpected that public health officials need to investigate? This category focuses on detection of signals that “do not have a specific risk event focus” [43]
System aims	A developed syndrome (such as SARS, AIDS, acute flaccid paralysis, or influenza-like illness)	Early symptoms (such as gastrointestinal complaints, influenza-like illness) Example: an increase in gastrointestinal illness cases indicating a water-borne outbreak
Data sources	“Constellations of medical signs and symptoms in persons seen in various clinical settings” [35], such as ICD-9 codes	In addition to the types of data sources at left, unusual patterns in health-related behaviors (e.g., over-the-counter and health product purchases, such as cough medicine; and absenteeism from work or school)
Example	“The syndromes to be notified where an outbreak is of urgent international public health importance are: acute hemorrhagic fever syndrome, acute respiratory syndrome, acute diarrheal syndrome, acute jaundice syndrome, [and] acute neurological syndrome. In addition, any other syndrome of severe illness not included in the above should be notified if an outbreak is of urgent international public health importance” [31]	“[In developing countries,] syndromic surveillance can identify outbreaks that do not fall into pre-established diagnostic categories, a capability essential for prompt control of new or changing diseases” [12] Southeast Asia’s Early Warning Outbreak Recognition System (EWORS) provides surveillance of 29 non-specific signs and symptoms, which are not grouped into specific syndromes [50]

of cough and cold medication or absenteeism rates” [43].

Fricker continues his summary of the types of syndromic surveillance by observing that the meaning of the term “syndrome” has evolved in the context of syndromic surveillance: “A syndrome is ‘a set of symptoms or conditions that occur together and suggest the presence of a certain disease or an increased chance of developing the disease’. In the context of syndromic surveillance, *a syndrome is a set of non-specific pre-diagnosis medical and other information* that may indicate the release of a bioterrorism agent or natural disease outbreak” [emphasis ours] [43]. Clearly this term “syndromic” as it is narrowly defined imperfectly captures the full range of these systems. An adjustment of the term, while maintaining the root of its meaning to ensure continuity in the field, can help strengthen and expand understanding of this field.

3.2. Proposed categorization

Table 2 outlines the two categories of syndromic surveillance system types-specific and non-specific. As explained above and demonstrated in the literature, the purposes of each syndromic surveil-

lance category are different. Whereas the “specific disease/syndrome detection” category focuses on detecting defined syndromes or a defined outcome of interest, the “non-specific disease detection” category aims to monitor or uncover non-specific indicators/trends that suggest an outbreak may be occurring. Based on this distinction, an alteration of the term “syndromic surveillance” to “syndrome-based” surveillance (SBS) referring to the more specific type of surveillance and “syndromic-non-specific” surveillance (SNS) referring to the now more common, non-specific category of disease detection is proposed. The categorization of SBS and SNS is confirmed by the examined literature and will be used throughout the remainder of the article to refer to these categories of surveillance.

Because of the terminological confusion with syndromic surveillance, this proposed categorization is necessary. Newcomers to the field of syndromic surveillance frequently have a narrow perspective of what these systems entail. Initial misconceptions include the false belief that it is surveillance based solely on syndromes (such as acute flaccid paralysis) or that this type of surveillance requires significant information technology (IT) capacity. The former point is immediately

clarified by separating the definition of syndromic surveillance into two separate terms: SBS and SNS. The latter point concerning technological capacity will be discussed later in the text where the characteristic of technological dependence is described as a gradation within the two larger categories.

Other attempts to categorize syndromic surveillance systems have also divided the field into two separate components; however, these categorizations do not encompass the full range of systems and most critical distinctions evident in the literature. One attempt separated systems into those based on a "data collection system that is dedicated to the purpose of this public health surveillance" (e.g., during a specific event) and those for the day-to-day monitoring of "data that are routinely collected for other purposes" [27]. Another categorization divided systems by data source: those data sources based on the use of health-care services and those based on health-related behaviors [6]. While these are useful distinctions to make when examining syndromic surveillance systems, they are not the most fundamental. The proposed categorization within the scope of this research addresses the most critical distinction among syndromic surveillance systems, which is the level of specificity of the outcome under surveillance. The distinction between data sources as sub-categories within each of the two larger categories (specific and non-specific detection) is taken into consideration because there is a fair amount of overlap. As noted in Table 2, the data sources used in SNS systems can include those data sources used in SBS systems, but frequently focus primarily on pre-clinical data.

4. Data sources

Data sources for public health surveillance have been traditionally divided into three levels: "pre-clinical data, clinical pre-diagnostic data, and diagnostic data. Syndromic surveillance usually uses two types of data sources: pre-clinical and clinical pre-diagnostic data; traditional surveillance generally focuses on diagnostic data" [17]. These levels can be further divided among the two categories of syndromic surveillance, with the SNS category being largely comprised of pre-clinical data, whereas the SBS category is focused on clinical pre-diagnostic data.

The 36 definitions are rife with examples of each level of data source. Frequently cited clinical pre-diagnostic data sources for the SBS systems include: patient chief complaints or ICD-9 coded health information from clinical records (outpa-

tient, emergency department, and hospital), billing databases, and emergency department triage and discharge data. Though ICD-9 coded health information is a form of diagnostic information, experts in the field of syndromic surveillance have suggested that general groupings of ICD-9 codes can be considered early diagnostic data [33,35,38,43]. Pre-clinical data used in SNS systems are often pulled from existing databases intended for other purposes [21,22,24,27] and are therefore "weakly linked" to the target disease [43]. Examples include "... 'indicator' (pre-diagnostic) data (e.g., syndromes, medication sales, absenteeism, patient chief complaints)" [12], pharmacy records, telephone health advice/consultation, poison control centers, 911 calls, "phone calls to or Internet use of a health-care information site" [18], laboratory test requests/orders [35], veterinary health records, health department requests for influenza testing [48], health care utilization patterns [24], ambulance services, and number of hospital admissions. Environmental data sources and water utility complaint lines [17] are similarly non-specific.

4.1. Classifications within SBS and SNS

Within the two overarching categories of SBS and SNS, three additional sub-classifications became evident through the literature review, specifically surveillance to detect influenza-like illness and possible bioterrorism events, as well as the gradations in technological capacity.

4.1.1. Influenza-like illness

One common use of syndromic surveillance is for the monitoring and detection of influenza-like illness (ILI), which is unique in that it falls within both specific and non-specific surveillance categories. As a specific syndrome, ILI can be used for monitoring known strains: the ILI syndrome is useful for "clarify[ing] the timing and characteristics of annual influenza outbreaks" [18]. Conversely, in SNS, an increased number of cases of respiratory symptoms and fever could indicate a bioterrorism-related event or a new strain of a virus with pandemic potential.

4.1.2. Bioterrorism

As previously mentioned, syndromic surveillance has evolved from specific disease detection to encompassing more non-specific disease detection. In line with this change, and in response to the anthrax event in 2001, syndromic surveillance came to be seen as potentially useful for the detection of bioterrorism outbreaks. Its utilization of data

from a variety of sources makes it a valuable addition to traditional surveillance methods [22]. While bioterrorism detection is not typically the primary use of syndromic surveillance today, non-specific disease detection continues to be thought of and investigated as a biosecurity tool [20]. Those in the bioterrorism field explain that syndromic surveillance, when applied to large, concentrated events, can “detect the early manifestations of illness that may occur during a bioterrorism-related epidemic... [such as] the prodromes of bioterrorism-related disease... [but] other uses of syndromic surveillance include detecting naturally occurring epidemics” [14], and it is more widely applicable than as merely a tool for bioterrorism detection [18].

The incorporation of biosecurity concepts into the syndromic surveillance field has contributed to the broadening of the five syndrome categories defined by WHO in 1998 (“acute hemorrhagic fever syndrome, acute respiratory syndrome, acute diarrheal syndrome, acute jaundice syndrome, and acute neurological syndrome”) [31,51] to include additional categories of symptoms that can be monitored through non-specific surveillance. A CDC-led, multi-agency workgroup identified 11 “syndrome categories to be monitored that were indicative of the clinical presentations of several critical bioterrorism-associated conditions,” including several of the WHO syndrome categories as well as more non-specific symptoms such as “rash” and “fever” [33,5,6].

4.1.3. Electronic capabilities

Within each of the two categories-specific (SBS) and non-specific (SNS)-there are varying degrees of technology that can be used for the syndromic surveillance system. Depending on the data sources available and the outcome of interest, some systems require significant IT and electronic capabilities [6]. However, there are also examples of less IT-dependent systems that monitor specific syndromes and/or non-specific disease indicators [44]. Thus, the distinction between high and low IT dependence is considered a sub-category within each of the two larger categories.

The literature review revealed that highly automated systems tend to be used in more developed countries, for large catchment areas, and when there is a focus on bioterrorism. Typically, these systems involve electronic collection and analysis of data [49], potentially utilizing the “automated extraction of data from electronic medical records” [38]. On the other hand, less automated, less IT-dependent systems are more frequently seen in developing countries

and often incorporate some element of manual data entry, extraction, or analysis, or the involvement of fax or mobile technology [52], resulting in detection that is “near real-time” as opposed to “real-time” [53]. In a basic form, syndromic surveillance “is a feasible and effective tool for surveillance in developing countries” and should be supported [13]. Given the significant applicability of syndromic surveillance systems to low- and medium-resource countries, it is critical that the definition of syndromic surveillance not be limited to highly IT-dependent, strictly automated systems. Clearly, though, where infrastructure allows, “automation of the full cycle of surveillance” allows for more real-time results [6].

5. Discussion

Early syndromic surveillance systems, including those part of the 1997–1999 WHO pilot study and as described in the 1998 Update on the Revision of the IHR, were largely focused on monitoring health events “for which the case definition is based on a syndrome... e.g., acute hemorrhagic fever syndrome, acute respiratory syndrome” [32]. Over time, the systems have transitioned to monitoring less specific outcomes [43]. Morse summarized this transition well: syndromic surveillance “once referred to the use of clinical syndromes as criteria for reporting. Now, it usually means data collected from automated non-diagnostic systems such as pharmacy records, ambulance call categories, personnel absences, or emergency department chief complaints” [41].

Of the 36 unique definitions found in the literature review, several appeared to be overly narrow and might contribute to the confusion ascribed to this term. Most of these narrow definitions suggested that syndromic surveillance is limited to highly IT-dependent systems, require automation or immediate analysis, or are limited to one function, such as bioterrorism [16,26,39,45]. The literature review makes evident that many systems that are considered “syndromic surveillance” are less IT-dependent, may include some manual component, and have much broader applicability. The importance of taking an all-inclusive view to the field of syndromic surveillance is put best by Fricker: “a myopic focus only on early event detection for bioterrorism in syndromic surveillance systems misses other important benefits electronic biosurveillance can provide, particularly the potential to significantly advance and modernize the practice of public health surveillance” [43].

5.1. Broadening the applicability of syndromic surveillance systems

An important contribution of a syndromic surveillance system is that it can be established in countries of any resource level. A broad definition, accounting for all of the purposes of syndromic surveillance and acknowledging the flexibility of the infrastructure requirements will facilitate its introduction and use in a variety of settings. A recent review described 10 syndromic surveillance systems in developing countries, demonstrating the “feasibility of ‘low-tech’ syndromic surveillance in low resource countries” [13], EWORS being one commonly cited example in Southeast Asia [52].

In developing countries, data sources not traditionally employed in surveillance can be useful, such as environmental sources assisting the detection of vector-borne and neglected tropical diseases, monitoring indoor resting densities of vectors, climate and land use data, and satellite imagery [40]. Surveillance of sexually transmitted infections could also be augmented by syndromic surveillance. According to WHO, syndromic surveillance of non-specific symptoms, including “urethral discharge and genital ulcer, are potentially useful for monitoring trends in STD incidence” [54].

5.2. Purpose of terminological clarifications

As the field has expanded, the truly broad nature of these surveillance systems has become apparent. Today, the term “syndromic surveillance” imperfectly describes all forms of syndromic surveillance systems. Fearnley suggests, “This terminological instability reflects an underlying ontological and normative instability,” and without a generalized consensus of the definition of syndromic surveillance, “designers and users [may] continue to dispute what syndromic systems can and should do” [42].

Based on the results of the literature review, and in order to improve the conceptualization of this term, it was necessary to categorize syndromic surveillance into SBS and SNS, based on the fundamentals of specific and non-specific disease detection. The sub-categorization of the systems by data source and IT-capacity required is based on the broad range of features that constitute syndromic surveillance systems. Prior categorizations, described above, have not sufficiently encapsulated all that syndromic surveillance can entail.

Recognizing that syndromic surveillance systems comprise these two categories with two different

purposes helps clarify the added value of this kind of surveillance and may reduce ontological instability. It is recognized, as mentioned above, that in practice, the distinction between specific and non-specific syndromic surveillance categories can be lost, since many of these systems—particularly those in the United States—incorporate both categories within the same system. These dual-function systems (specific and non-specific detection) collect data from several sources—both the pre-clinical and clinical non-diagnostic types. Nevertheless, the acceptance and application of improved terminology regarding these systems can reduce ambiguity in the field and increase adoption of syndromic surveillance systems where appropriate. Future research must explore the combination of the SBS and SNS systems in more depth.

These ongoing questions highlight the importance of incorporating robust system evaluation into future syndromic surveillance implementation efforts. Empirical, quantifiable evidence about the utility of these systems for improved surveillance and detection must be established. Such evidence will be essential for decision makers contemplating investing in syndromic surveillance to help meet IHR (2005) obligations.

6. Conclusion

Despite early concerns about the benefits of the syndromic approach to surveillance [34,42] and the continued need for further research, this approach has been proven successful in a wide variety of settings [5,17,18,30]. This paper has attempted to take a broad perspective on the field of syndromic surveillance, acknowledging the numerous syndromic surveillance systems that have been making important contributions to public health for over a decade, and summarizes the term’s many definitions. By providing an accurate and comprehensive picture of this field’s capabilities, and differentiating between SBS and SNS, it is hoped that syndromic surveillance will be seen more widely as a tool that can help any nation (high, middle, or low income) build comprehensive disease surveillance capacity.

Contributors

All authors contributed to this manuscript. Rebecca Katz and Larissa May conceptualized the project, directed the research, and reviewed and edited drafts of the manuscript. Elisa Test and Julia Baker conducted the literature review

and drafted the manuscript. All authors approved the final article.

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Conflict of interest

None declared.

References

- [1] WHO. Revision of the International Health Regulations: progress report, February 2001. *Wkly Epidemiol Rec* 2001;76 (2001):57–64.
- [2] WHO. International Health Regulations (2005). 2nd ed.; 2008, <<http://www.who.int/ihr/en/>> [accessed 16.02.11].
- [3] WHO. Regional Office for South-East Asia. Epidemiological Surveillance and International Health Regulations. Report of an intercountry meeting, Colombo; 15–18 December 1998. Report No. SEA/EPID/126.
- [4] Cooper D, van Aston L. Syndromic surveillance – a European perspective. *The International Society for Disease Surveillance: Global Outreach Committee eNewsletter*; September 2008, <http://www.syndromic.org/GOnewsletter_v1_2008.html> [accessed 18.02.11].
- [5] Sosin DM, DeThomasis J. Evaluation challenges for syndromic surveillance-making incremental progress. *MMWR Morb Mortal Wkly Rep* 2004;53 (2004):125–9.
- [6] Buehler JW, Sonricker A, Paladini M, Soper P, Mostashari F. Syndromic surveillance practice in the United States: findings from a survey of state, territorial, and selected local health departments. *Adv Dis Surv* 2008;6 (2008): 1–20.
- [7] United States Government Accountability Office. Biosurveillance: efforts to develop a national biosurveillance capability need a national strategy and a designated leader. Report to congressional committees; June 2010. Report No. GAO-10-645.
- [8] The Center for Biosecurity of UPMC. International disease surveillance: United States government goals and paths forward; June 2010, <<http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA528990&Location=U2&doc=GetTRDoc.pdf>> [accessed 18.02.11].
- [9] Centers for Disease Control and Prevention, Coordinating Office for Terrorism Preparedness and Emergency Response. Concept plan for the implementation of the national biosurveillance strategy for human health; January 2010, <http://www.cdc.gov/osels/pdf/Concept_Plan_V1+5+final+for+print+KMD.PDF> [accessed 18.02.11].
- [10] USAID. Emerging pandemic threats – program overview; February 2010, <http://www.usaid.gov/our_work/global_health/home/News/ai_docs/emerging_threats.pdf> [accessed 18.02.11].
- [11] Chretien JP, Happel Lewis S. Electronic public health surveillance in developing settings: meeting summary. *BMC Proc* 2008;2 (2008):51.
- [12] Chretien JP, Burkom HS, Sedyaningsih ER, Larasati R, Lescano AG, Mundaca CC, et al. Syndromic Surveillance: adapting innovations to developing settings. *PLoS Med* 2008;5 (2008):e72.
- [13] May L, Chretien JP, Pavlin JA. Beyond traditional surveillance: applying syndromic surveillance to developing settings-opportunities and challenges. *BMC Public Health* 2009;9 (2009).
- [14] Buehler JW, Berkelman RL, Hartley DM, Peters CJ. Syndromic surveillance and bioterrorism-related epidemics. *Emerg Infect Dis* 2003;9 (2003):1197–204.
- [15] Fricker RDJ, Hegler BL, Dunfee DA. Comparing syndromic surveillance detection methods: EARS' versus a CUSUM-based methodology. *Stat Med* 2008;27 (2008):3407–29.
- [16] Stoto MA, Schonlau M, Mariano LT. Syndromic surveillance: is it worth the effort? *Chance* 2004;17 (2004):19–24.
- [17] Berger M, Shiao R, Weintraub JM. Review of syndromic surveillance: implications for waterborne disease detection. *J Epidemiol Community Health* 2006;60 (2006): 543–50.
- [18] Sosin DM. Syndromic surveillance: the case for skillful investment. *Biosecur Bioterror* 2003;1 (2003):247–53.
- [19] Sosin DM. Draft framework for evaluating syndromic surveillance systems. *J Urban Health* 2003;80 (2003): 18–113.
- [20] Centers for Disease Control. Syndromic surveillance: an applied approach to outbreak detection; 2008, <<http://www.cdc.gov/ncphi/diss/nndss/syndromic.htm>> [accessed 08.02.11].
- [21] Pavlin JA. Investigation of disease outbreaks detected by "syndromic" surveillance systems. *J Urban Health* 2003;80 (2003):i107.
- [22] Mandl KD, Overhage JM, Wagner MM, Lober WB, Sebastiani P, Mostashari F, et al. Implementing syndromic surveillance: a practical guide informed by the early experience. *J Am Med Inform Assoc* 2004;11 (2004):141–50.
- [23] Buehler JW, Whitney EA, Smith D, Prietula MJ, Stanton SH, Isakov AP. Situational uses of syndromic surveillance. *Biosecur Bioterror* 2009;7 (2009):165–77.
- [24] Sintchenko V, Gallego B. Laboratory-guided detection of disease outbreaks: three generations of surveillance systems. *Arch Pathol Lab Med* 2009;133 (2009):916–25.
- [25] Azarian T, Winn S, Zaheer S, Buehler J, Hopkins RS. Utilization of syndromic surveillance with multiple data sources to enhance public health response. *Adv Dis Surv* 2009;7 (2009).
- [26] Henning KJ. What is syndromic surveillance? *MMWR Morb Mortal Wkly Rep* 2004;53 (2004):7–11.
- [27] Mostashari F, Hartman J. Syndromic surveillance: a local perspective (editorial). *J Urban Health* 2003;80 (2003):i1–7.
- [28] Smolinski MS, Hamburg MA, Lederberg J. Microbial threats to health: emergence, detection, and response, National Academies Press, Washington, DC, 2003.
- [29] International Society for Disease Surveillance. Annual conference; 2010, <<http://www.syndromic.org/annual-conference/main>> [accessed 11.02.11].
- [30] May L, Katz R, Test E, Baker J. Applications of syndromic surveillance in resource poor settings: a series of case studies. *Int J Epidemiol*, submitted for publication.
- [31] WHO, Regional Office for South-East Asia. Revision of the International Health Regulations – regional committee document; 1998 July 27. Report No. SEA/RC51/11 Add.1.
- [32] WHO, Department of Communicable Disease Surveillance and Response. WHO recommended surveillance standards. 2nd ed.; 2001 March 29. Report No. WHO/CDS/CSR/ISR/99.2.

- [33] Centers for Disease Control and Prevention. Syndrome definitions for diseases associated with critical bioterrorism-associated agents; 2003 October 23, <<http://www.bt.cdc.gov/surveillance/syndromedef/>> [accessed 14.01.11].
- [34] Reingold A. If syndromic surveillance is the answer, what is the question? *Biosecur Bioterror* 2003;1 (2003):1–5.
- [35] Buehler JW, Hopkins RS, Overhage JM, Sosin DM, Tong V. Framework for evaluating public health surveillance systems for early detection of outbreaks. Recommendations from the CDC working group. *MMWR Morb Mortal Wkly Rep* 2004;53 (2004):1–11.
- [36] MMWR Editorial Committee. Preface to syndromic surveillance: Reports from a national conference, 2003. *MMWR Morb Mortal Wkly Rep*. 2004;53 (2004):3.
- [37] Lombardo JS, Burkom H, Pavlin J. ESSENCE II and the framework for evaluating syndromic surveillance systems. *MMWR Morb Mortal Wkly Rep* 2004;53 (2004):159–65.
- [38] Ang BC, Chen MI, Goh TL, Ng YY, Fan SW. An assessment of electronically captured data in the Patient Care Enhancement System (PACES) for syndromic surveillance. *Ann Acad Med Singapore* 2005;3 (2005):539–44.
- [39] Stoto MA, Fricker RD, Jain A, Diamond A, Davies-Cole JO, et al. Evaluating statistical methods for syndromic surveillance. In: Wilson AG, Wilson GD, Olwell DH. *Statistical methods in counterterrorism: game theory, modeling, syndromic surveillance, and biometric authentication*, Springer, New York, 2006. p. 141–72.
- [40] Chaves LF, Pascual M. Comparing models for early warning systems of neglected tropical diseases. *PLoS Negl Trop Dis* 2007;1 (2007):e33.
- [41] Morse SS. Global infectious disease surveillance and health intelligence. *Health Aff* 2007;26 (2007):1069–77.
- [42] Fearnley L. Signals come and go: syndromic surveillance and styles of biosecurity. *Environ Plan A* 2008;40 (2008):1615–32.
- [43] Fricker RDJ. Syndromic surveillance. In: Melnick E, Everitt B. *Encyclopedia of quantitative risk assessment*, John Wiley & Sons Ltd., 2008. p. 1743–52.
- [44] Jefferson H, Dupuy B, Chaudet H, Texier G, Green A, Barnish G, et al. Evaluation of syndromic surveillance for the early detection of outbreaks among military personnel in a tropical country. *J Public Health (Oxf)* 2008;26 (2008):1–9.
- [45] Nordin JD, Kasimow S, Levitt MJ, Goodman MJ. Bioterrorism surveillance and privacy: intersection of HIPAA, the common rule, and public health law. *Am J Public Health* 2008;98 (2008):802–7.
- [46] Tsui K, Chiu W, Gierlich P, Goldsman D, Liu X, Maschek T. A review of healthcare, public health, and syndromic surveillance. *Qual Eng* 2008;20 (2008):435–50.
- [47] Gault G, Larrieu S, Durand C, Josseran L, Jouves B, Filleul L. Performance of a syndromic system for influenza based on the activity of general practitioners, France. *J Public Health (Oxf)* 2009;31 (2009):286–92.
- [48] Zhang Y, Dang Y, Chen H, Thurmond M, Larson C. Automatic online news monitoring and classification for syndromic surveillance. *Decis Support Syst* 2009;47 (2009):508–17.
- [49] Josseran L, Fouillet A, Caillere N, Brun-Ney D, Ille Dea. Assessment of a syndromic surveillance system based on morbidity data: results from the OScour Network during a heat wave. *PLoS One* 2010;5 (2010):e11984.
- [50] Siswoyo H, Permana M, Larasati RP, Farid J, Suryadi A, Sedyaningsih ER. EWORS: using a syndromic-based surveillance tool for disease outbreak detection in Indonesia. *BMC Proc* 2008;2 (2008):S3.
- [51] WHO, Fifty-First World Health Assembly. Revision of the International Health Regulations: progress report by the Director-General; March 1998. Report No. A51/8.
- [52] Marcus A, Davidzon G, Law D, Verma N, Fletcher R, Khan A, et al. Using NFC-enabled mobile phones for public health in developing countries. In: *Proceedings of the 2009 1st international workshop on near field communication*; 2009. Art. No. 5190414. p. 30–5.
- [53] Chretien JP, Blazes DL, Glass JS, Mundaca CM, Lewis SH, Lombardo JS, et al. Surveillance for emerging infection epidemics in developing countries. In: Lombardo JS, Buckeridge D. *Disease surveillance: a public health informatics approach*, John Wiley & Sons, Inc., New Jersey, 2007.
- [54] WHO, Regional Office for South-East Asia. Guidelines for surveillance of sexually transmitted diseases; 2000. Report No. SEA-STD-39, WHO Project: ICP RHR 001.

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