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Characteristics of Public Health Surveillance Evaluations, 1992 – 2012

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Characteristics of Public Health Surveillance Evaluations, 1992 – 2012

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Abstract

Characteristics of Public Health Surveillance Evaluations, 1992 – 2012

By Larisa Fedarushchanka

Background: Public Health Surveillance (PHS) evaluations are triggered by various events or circumstances that can affect the evaluation scope, objectives, methods, and cost. However little is known about what triggers them and how this information might be used prospectively to enhance evaluation efficiency and effectiveness. We performed a systematic literature review that identified and defined triggers initiating PHS evaluations.

Methods: Articles published about PHS evaluations in English between January 1, 1992 and December 31, 2012 were collected from MEDLINE/PubMed, Goggle Scholar, Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) web sites.

Results: A total of 2,705 publications were identified through MEDLINE/PubMed, Google Scholar. CDC and WHO web sites. Nine were identified through a review of the primary articles' references. Fourteen duplicates were excluded, and after applying the exclusion criteria, 217 publications remained in the final dataset. Most PHS evaluations were published between 2007 and 2012 (115 [53%]); 50 (23%) from 2002 to 2006; 36 (17%) from 1997 to 2000; and 16 (7%) from 1992 to 1996. Fifteen triggers were identified and placed into six categories: general, economic change, technical, new component, emergency, and public health measure. The most frequently reported trigger of a PHS evaluation was data quality monitoring 59 (27%), followed by new technology or innovation 25 (12%), comparison of systems 23 (11%), initial evaluation 20 (9%), formal request 13 (6%), new standards 13 (6%), syndromic surveillance 12 (6%), change in public health policy 11 (5%), occurrence of a public health event 11 (5%), change in definitions 9 (4%), introduction of new control measures 8 (3%), determination of cost six (3%), mass gathering 3 (1%), preparedness 2 (1%), and structural changes 2 (1%).

Conclusion: The number of evaluations of PHS increased several-fold over the past 20 years, with the most common trigger being data quality monitoring. Trigger identification during the planning stage of PHS evaluation can guide strategy and budget cost. This new concept should assist public health officials conduct the evaluation process more effectively and efficiently.

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Acronyms

CDC- Centers for Disease Control and Prevention

CDSS - communicable disease surveillance systems

HAI - hospital acquired infections

ISS – injury surveillance system

MMWR - Morbidity and Mortality Monthly Report

NCDD – noncommunicable disease surveillance systems

NGO - non-governmental organizations

NPV – predictive value negative

PHS - Public health surveillance

PHSS - public health surveillance system

PPV – predictive value positive

TESSy - The European Surveillance System

TB – tuberculosis

WHO - World Health Organization

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Chapter 1: Introduction

Background

Public health surveillance (PHS) is defined as, "an ongoing, systematic collection, analysis, interpretation and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health"[78]. PHS is an integral part of a healthcare system with the basic function to monitor priority health outcomes. PHS is an essential tool to detect outbreaks by establishing an early warning system. Its function is to detect and clarify the magnitude of the health outcome, monitor changes, determine geographic distribution, and guide development of rapid responses and inform policy. It assesses the health status of the population to determine public health policy priorities, reduce the burden of disease and injuries by targeting prevention and control programs, and stimulate public health research.

According to the WHO Health Systems Strengthening Glossary, "evaluation is the systematic and objective assessment of the relevance, adequacy, progress, efficiency, effectiveness and impact of a course of actions in relation to objectives and taking into account the resources and facilities that have been deployed"[236]. Evaluation of public health surveillance system (PHSS) is necessary to: prioritize the events under surveillance; identify the elements of the system that are weak and need improvement; qualify the epidemiological information; determine if the current system can detect and report health events and provide a timely response; and present baseline information for surveillance policy and control.

PHS should be evaluated periodically to provide recommendations for improving efficiency, quality, and usefulness. PHS evaluations are initiated by recommendations

from Ministries of Health, donor organizations, non-governmental organizations (NGO), and research institutions. The purpose of a PHS evaluation is to:

- obtain information about whether the PHS is meeting objectives;
- identify strengths and weaknesses;
- determine country needs regarding communicable disease prevention and control;
- understand if the surveillance supports and benefits stakeholders; and
- find gaps and opportunities for improving the performance and efficiency.

Two review articles related to evaluation of surveillance systems were published between 2004 and 2012. Drewe J.A., *et* al. discussed the existing framework for the evaluation of animal and PHS systems, performance indicators, methods and attributes used in the main CDC and the generic guidelines to assess the framework's strengths and weaknesses[59]. They also discussed how to analyze a PHS applied to animal health. They reported a lack of standardization in human and animal health surveillance and suggested creating a generic framework that would consist of a limited number of primary and secondary attributes, depending on the purpose of the surveillance and the health outcome under survey. They recommend including economic evaluation as an integral part of the surveillance evaluation process to assist decision-makers in cases of limited or diminishing resources.

Sahal N., *et* al. compared the evaluation of communicable disease surveillance systems (CDSS) in developed and developing countries to ensure that CDSS are monitored efficiently and effectively, to learn lessons from both developing and developed countries' experience, and to improve systems quality everywhere[194].

Several studies reviewed published literature that related to evaluation, not of the whole PHS, but of single attributes. Doyle T.J., *et* al. studied the completeness of notifiable infectious disease reporting in the United States with the aim of identifying factors associated with reporting completeness[58]. Jajosky R.A., *et* al. looked at the timeliness of PHSS for infectious diseases to determine if the National Notifiable Diseases Surveillance System in the United States could support a timely response to multistate outbreaks on the state level[108]. E. Lopez-Gonzalez examined the influence of personal and professional characteristics of healthcare workers on reporting of adverse drug reaction[136].

However, none analyzed what initiated the evaluation. Evaluations are triggered by various events or circumstances that affect the scope, objectives, methods, and cost. We identified and classified the triggers of PHS evaluations performed between 1992 and 2012 and how the evaluation processes differed, by trigger.

Research Question

The aim of this systematic review was to identify and define triggers that initiated evaluation of PHS from 1992 to 2012 and how those triggers influenced the evaluation purpose and its attributes. The secondary questions were to determine if triggers vary by date, geographic distribution, and condition of interest (health outcome).

Potential Study Implications

The new concept of trigger identification during the planning stage for PHS evaluation includes identifying or developing an initial strategic framework, methods and attributes to be assessed, cost, potential input and output measures, and stakeholders

involved. This concept can be used in developing a new framework for PHS evaluation to make it more effective and efficient.

Chapter 2: Literature Review

Historical aspects of PHS

The history of disease surveillance began in the 14th century in the Venetian Republic when quarantine measures were applied to control the spread of pneumonic plague[77]. The first "Bills of Mortality" were created in London in 1532 by an unknown person but were not used for public health research[56]. In the 17th century, early plague surveillance was established in London, where the information about the number of plaque deaths was collected by the Clerk of the Hall and reported weekly in a "Bill of Mortality."[82] John Graunt , who was the first to analyze the data from the weekly "Bill of Mortality," estimated the size of the population of London and the number of deaths from specific causes and suggested that numerical data could be used to study the etiology of diseases[82,116]. During the 18th century, public health surveillance became an integral part of population health. In Germany, Johann Peter Frank formulated comprehensive and detailed health policy in relationship to school health, maternal and child health, injury prevention, and public water and sewage treatment[220]. His ideas were accepted in Hungary, Italy, Denmark and Russia[56].

In the 19th century, the concept of data collection, interpretation and implementation was fully developed. In England, Sir Edwin Chadwick was the first person to demonstrate the connection between the level of poverty and health[214]. The importance of complete mortality data in the United Kingdom (U.K.) lead to the establishment in 1836 of the General Register Office[56], the medical certification of death, and universal death registration in 1837[56]. William Farr became the first medical statistician to create a modem surveillance system and developed the modern concept of

surveillance[66]. In 1885, the International Statistical Institute was founded in London and it published the international list of causes of death. In 1888, the mandatory reporting of eleven communicable diseases and death certificates was established in Italy[56].

In the United States, the history of reporting of notifiable disease started in two states: Massachusetts and Michigan. In Massachusetts in 1874, the Board of Health asked physicians to notify them by postcard about the prevalence of 14 infectious diseases[127]. In 1883, the state of Michigan passed a law about notification requirements to the Board of Health of four infectious diseases: smallpox, cholera, diphtheria and scarlet fever, as well as any infectious diseases that could be dangerous to the public health[127].

The 20th century saw the development of many different surveillance systems[221]. In 1911, the data from the National Health Insurance started to be used for surveillance purpose in the U.K.[56] In the U.S., in 1912 at the 10th annual conference of state and territorial health officers, the importance of gathering information about dangerous infectious diseases not only within the state but between states was discussed[56]. The territorial health officers agreed with the Public Health Service that five diseases (cholera, plague, Rocky Mountain spotted fever, typhus fever and yellow fever) would be immediately notifiable by telegraph to the Surgeon General and there would be monthly reporting by letter of 15 diseases (diphtheria, dysentery, leprosy, measles, meningitis, poliomyelitis, scarlet fever, smallpox, typhoid fever and Rocky Mountain spotted fever)[127]. The First National Health Survey in the U.S. was performed in 1935[234]. In 1961, the responsibilities for the collection and publication of information about notifable diseases was assign to the CDC, which started to published the Morbidity and Mortality Monthly Report (MMWR) report from January 6, 1961 [224]. In 1963, Alexander D.

Langmuir, Chief of the Bureau of Epidemiology at CDC, stated, "Surveillance, when applied to a disease, means the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data. Intrinsic in the concept is the regular dissemination of the basic data and interpretations to all who have contributed and to all others who need to know"[127].The Epidemiological Surveillance Unit in the Division of Communicable Diseases at the WHO headquarters was established in 1965 in Geneva, and the following year the first Communicable Disease Surveillance Report by the WHO was published[56]. In 1967 in the Netherlands and the U.K., the General Practitioners' Sentinel Surveillance System was developed[56].

Bernard C. K. Choi and Anita W. R. Pak in a 2001 review of the 5,000 years of history of major epidemics derived 12 lessons for PHS for the 21st century[44]. They suggested that PHS needs to be converted into an ongoing, comprehensive, systematic, population-based system containing data on health outcomes as well as risk factors; use effective data collection and analysis strategies; provide information for early warning of emerging health risks and deliver the information for evaluation and intervention programs; stimulate research; and equally and effectively distribute the information to all participants.

PHS Description

PHS is defined as "an ongoing, systematic collection, analysis, interpretation and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health."[78] The first health condition that was put under survey was communicable disease[56]. Over time, the health events under

surveillance changed and increased and now include: non-communicable diseases; injuries; occupational disease and injuries; adverse drug events; hospital acquired infections (HAI); behavioral risk factors and mental disorders; growth, development and nutritional status; environmental hazards; and animal health.

PHS vary from country to country and may be managed by different institutions and control programs. Vertical control is potentially good for specific notifiable diseases, but at the same time it may cause the overall PHS to be disjointed and inefficient because of the multiple methods used, the multiple reports forms, and the terminology that overwhelms and causes a lack of motivation in health workers. On the other hand, when PHSS in not well controlled, data may be underreported and there may be a delay in reporting, resulting in poorly analyzed data that is not helpful to decision makers[167].

In a 1994 review, Declich Sand Carter A.O. described the three major objectives of PHS: "To describe the ongoing pattern of disease occurrence and to link with public health action; to study the natural history and epidemiology of the disease and to provide information and baseline data"[56]. Through the primary objective of PHH of describing the ongoing disease occurrence, it can measure the disease incidence and distribution; identify trends and patterns of disease; observe changes in the relationship of the infectious agent and the host to assess the potential risk of reoccurrence of the disease; and detect changes in medical practice (e.g., the increasing number of organ transplantation, cardio-surgery interventions)[56,78]. For prevention purposes, PHS can investigate the source of a communicable disease and the way of it spreads, stimulate action (e.g., warning the public about a possible threat, prevent the food product from being distributed on the market) and evaluate the effectiveness of control measures

(vaccination) [56, 78]. While providing baseline data, PHS can help the government and health care providers to assess prevention and control measures before and after implementation[56, 78].

PHS data can be collected routinely or actively through investigations, or accumulated for other purposes but used for surveillance. Sources of data differ from country to country and depend on the stage of development and technical characteristics of a PHS, the quality of laboratory facilities, and available funding. The traditional sources of PHS data are: morbidity/mortality data; epidemic reporting; laboratory reporting; individual case reports; epidemic field investigation; surveys; animal reservoir and vector distribution studies; and demographic and environmental data[56]. Additional data sources that are usually collected for non-surveillance purposes could be used as a supplemental resource or for the evaluation of a special disease situation (e.g., absenteeism from school or work due to an influenza epidemic). These sources could be hospital and medical care statistics; general practitioners' network, public health laboratory reports, disease registries, drug and biologics utilization and sales data, health and general population surveys, and newspaper and news broadcasting reports[56]. According to the updated 2001 CDC guidelines for evaluating public health surveillance systems, PHSS data can be used to: guide immediate response to public health threats; describe the clinical pictures of the diseases, measure its public health burden and monitor trends of a disease or health related event (outbreak/epidemic/pandemic detection); direct the planning, implementation and assessment of PHS to prevent and control the disease (or other health-related event); detect changes in health care systems

and measure the effect of those changes; highlight the allocation of health resources; and provide a basis for research[78].

PHS should collect the information that is required to achieve its objectives. The data may differ from disease to disease, but many elements are similar and could be obtained from the same data source. There are five traditional methods of data collection for PHS: passive PHS (ongoing, routing data collection); active PHS (actively searching for cases during an outbreak, expensive and limited in time); sentinel PHS (relies on a pre-arranged sample of reporting sources after preliminary agreement); PHS based on secondary data analysis (for chronic disease or for infectious disease not under routine surveillance) and special PHS surveys and investigations. PHS data have to be analyzed in terms of time, place and person, as well as interpreted and distributed among all participants and those who need to know for further action[56].

European PHS

In the section on PHS of communicable diseases in the European Union's (EU) long-term strategy (2008-2013), PHS is defined as "the ongoing collection, validation, analysis and interpretation of health and disease data that are needed to inform key stakeholders (in Member States and elsewhere) in order to permit them to take action by planning and implementing more effective, evidence-based public health policies and strategies relevant to the prevention and control of disease or disease outbreaks."[60]

The long-term vision and strategy for infectious disease PHS in Europe was developed and approved by the European Center for Disease Prevention and Control (ECDC) Management Board in October 2005 and extends to 2013. The strategy attempts to define the terms and scope of surveillance, its aims and objectives, and its

organizational requirements, with the goal of reducing the incidence and prevalence of communicable diseases in the European Union by providing valid and comparable public health data, information and reports to all PHS system participants (i.e., decision makers, public health specialists and health care professionals).

The strategic plan describes the new concept of a two PHS approach: indicator-based and event-based. Indicator-based is the traditional approach for CDSS and consists of routinely collecting data from health care providers about the occurrence of predefined diseases or conditions. From the viewpoint of traditional PHS, it could be active, passive, sentinel or syndromic surveillance. The ECDC developed a system for infectious disease indicator-based PHS: The European Surveillance System (TESSy). TESSy was launched in 2008 and aims to provide the basis for data analysis and interpretation for further public health actions. The 27 EU Member States and the European Economic Area countries report data on communicable diseases to the system. Each Member State identifies an individual who serves as the main contact point for two-sided communication with the ECDC to ensure a solid working relationship. TESSy incorporates all data collection systems that were in place for the Dedicated Surveillance Network projects. The reduced common set of variables is defined for routine surveillance and applied to all communicable diseases. An additional set of variables was created for selected diseases that require enhanced surveillance.

Event-based PHS uses advance information technology (i.e., mass media, internet) to detect information that may help in the recognition of emerging threats. This is complementary to the indicator-based approach and not well studied or verified yet. The Threat Tracking Tool is an information system for event-based surveillance at the

European level, developed by the ECDC. The Threat Tracking Tool allows access to data related to public health threats, and verifies and distributes it to Member States' representatives through a daily update bulletin and weekly threat bulletin (the Communicable Disease Threat Report).

Evaluation of PHS

Saqib S. (2009) found that the number of specific frameworks to guide evaluation of PHS has increased[197]. The CDC framework is the one most often cited, but the Public Health Agency of Canada recommends its own framework for evaluation of PHSS in Canada.

CDC Guidelines for Evaluation of Surveillance Systems

The CDC Guidelines for Evaluating Surveillance Systems was published in 1988, and states that an evaluation of PHSS needs to be performed regularly in order to detect if the system is working efficiently and meeting its objectives[87]. PHS vary by scope, objectives and methodology, and an attribute that is important for one system may be less important to another, so the guidelines describe many potential measures, but the evaluation process should be flexible and adapted to the field according to the PHS evaluation objectives.

The Guidelines consists of: a description of the public health importance of the health condition under surveillance; a framework for describing the components of a surveillance system; definitions of the surveillance system attributes (simplicity, flexibility, acceptability, sensitivity, predictive value positive, representativeness, and

timeliness) that potentially affect the usefulness and cost of a system; a description of the necessary resources for PHSS operation; and conclusions and recommendations.

In 2001, the CDC Guidelines for Evaluating Surveillance Systems was updated to measure the integration of PHS and health information systems and electronic health data bases, assess the implementation of new data standards, and address new objectives for PHS to manage the emerging health threats (outbreaks, epidemic/pandemic)[78]. Two attributes were recommended, in addition to seven suggested in 1988: data quality that reflects the completeness and validity of PHSS data and stability, which refers to the ability to "collect, manage, and provide data properly without failure" and availability of PHS[78].

The Guidelines describe the tasks for evaluation and standards for effective evaluation (i.e., utility, feasibility, propriety, and accuracy) that were adapted from the Framework for Program Evaluation in Public Health and based on the original 1988 CDC guidelines[70, 87]. The following tasks and activities were recommended[78]:

- Task A. Engage the stakeholders in the evaluation
- Task B. Describe the surveillance system to be evaluated:
  - B.1. Public health importance of the health-related event under surveillance
  - B.2. Purpose and operation of the system
  - B.3. Resources used to operate the system (funding source(s); personnel requirements; other resources)
- Task C. Focus the evaluation design to ensure that time and resources are used as efficiently as possible.

- Task D. Gather credible evidence regarding the performance of the surveillance system
  - D.1. Indicate the level of usefulness
  - D.2. Describe each system attribute (simplicity; flexibility; data quality; acceptability; sensitivity; PPV; representativeness; timeliness and stability)
- Task E. Justify and state conclusions, and make recommendations
- Task F. Ensure use of evaluation findings and share lessons learned

In 2004, the CDC published the Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks as a supplement to the 2001 guidelines with enhanced attention to the assessment of timeliness and validity for outbreak detection[29]. The framework was designed to address the threat of terrorism and support assessment of early outbreak detection. The measurement of the performance of PHSS for outbreak detection is necessary to assess the relative value of different surveillance approaches and to provide information for improvement of PHS efficacy. The framework is organized into four categories: system description (purpose, stakeholders, operation); outbreak detection (timeliness, validity), system experience (usefulness, flexibility, acceptability, portability, stability and cost); and conclusions and recommendations for use and improvement of systems for early outbreak detection. It also suggests evaluating timeliness and the balance among sensitivity, predictive value positive (PVP) and predictive value negative (PVN) compared with alternative surveillance systems to determine the best approach for outbreak detection. The framework encourages the evaluation team to describe the design and performance of the

system in a real setting, so it is more applicable for a PHS that experiences the detection of an outbreak and has the data, but can also be used by the new systems at their early stage of development or planning.

Framework and Tools for Evaluating Health Surveillance Systems, Canada

The Canadian framework was published in 2004 and was designed to assist managers of PHSS in identifying and reporting issues related to the performance and effectiveness of the systems[32]. It is based on the government of Canada's Results-Based Management and Accountability Framework that includes five major components: program profile, logic model, performance measurement, evaluation and reporting.

The framework outlines six steps in evaluating health surveillance: 1) establishing the context of the surveillance system (purpose, roles and responsibilities, design and scope); 2) developing evaluation questions by using SMART (specific, measurable, actionable, relevant and timely) strategies; 3) measuring surveillance system characteristics – such as acceptability, simplicity, flexibility, data quality, PPV, sensitivity, representativeness, timeliness, stability and compliance – and system performance characteristics – such as effectiveness, efficiency and usefulness; 4) designing the process for data collection and management, and collating and presenting the findings; 5) reviewing an evaluation report; and 6) following up on the use of findings.

WHO Protocol for the Assessment of National Communicable Disease Surveillance and Response Systems, 2001

The WHO Protocol for the Assessment of National Communicable Disease Surveillance and Response Systems was published in 2001 as a generic document for

evaluation of CDSS[167]. The evaluation protocol recommended: prioritizing the disease for surveillance within the country; assessing the organization of the surveillance and response systems and relationship within the level of PHS (i.e., central, intermediate, district, health facility, and community level); assessing the main task for CDSS at each level (i.e., case detection, confirmation, reporting, analysis, investigation, response, feedback and monitoring); supporting functions (i.e., training, supervision, communication systems, providing resources); assessing output and providing information about the effectiveness and efficiency of CDSS by considering the system attributes (simplicity, flexibility, completeness, sensitivity, timeliness, representativeness); evaluating the level of the national surveillance system's potential integration/synergy that can affect sustainability, as well as the direct and indirect costs and performance of the CDSS; and assessing the laboratory capacity and communication systems.

Chapter 3: Methods

An exhaustive literature review was conducted of all published articles on PHSS evaluations. These documents included peer-reviewed and grey-literature publications that evaluated PHS published in English between January 1, 1992 and December 31, 2012. These articles were collected from four sources: MEDLINE/PubMed, Goggle Scholar, Centers for Disease Control and Prevention (CDC) for Morbidity and Mortality Weekly Reports (MMWR), and World Health Organization (WHO) for the Weekly Epidemiological Records (WER). PubMed literature was gathered that contained Medical Subject Headings (MeSH) terms "population surveillance" in different combinations with "program evaluation," "quality assurance," "health care," "systems analysis," "comparison," "compare," "validation," "validity," "validate," "program," and "system." Similar search terminologies in Google Scholar were used to find grey-literature theses, conferences abstracts, and reports. MMWR and WER reports were gathered manually. Secondary searches were conducted by reviewing references quoted in key articles. EndNote® Web was used to concatenate references. Duplicates were identified and removed from the final dataset of articles (Figure 1).

Studies were included if the title and abstract were deemed relevant to the project scope. A two-step selection process was used in the retrieval process. Data were extracted including the source of the publication; reference; title; author(s); publication year; country; type of PHS (e.g., indicator-based, event-based, syndromic); health outcome, such as communicable diseases, non-communicable diseases, injury, hospital-acquired infections (HAI), adverse events (the descriptions of health outcomes are presented in Table 1); purpose; trigger category; trigger; evaluation method; system

attributes and guidelines. The definitions of surveillance system attributes are presented in the Table 2.

We stratified four groups of articles according to the publication date (1992-96; 1997-01; 2002-06; and 2007-12). The six categories of triggers – general, economic change, technical, new component, emergency, and public health measure – and the fifteen triggers – initial evaluation, compare systems, formal request, determine cost, data quality monitoring, new technology or innovation, new standards, change in definitions, syndromic surveillance, mass gathering, occurrence of a public health event, preparedness, change in public health policy, introduction of new control measure(s) and structural changes – were identified during the literature retrieval (Table 3).

The present research project did not require Institutional Review Board approval, because it does not meet the definition of research involving "human subjects."

Chapter 4: Results

A total of 2,700 publications were screened during this systematic review: 2,705 publications were identified through searching MEDLINE/PubMed, Google Scholar, CDC and WHO official web sites; nine publications were added after reviewing the references of the primary articles; and fourteen duplicate articles were excluded. After applying the exclusion criteria (Figure 1), 217 publications remained in the final dataset (Annex 1). Of these, 185 were published in peer-reviewed journals, three in WRE, eleven in MMWR, nine were official reports and six were materials from scientific conferences. One hundred and four publications were open source and 113 not open source. Data from these publications were extracted and included in this review.

The majority of PHS evaluations were included in the review and published between 2007 and 2012 (115 or 53%); 50 (23%) articles were published between 2002 and 2006; 36 (17%) between 1997 and 2000; and 16 (7%) between 1992 and 1996.

Geographic Locations of PHS Evaluation

The 217 evaluations included in this review occurred in 55 countries (Table 4). The majority were conducted in the United States (82 [38%]); Australia 17 (8%); Canada 13 (6%); the U.K. eight (3%); Italy and the Netherlands six (3%); South Africa five (2%); Germany and Pakistan four each (2%). Nine articles (4%) described the evaluation of surveillance systems occurring in more than one country.

Guidelines and PHS Attributes in the Evaluation

The CDC guidelines for evaluation of PHS were used in 45 (21%) publications, while 31% were performed in the United States, 20% in Australia, 7% in Canada, 4% in

the U.K. and 38% in the others countries. The most recently updated (2001) version of the CDC guidelines was used in 28 studies published from 2007 to 2012 and in ten studies published from 2002 to 2006. The previous 1988 version of the CDC guidelines was used in seven studies published in 2001 or earlier. The WHO guidelines were used in three studies published from 2007 to 2012 and in two studies published in 2006 or earlier. The WHO/CDC guidelines were used in studies published in 2000 and 2002. The WHO guidelines were used in five (2%) articles in China, Mexico, Iraq, and Mozambique and Saudi Arabia. Both the WHO and CDC guidelines were modified and used in Australia and Uganda. Authors of 165 publications did not mention any guidelines used during the evaluation of PHS.

Only 15 studies reported nine evaluation attributes recommended by CDC guidelines such as simplicity, flexibility, data quality, acceptability, sensitivity, PPV, representativeness, timeliness and stability and were initiated by various triggers: compare systems (2/14), data quality monitoring (4/14), formal request (2/14), initial evaluation (2/14), new standards (1/14), new technology or innovation (2/14), occurrence of public health event (1/14) and syndromic surveillance (1/14). Two studies evaluated usefulness in addition to nine recommended attributes, but none of those 14 studies evaluated cost of PHS.

Effectiveness, usefulness, accuracy, negative predictive value, completeness, cost of surveillance, validity and value were evaluated in addition to those nine attributes in 172 articles included in the present review (Figure 2). Single, paired or group of more than two but less than nine attributes can be evaluated in the study if the authors

addressed the CDC guidelines. Sensitivity (84/217), timeliness (68/217), data quality (57/217), and completeness (52/217) reported on a single attribute.

Health Outcomes Evaluated

The 217 articles were grouped by health outcome: communicable diseases (CD), non-communicable diseases (NCD), HAI, injuries, adverse event, and demographical data. The guidelines (CDC, WHO, CDC/WHO) were most used in evaluating CD 37 (71%) and injury surveillance eight (15%). CDS were the most frequently evaluated (149/217), followed by injury (35/217), HAI (15/217), NCD (9/217), adverse events (6/217) and demographics (1/217) (Figure 3).

Triggers and Trigger Categories Identified During Systematic Literature Review

As a result of the systematic review, six categories of triggers: general, economic change, technical, new component, emergency, and public health measure plus fifteen triggers: initial evaluation, compare systems, formal request, determine cost, data quality monitoring, new technology or innovation, new standards, change in definitions, syndromic surveillance, mass gathering, occurrence of a public health event, preparedness, change in public health policy, introduction of new control measure(s) and structural changes were defined.

CDC, WHO, and generic CDC/WHO were used in studies initiated by triggers from the trigger category: general (21/52), technical (13/52) and new component (10/52) (Figure 4). CDS were evaluated more frequently than any other PHS. We found there were trigger categories identified more often than others: technical 52 (35%), general 34 (23%), new component 27 (18%), emergence (11%), public health measure 15 (10%), and economic (3%) (Figure 5). The range of trigger categories for PHS evaluation for the

entire period of the search was technical 84 (38%), general 56 (26%), new component 34 (16%), public health measure 21 (10%), emergency 16 (7%) and economic changes six (3%). From 1992 to 1996, the technical category was found in 69% of the total number of publications; new component in 13%, and economic change, emergency, and public health measure in 6% each (Figure 6). In groups of articles published between 1997 and 2001, technical category was 39%; new component 31%, general 19%, emergency, and public health measure in 6% each. In groups of articles published between 2002 and 2006, technical category was 34%; general 32%, public health measure 16%, new component, and emergency 8% each, and economic change in 2%. In groups of articles published from 2007 to 2012, technical category was 37%, general was 29%, new component was 15%, public health measure was 9%, emergency was 8%, and economic change was 3%.

We compared the trigger categories' frequencies found in studies performed in the U.S. with groups of countries where only one article or more but fewer than 82 articles were published. (Figure 7) The number of articles by country and trigger is shown in Table 5.

The range of triggers for PHS evaluation for the entire period was data quality monitoring 59 (27%), new technology or innovation 25 (12%), compare systems 23 (11%), initial evaluation 20 (9%), formal request 13 (6%), new standards 13 (6%), syndromic surveillance 12 (6%), change in public health policy 11 (5%), occurrence of a public health event 11 (5%), change in definitions 9 (4%), introduction of new control measures 8 (3%), determine cost six (3%), mass gathering 3 (1%), preparedness 2 (1%), and structural changes 2 (1%) (Table 6).

Four triggers were unique for communicable disease PHS evaluation – occurrence of a public health event (11/217), change in definitions (9/217), mass gathering (3/217) and preparedness (2/217). Data quality monitoring was the most frequent trigger for CDS (35/149), HAI (7/15), adverse events (4/8) and injury surveillance system (ISS) (11/35). The initial evaluation trigger was most frequent among NCDS (3/9) (Table 7).

Guidelines (CDC, WHO, or CDC/WHO) were used in studies initiated by an initial evaluation trigger (10/52), followed by data quality monitoring and formal request triggers (8/52). (Figure 8)

Data quality monitoring was the most frequent trigger for PHS evaluation for all years of publication and was included in 69% of the total number of articles published from 1992 to 1996; 35% of the total number of articles published from 1997 to 2001; 20% of the total number of articles published from 2002 to 2006, and 25% of the total number of articles published from 2007 to 2012. In a group of articles published between 1997 and 2001, initial evaluation, new standards and new technology or innovation were the second most frequent triggers (14% of all studies). In a group of articles published between 2002 and 2006, new technology and compare systems, followed the data quality monitoring triggers were 14% of all studies. In a group of articles published between 2007 and 2012, compare systems (14%) was the second most frequent trigger, followed by new technology or innovation (11%). Initial evaluation and syndromic surveillance were 9% each of the total (Figure 9).

Chapter 5: Discussion

Conclusion

This systematic literature review of PHS evaluations published in English from 1992 to 2012 yielded six categories of triggers: general, economic changes, technical, new component, emergency, and public health measures. It also yielded fifteen triggers: initial evaluation, compare systems, formal request, determine cost, data quality monitoring, new technology or innovation, new standards, change in definitions, syndromic surveillance, mass gathering, occurrence of a public health event, preparedness, change in public health policy, introduction of new control measure(s), and structural changes. CDS and ISS were evaluated more often than HAI, adverse events or NCDSS. Most evaluation studies were initiated by the technical category triggers (i.e., when a public health practitioner suspects a problem with the PHS data quality or after implementing a new technology or other innovation). The attributes of completeness, data quality, timeliness, sensitivity, and validity should be evaluated to confirm if the PHS data are reliable. Sensitivity, specificity, timeliness, data quality and validity attributes were the basis for evaluation after the implementation of a new technology or other innovation. Not all nine surveillance system attributes recommended by the updated CDC guidelines for evaluating public health surveillance systems were applied in the evaluation process. The systematic assessment was undertaken if a formal requested was made by the government, NGO sponsoring organizations or PHS owners, or in the case of preparedness for a mass gathering event. The number and type of suggested attributes depended on the purpose of the study and trigger. We did not find a significant difference among the categories of PHS (CDS, NCDS, ISS, Adverse event

and HAI) and triggers; nor as well as among types and numbers of the evaluated attributes and triggers.

Guidelines Used and PHS Attributes Evaluated

CDC guidelines for evaluating PHS (1988) and its updated (2001) version were used by author's of 45 publications; but only 15 (33%) reported all nine suggested evaluation attributes (e.g., simplicity, flexibility, data quality, acceptability, sensitivity, PPV, representativeness, timeliness, and stability). Systematic assessments were initiated by the following triggers: data quality monitoring[8, 152, 158,193]; new technology or innovation[105, 185]; compare systems[34, 104]; formal request[84, 120]; initial evaluation[69, 153]; new standards[114]; syndromic surveillance[36], and occurrence of public health events[61]. Thirty studies mentioned the CDC guidelines in the methods section. But they did not analyze all attributes because of the absence of data or logistic constraints; the adaptation of the CDC guidelines to the special context; or concerns about not requiring the whole system to be evaluated (Figure 2).

Drewe J.A., *et* al. found most studies measured single or paired attributes, even if the evaluation was a systematic assessment[59]. They consider those evaluations could be biased and not provide true information for stockholders. So they suggested creating a generic framework with the number of attributes specified by the research purpose and health outcome. The purpose of our systematic review was to determine what attributes were appropriate to be evaluated by trigger.

We expected that evaluations performed for the first time would be a systematic evaluation. In case of formal evaluation, the fundamental assessment was preferred with the aim to discover if the current PHS achieved its objectives and purposes, and if it

fulfilled the CDC PHS evaluation criteria. But only two studies evaluated all nine attributes[84,120]. Sekhobo J. P., *et* al did not report stability and data quality, but described the system structure in detail and analyzed its usefulness and cost-effectiveness[201]. Hajdu A., *et* al. used attributes addressing implementation and compliance because of their importance to HAI PHS[91]. We can assume that three official reports assessed all of elements, but the authors used attributes that differed from the CDC (i.e., structure, process, response, core capacities, shortcomings, and limitations) [10, 161, 164].

Most initial evaluations of PHS in this review were performed one to three years after establishment. Two studies were published in 1998[69, 129], all other studies after 2000, and the number of publications doubled during the last six years in comparison with the prior years (2002 – 2006). Studies that mentioned the CDC or WHO guidelines were more complete than formal request evaluations, and 50% of them assessed nine or ten attributes; the others addressed at least four attributes related to their purpose.

We would recommend usefulness, data quality, and flexibility to describe the qualitative aspects of a PHS; acceptability, validity and usefulness to assess the utility of a PHS; simplicity, timeliness, data quality and representativeness to monitor the effectiveness of a PHS.

Economic Change Category

Cost evaluation of PHS is necessary to understand if the system performs effectively; its value for human, technical, and financial resources increases; and the efficiency of the resources allocation is maximized. We found six studies that evaluated the cost-effectiveness of the PHS by using different methods: the activity-based cost of tuberculosis (TB) surveillance and application of a new conceptual framework for PHS

and action on a country level[146]; analysis of relevance of new technical and financial investments into the system[157]; comparison of productivity funded and non-funded by the federal government viral hepatitis surveillance[105]; analyzing the implementation costs of establishing and operating activities for the new PHS[210]; evaluation of the cost-effectiveness of three alternative strategies of screening of antibiotic resistance[121]; and analysis of PHS effectiveness measured by the usefulness and application of surveillance data[226]. The data quality, completeness, timeliness, representativeness, usefulness, and cost effectiveness surveillance attributes were assessed in these studies. The number and type of attribute can differ by objective and secondary research question.

Communicable Disease Surveillance

Two kinds of PHS were evaluated more often than others: CDS and ISS. CDS was established earlier than any other, so there is no wonder that it had the greatest number of articles published between 1992 and 2012. From 2007 to 2012 the number of publications increased six fold in comparison to years 1992 – 1996, with the majority of the studies performed in the United States, Australia, Canada, the UK, and Italy. One hundred and forty-nine evaluations of CDS were initiated by each of the 15 triggers. Twenty-three evaluations mentioned using the CDC guidelines in the method section, but only nine performed a complete evaluation[120,153]. The rest evaluated a single attribute, paired attributes, or a group of them. The number of assessed attributes depended on the purpose for the evaluation and triggers. If the CDS was formally evaluated, initially evaluated, or was aimed to determine if the existing system can manage the special circumstances of the mass gathering event, paired attributes, such as sensitivity and specificity, completeness and timeliness, simplicity and acceptability, were evaluated

more often than guidelines being used. If study was initiated by changes in the disease definition and the necessity of measuring the data quality, it was more likely that completeness would be assessed as a single attribute[110]; or completeness and timeliness as paired attributes[125,201]. After the application of the new public health policy (e.g., introduction of a new vaccine, management of antimicrobial resistance) on the concerned population or introduction of a new control measure into the CDSS, sensitivity and completeness could be assessed separately[166, 208], or sensitivity, flexibility, and timeliness could be assessed together[196,122]. While comparing several CDS, the authors evaluated sensitivity and specificity as part attributes[187] or in combination with timeliness or PPV[72, 104, 156, 170,].

Emergency Trigger Category

The emergency trigger was unique for the evaluation of CDS and was initiated by the occurrence of various public health events (e.g., outbreak, mass gatherings, or requirements from the public health institution) to assess preparedness of PHS for emerging communicable disease threats. We included 11 studies that evaluated the capability of CDS to respond during outbreaks and were published from 1995 to 2012. Influenza, food-borne disease, malaria and hepatitis A surveillance studies assessed the current performance of early warning and reporting systems, characterized its complains to detect outbreaks, completeness[18,235], sensitivity and timeliness of data reporting[130,135] and to describe experience of using the pandemic case register before and during the pandemic from the perspective of users[39], summarized PHS results after the CDS implementation and analyzed its usefulness and possible ways of improvement[18,178]. Sensitivity, specificity, timeliness, data quality, acceptability, and usefulness were

predominantly evaluated. The number of publications increased three times during 2007 – 2012 in comparison to 2002 – 2006, that confirmed the attention of the public health specialists to this problem. We recommend a group of basic attributes (e.g., timeliness, flexibility and sensitivity) to be assessed if one wants to measure the suitability of PHS for dealing with public health threats.

Mass gatherings add CD health risks because of the increased population density, changes in provision supply with a potential risk for food-borne disease, migration of population and import/export of microorganisms with high pathogenicity. Three studies analyzed if the existing CDSS delivers appropriate, accurate and timely information to stakeholders in order to implement adequate prevention and control measures. Trinidad and Tobago 2007 described the development, implementation, major findings, and recommendations from the mass gathering surveillance that supported the International Cricket Council's Cricket World Cup West Indies[27]. The second study of the new PHS system for undiagnosed serious infectious disease during the London 2012 Olympic and Paralympic Games discussed the system establishment and pilot evaluation undertaken during the first six months[97]. It is necessary to make sure that PHS is adequately ready for the mass gathering event, so all PHS needs to be evaluated. The German study performed a pre-event and post-event assessment of the enhanced PHS for the small-scale mass gathering in the example of the FIFA Women's World Cup, and suggested that conducting a needs assessment would be more effective if the stakeholders were involved at the early stage of planning; the following post-event evaluation was helpful for the future enhanced surveillance systems[216].

Early detection of the CD threat is important for the notification of public health authorities and mobilization of the resources for epidemiologic investigation preventing disease spread. In addition, mass prophylaxis and treatment are necessary. So the assessment of the CDS's ability to react effectively in the face of potential hazards needs to be performed regularly. It is not necessary to evaluate all PHS attributes in this situation. We included two studies in our review that evaluated the CDS preparedness for the influenza epidemic in the United States and Australia. The New York City study examined the potential bias involved in the emergency medical services ambulance dispatch-based syndromic surveillance versus the emergency department-based surveillance for the influenza-like illness to determine the sensitivity and predictive value positive for selected call types[83]. The Australian study was initiated by the Australian Government Department of Health and Ageing to evaluate how the Australian sentinel practice research network, the national network of general practitioners, can contribute to the surveillance of emerging infectious disease, to assess its simplicity, flexibility, acceptability, timeliness, stability, data quality, and representativeness, and to use the findings for further CDS re-development as a part of the Biosecurity Surveillance System Project[46].

Technical Trigger Category

The most frequent reason for performing an evaluation of CDS from 1992 to 2012 was the assumption that there was a problem with some aspect of data quality that needed to be investigated further or the introduction of new technology. HIV/AIDS and TB under-reporting was the major concern for CDS, as well as rubella, meningococcal meningitis and poliomyelitis. HIV/AIDS PHSS were evaluated in five United States, one

U.K., and one Italian study to assess the completeness of AIDS case reports and assess whether it differs in various populations[81]; analyze the quality of the AIDS death certification to estimate the HIV/AIDS prevalence and mortality[231]; and examine the quality of the HIV serosurveillance[137] plus gaps in data needed for a reliable estimation of HIV prevalence and size of populations-at-risk for infection[99,189]. The TB Italian study was conducted to assess the quality of surveillance at the local hospital over the 10-year period because the country under-reporting of TB ranged from 12% to 37-54% in different areas[148]. The aims of the U.S. TB studies were to assess the completeness and timeliness of TB reporting at a state level, inform the TB case report revision process, and evaluate the usefulness of the laboratory and hospital discharge data[50,213,223]. We assume that in order to get the picture of the possible problem with the epidemiologic data quality monitoring, completeness, data quality, timeliness, sensitivity, and validity could be the basic attributes for evaluation.

In the 21st century we face rapid introduction of new technology, aimed to make our life and work more efficient and easier. PHS is not apart from this continuous development, but in order to be approved by the public health and scientific professionals, all innovations need to be assessed to find out if they are as efficient as or more efficient than the previous ones. Seventeen evaluations of the application of new technology in CDS were published from 1992 to 2012. The replacement of an old surveillance system for a new one (Vaccine Adverse Event Reporting System instead of Monitoring System for Adverse Events Following Immunization and Food and Drug Administration system in the U.S.)[240], integration between PHS (enhanced Lymphogranuloma Venereum with the routine internet-based sexually transmitted

infection in the Netherlands)[123], application of a new software (ICD-codes for syndromic surveillance in the electronic surveillance system for the early notification of community-based epidemics)[22], transition from the paper-based to the eSurveillance (Computerized Network for the Surveillance of Communicable Diseases in Italy)[35] are examples of innovations that were evaluated. All nine attributes recommended by CDC were evaluated in different combinations. The most useful attributes would be sensitivity, specificity, timeliness, data quality, and validity.

New Component Trigger Category

The "change in definition" trigger occurred when CDS faced new challenges, such as HIV/AIDS or when the PHS needed to be reviewed after the implementation of a new opinion on a well-known disease (TB, Syphilis, Malaria) or after the discovery of a new discovery of the way of disease transmission or a new aspect pathogenesis. Five studies, published in 1999 – 2001 and included in the present review were related to HIV/AIDS surveillance after the 1993 change in the AIDS case definition. The main purpose of those studies was to assess the completeness, timeliness, and validity of PHS, and determine what was different in HIV and AIDS surveillance[110, 209]. One Australian study evaluated the flexibility, sensitivity, representativeness, timeliness, and usefulness of Australian National Creutzfeldt-Jakob Disease Registry after the discovery of a new form of transmission of Creutzfeldt-Jakob Disease through consumption of the BSE-contaminated beef[186]. The New Jersey Department of Health study addressed the question of how a new definition of congenital syphilis influenced the accuracy and completeness of reporting and of the cost associated with identifying and classifying new cases[41]. The Italian study aimed to assess the coverage and validity of the National

Compulsory Surveillance System, and it was triggered by changes in the reporting criteria and definition of tuberculosis[151]. One of the most important objectives for the evaluation influenced by a change in the disease definition is to determine how this new definition was accepted by public health and medical specialists and if there was no delay or over/under reporting of the health condition.

Syndromic surveillance was initially created and implemented in response to bioterrorist threats and for the timely detection of naturally occurring disease outbreaks (e.g., influenza, influenza-like illness). The majority of studies included in the present review assessed from one to four attributes (e.g., completeness, timeliness, accuracy, simplicity, usefulness, data quality, degree of adoption, and compliance of the surveillance system) with the purpose of assessing the capabilities of the system, identifying early signals of outbreaks, evaluating the role of the system in informing public health action, describing users' perceptions of the value of the syndromic surveillance within the context of other surveillance systems[52, 57, 100, 112, 122, 171, 198, 243].

In the publications included in the present review, the introduction of new PHSS standards, such as the list of reportable health outcomes (new nosology in injury surveillance)[115], implementation of the existing system into a new area (the Navy surveillance system implemented into the Army, and the military surveillance implemented into the civilian)[150] and inclusion of new cases into the existing PHS (the general practitioner network for the influenza-like illness active surveillance)[117].

Most evaluations were performed in the United States and published between 1997 – 2001 and 2007 – 2012. Initiated by WHO, evaluation of the epidemiologic surveillance in Ethiopia was performed as a part of implementation of a comprehensive

health sector development program and a new PHS that focused on 17 communicable diseases and syndromes with the further assessment of the baseline for action planning and strengthening, assessment of existing PHS resources (human, financial, material) and system performance[175].

Public Health Measure Trigger Category

Changes in public health policy, such as application of the new health care management by law, introduction of a new vaccine, treatment protocols, and diagnostic procedures, initiated the evaluation of PHSS mostly during the last ten years, and a number of publication was increasing from year to year. The evaluation of the dracunculiasis surveillance system was initiated after the implementation of a new educational program on a local level through the collaboration of volunteers and medical professionals in Ghana[144]. The Mexican study evaluated the results of the implementation of a new malaria control program and usage of a quick diagnostic test (diagnostic strips) instead of the diagnosis through thick blood smears[23]. The Netherlands study evaluated the completeness of the Dutch malaria notification system after the implementation of a new infectious disease law in 1999, when laboratories were obliged to report malaria cases to the Municipal Health Service[124]. The studies related to the vaccine preventable disease were initiated to evaluate the existing CDSS before the introduction of a new vaccine to reveal whether the system had any limitation in the data management (completeness, timeliness), specimen collection and laboratory equipment to provide the appropriate data before the start of a vaccination program; to analyze the completeness and timeliness of PHSS and effectiveness of the vaccination company after the implementation of a new vaccine; and to provide the fundamental evaluation of the

National PHSS concerning the diseases targeting for elimination (diphtheria, mumps, tetanus, poliomyelitis, rubella, hepatitis B, measles, and pertussis in Georgia)[155].

We found only two articles related to the evaluation of PHSS due to structural changes in the health care system that were published in 1992-2012. In 1991 the Soviet Union was destroyed and the previously centrally planned infectious disease SS lost its effectiveness because of the economic crisis, under-budgeting public health system, and migration of well-trained specialists. Wuhib T. et al. performed a fundamental assessment of the infectious disease SS in Armenia after dissolution of the Former Soviet Union in 1991 by using the CDC guidelines to discover weaknesses of the system and to provide recommendations for its improvement[241]. The evaluation of effectiveness of the nosocomial infections surveillance system in the U.S. was performed 20 years after the previous assessment had been done. The authors did not mention any particular changes in the health care system, but they assumed that the system had changed dramatically from 1974 till 1994, and this made them initiate the evaluation[162]. A lot of countries, especially those with an unstable political situation, re-imaging economic crisis, could face the same problem, and those examples can help in the initial planning of either establishing the new SS or modifying the existing one.

From eight evaluations of PHSS that were triggered by the introduction of a new control measure, such as national polio or measles eradication programs, controlling nosocomial infections, growth monitoring and promotion programs, two were published in 1992 and 1998, and other six were published during last six years. The study related to the national eradication programs was performed both in developed and developing countries. The study performed in India and published in 1992, assessed the sensitivity of

the acute flaccid paralysis surveillance by comparing the number of reporting polio cases with the number determined by the survey after the establishment of the national poliomyelitis eradication program in co-ordination with WHO in 1988[206]. Published in 2009 and performed in 2000-2005, the Australian study used the scenario tree model to assess the sensitivity of the acute flaccid paralysis surveillance among children of 15 years old and younger to see if the current system is sufficient and still economically effective[232]. Four studies published after 2006 evaluated accuracy in the data coverage, representativeness, sensitivity, and validity of measles surveillance in Saudi Arabia, Iraq, Caribbean, and Mozambique[6, 65, 107, 111].

General Trigger Category

The formal request and initial evaluation triggers have been discussed above. The purpose of the majority of comparative studies has been to compare the performance of the different kinds of CDSS for the same disease within the country or between several countries to identify which one is more accurate and sensitive, to analyze the agreement between the data recorded electronically and the data extracted from the hardcopy medical documentation, which system is more valid and provides more useful data, and which system has less under-reporting and less delay in timeliness.

Among communicable diseases, such as measles, influenza and influenza-like illness, tuberculosis surveillance systems were evaluated more frequently, and the authors compared the sentinel surveillance with the mandatory notification and data from health insurance companies (measles), or sentinel with syndromic surveillance; school-based and national surveillance for influenza; active surveillance and national notifiable disease

surveillance system; paper-based and electronic data-based surveillance systems; community-based (door to door) and school-based surveillance.

Injury PHS

Improving the inquiry surveillance became a priority for public health specialists after the first World Conference on Injury Prevention and Control held in Stockholm, Sweden, in 1989. The conference showed that there was a shortage of information, difference in classification between countries, and lack of standardization in the injury surveillance data. Only one article was published in 1996 by Davis Y et al.[54] in comparison to 16 articles published from 2007 to 2012. The data quality monitoring, systems of comparison and new standards were three most frequent triggers for the evaluation of ISS. Only four studies published from 1992 to 2012 evaluated all nine surveillance system attributes, according to the CDC guidelines[69, 84, 106, 114]. The rest of the studies evaluated single, paired and multiple attributes.

The injury surveillance is younger and not so well structured as the communicable disease surveillance and the comparative studies of the acute lung injury, violent injury, traumatic firefighter's fatalities, occupational injury and sport injury surveillance. It has been initiated to create a basement for further improvement, and it has specified which data management is better, and how these national systems can integrate into the international network.

From 1992 to 2012, Canada followed by the U.S., South Africa and the U.K. was the leading country in the articles that evaluated both, local and international ISS, initiated by a problem of the underreporting of injury cases. The aim of evaluations was to estimate the underreporting of occupational injuries and illnesses in the national

surveillance system[190]; to describe the accuracy of the death certificate surveillance[188]; to assess the accuracy of the injury information database[118]; to estimate the surveillance system's ability to determine cases in the absence of a standard for the true number of cases[54]; and to assess the sensitivity and timeliness of evaluation methods in order to provide recommendations for further ISS improvement[139,237].

Limitations

Our study had limitations: in order to make a judgment on what the trigger for the PHSS evaluation is, it is necessary to have a description of the pre-existing situation in the country, health care, public health system, or a general picture of condition of interest; also the study objectives need to be specified by the authors. Not all studies included in the present review stated their objectives clearly and used the standard attributes for evaluation. In such a situation, we have clarified the purpose of the study on our own after reviewing the entire document and then determining the trigger. We did not include the articles published in languages other than English into the study, so we did not have the whole picture of studies performed in non-English-speaking countries. That can limit the number of publications related to the emergency situation or specific for those countries' condition of interest.

Applications

The trigger identification during the planning stage for surveillance system assessment can be used in developing a new framework for PHSS evaluation. This new concept will assist public health specialists and will make the evaluation process more effective and efficient.

Table 1. Definition of Public Health Outcomes, Systematic Literature Review, 2002 – 2012

Health outcome	Definition
Communicable disease	An illness due to a specific infectious agent or its toxic products that arises through transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector, or the inanimate environment
Noncommunicable diseases	Chronic diseases, are not passed from person to person
Injury	Physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy
Adverse events	Any unfavorable and unintended sign (including an abnormal laboratory finding), symptom, or disease temporally associated with the use of a medical treatment or procedure that may or may not be considered related to the medical treatment or procedure
Hospital-acquired infections	Infections that patients acquire during the course of receiving healthcare treatment for other conditions

Table 2. Definition of Attributes, Systematic Literature Review, 2002 – 2012[32, 78, 167]

Attribute	Definition
Acceptability	The willingness of persons and organizations to participate in the surveillance system
Simplicity	The system's structure and ease of operation
Flexibility	The ability of the surveillance system to accommodate changes in operating conditions or information needs
Data Quality	The completeness and validity of the system data
Positive Predictive Value	The proportion of cases reported to the system that actually have the health event
Sensitivity	The proportion of cases of a health event detected by the surveillance system; and the system's ability to detect outbreaks, including the ability to monitor changes in the number of cases over time.
Representativeness	The extent to which a surveillance system accurately portrays the incidence of the health event in the population by person, time and place.
Timeliness	The interval between the occurrence of an adverse health event and the report of the event to the appropriate health agency, the identification by that agency of trends or outbreaks, or the implementation of control measures
Stability	The reliability and availability of the system. Stability can be measured by the amount of time required to manage and disseminate the information to decision makers.
Compliance	Before a surveillance system can become operational, it must first satisfy a Privacy Impact Assessment.
Effectiveness	The measure of how well a surveillance system can achieve its intended results. In order to measure this, the specifications and functioning of the surveillance system must be documented and well known among the contributors and stakeholders
Efficiency	Inputs (resources), activities and outputs largely under the control of the organization; assessments of efficiency (cost-benefit, cost-effectiveness) provide a frame of reference and a discipline for relating costs to program results.
Usefulness	An assessment of the usefulness of a surveillance system with

	respect to program objectives
Accuracy	Degree to which a measurement or an estimate based on measurements represents the true value of the attribute that is being measured
Cost	Indirect and direct costs, measured in relation to the benefits obtained.
Validity	Degree to which statistical information correctly describes the phenomena it was designed to measure.
Negative predictive value	The proportion of cases reported to the system that actually have no the health event
Completeness	Proportion of all expected data reports that were actually submitted to the public health surveillance system.

Table 3. Triggers and Reasons for Evaluations of Public Health Surveillance, Systematic Literature Review, 2002 – 2012

Category	Trigger	Reason
General	Initial evaluation	First attempt to evaluate the PHSS after establishment
	Compare systems	Comparison of different PHSS (e.g., paper-based, laboratory, electronic) of the same health outcome
	Formal request	Assessment of PHSS at request of owner or external stakeholder
Economic	Determine costs	Determine cost of PHSS because of need to prioritize (e.g., downsize)
Technical	Data quality monitoring	Undercover problems with data quality (e.g., underreporting)
	New technology or innovation	New software, technology, or innovation that may enhance PHSS effectiveness or efficiency (e.g., mobile phones, e-surveillance)
New component	New standards	Need to know if new PHSS standards (e.g., list of reportable health outcomes, determine if surveillance objectives are appropriate)
	Change in definitions	Change in case definition(s) may impact case classification
	Syndromic surveillance	Is syndromic surveillance system accepted by its users and effective for outbreak detection and trends assessments?
Emergency	Mass gathering	Determine if the existing PHSS can manage the special circumstances of the mass gathering event or if other components need to be added
	Occurrence of public health event	Can the current surveillance system handle early warning and response function in case of outbreaks, epidemic and pandemic?
	Preparedness	Assess how surveillance system can contribute to emerging communicable disease that can represent a global threat.
Public	Change in public	Capacity of the surveillance system to measure

health measure	health policy	the impact of the change in a public health policy (e.g. introduction of a new vaccine, management of antimicrobial resistance) on the concerned population.
	Introduction of new control measure(s)	Can surveillance system collect the necessary information (e.g. disease incidence and prevalence) to monitor the national eradication programs? Is participation in surveillance programs decrees the incidence of disease in question (e.g. tuberculosis, nosocomial infections)?
	Structural changes	Change of health-care structure due to political situation (dissolution of Former soviet Union) or health-care reform (UK switch from secondary into primary care).

Table 4. Geographic Locations of Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

Location	No.	References
United States	82	3, 15, 16, 18, 20, 22, 24, 26, 33, 36, 38, 40, 41, 48, 50, 51, 53, 54, 64, 69, 74, 80, 81, 83, 86, 92, 94, 95, 98, 104,105, 106, 110, 113, 114, 115, 121, 125, 129, 130, 131, 132, 133, 137, 140,143, 146, 152, 159, 161, 162, 168, 172, 175, 176, 177, 180, 184, 188, 189, 190, 191, 195, 200, 201, 202, 204, 205, 207, 209, 212, 213, 215, 223, 228, 229, 231, 233, 237, 238, 240, 243
U.K.	8	57, 68, 97, 99, 126, 157, 169, 203
Australia	17	46, 49, 67, 71,76, 79, 85, 89, 100, 145, 153, 170, 171, 185, 186, 196, 232
Canada	13	25, 84, 118, 128, 138, 139, 141, 154, 174, 198, 199, 239, 245
Multi country	9	5, 21, 34, 42, 147, 156, 163, 210, 222
Italy	6	17, 19, 35, 148, 151, 173
Netherlands	6	123, 124, 142, 181, 226, 235
South Africa	5	30, 31, 47, 96, 247
Germany	4	62, 75, 216, 246
Pakistan	4	8, 39, 158, 193
China	3	61, 134, 135
Korea	3	4, 165, 244
Peru	3	101, 187, 211
France	2	119, 160
Brazil	2	73, 219
French Guiana	2	52, 112
Jamaica	2	9, 65
Japan	2	72, 218
Mexico	2	23, 227
Mozambique	2	11, 109
Norway	2	1, 91
Sweden	2	12, 183
Taiwan	2	102, 217
Tanzania	2	120, 192

Trinidad and Tobago	2	27, 43
Finland	1	103
Armenia	1	241
Botswana	1	7
Argentina	1	242
Cambodia	1	230
Colombia	1	88
Ethiopia	1	13
Georgia	1	155
Ghana	1	166
Honduras	1	90
Hungary	1	149
India	1	206
Iraq	1	111
Israel	1	122
Kosovo	1	150
Malawi	1	107
Nepal	1	178
New Zealand	1	117
Niger	1	55
Nigeria	1	179
Philippines	1	164
Poland	1	144
Saudi Arabia	1	6
Slovenia	1	208
Spain	1	2
Sri Lanka	1	10
Switzerland	1	182
Thailand	1	45
Uganda	1	37
Vietnam	1	63
Total	217	

Table 5. Triggers Stimulating Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

Country	Triggers															
	Change in definition	Change in public health	Compare systems	Determine cost	Data quality monitoring	Formal request	Initial evaluation	Introduction of new	New standards	Mass gathering	New technology or	Occurrence of a public health event	Preparedness	Structural changes	Syndromic surveillance	Total
US	5	1	11	3	24	4	5		7		14	4	1	1	2	82
Australia	1	1	2		3		4	1			2		1		2	17
Canada					8	1	1				1				2	13
UK				1	3	1	1			1					1	8
Italy	1				3		1				1					6
The Netherlands		1		1	2						1	1				6
South Africa					1	1	1		1			1				5
Multi country	1	2	5	1												9
Others	1	6	5		15	6	7	7	5	2	6	5		1	5	71
Total	9	11	23	6	59	13	20	8	13	3	25	11	2	2	12	217

Table 6. Trigger Categories Stimulating Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

Trigger Category	Trigger	1992-96	1997-01	2002-06	2007-12	Total
General	Compare systems			7	16	23
	Initial evaluation		5	5	10	20
	Formal request		2	4	7	13
Technical	Data quality monitoring	11	9	10	29	59
	New technology or innovation		5	7	13	25
New component	New standards		5	1	7	13
	Syndromic surveillance			2	10	12
	Change definitions	2	6	1		9
Economic changes	Determine cost	1		1	4	6
Emergency	Occurrence of public health event	1	2	2	6	11
	Preparedness			2		2
	Mass gathering				3	3
Public health measure	Introduction of new control measure (s)	1	1	3	3	8
	Structural changes		1	1		2
	Change in public health policy			4	7	11
Total						217

Table 7. Triggers Stimulating Public Health Surveillance Evaluations, by Health Outcome, Systematic Literature Review, 2002 – 2012

Trigger	Health Outcome						
	Communicable disease	Non-communicable disease	HAI	Injuries	Demographic surveillance	Adverse events	Total
Change in case definition	9						9
Change in public health policy	8			2		1	11
Compare systems	12	2		8		1	23
Determine cost	5		1				6
Data quality monitoring	35	2	7	11		4	59
Formal request	10	1	1	1			13
Initial evaluation	12	3	1	3	1		20
Introduction of new control measures	6	1	1				8
New standards	7		1	5			13
Mass gathering	3						3
New technology or innovation	17		2	4		2	25
Occurrence of a public health event	11						11
Preparedness	2						2
Structural changes	1						2
Syndromic surveillance	11			1			12
Total	149	9	15	35	1	8	217

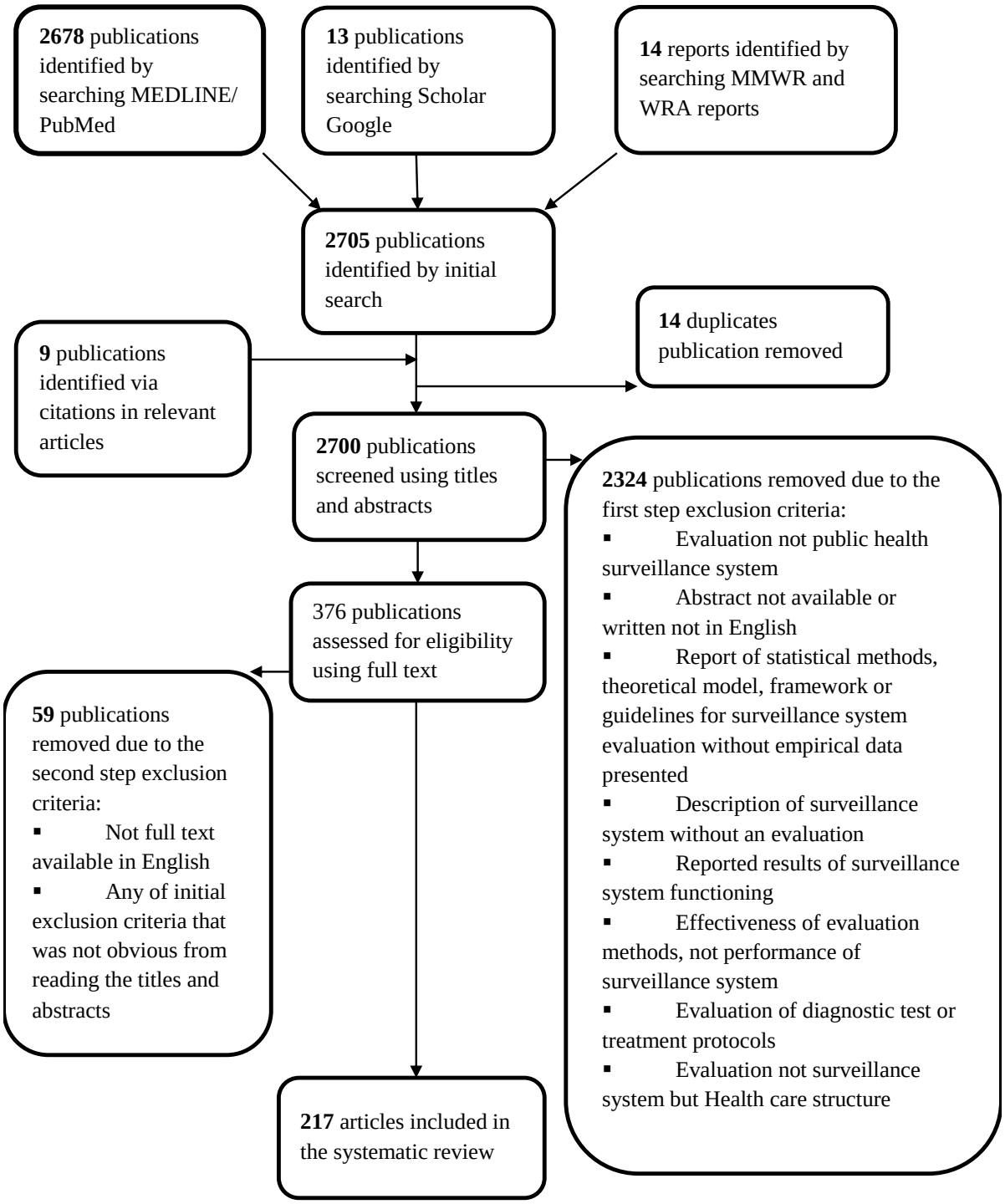

Figure 1. Flowchart of Literature Stimulating Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

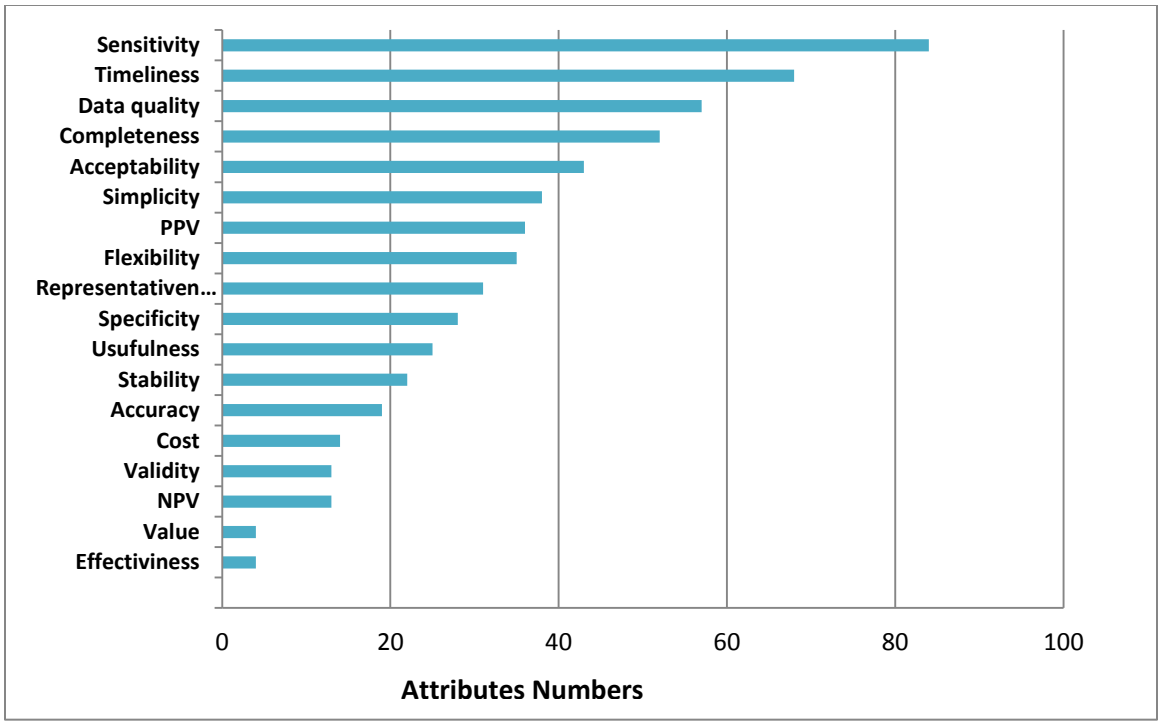

Figure 2. Surveillance Attributes Examined during Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

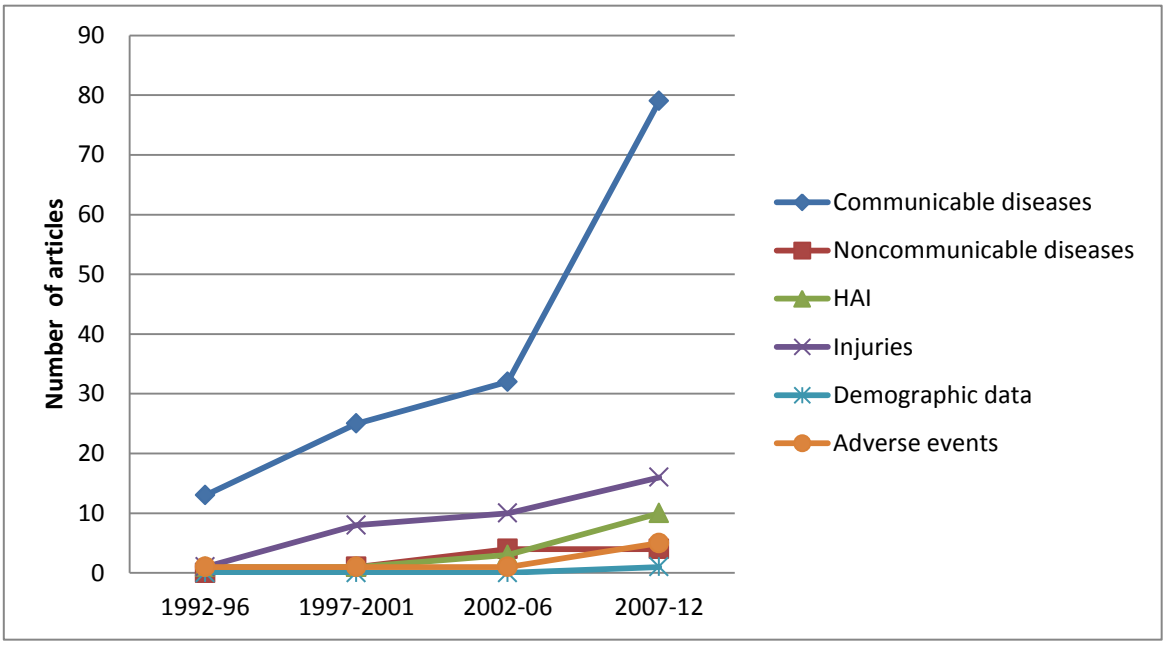

Figure 3. Public Health Outcomes Assessed, Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

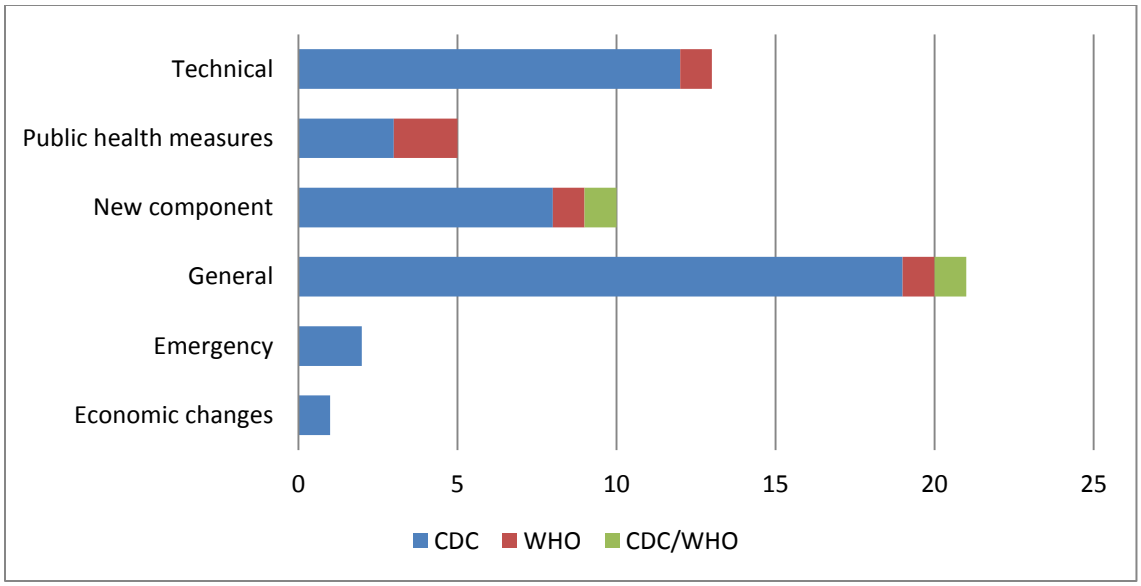

Figure 4. Trigger Categories Stimulating Public Health Surveillance Evaluations, by Guideline, Systematic Literature Review, 2002 – 2012

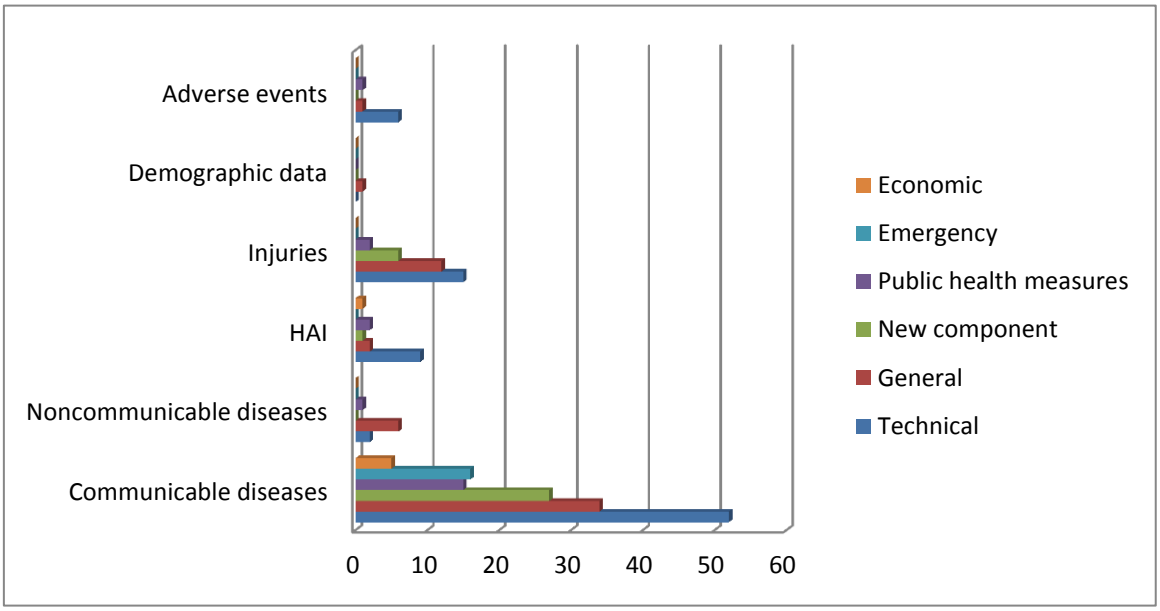

Figure 5. Trigger Categories and Triggers Stimulating Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

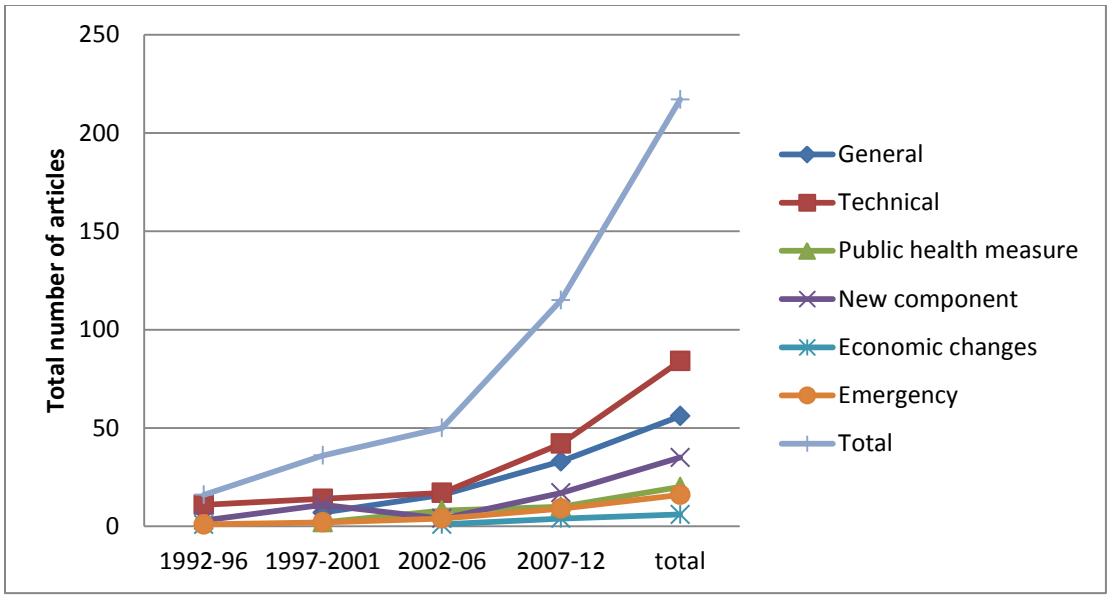

Figure 6. Number of Articles, Stimulating Public Health Surveillance Evaluations, by Time and Trigger, Systematic Literature Review, 2002 – 2012

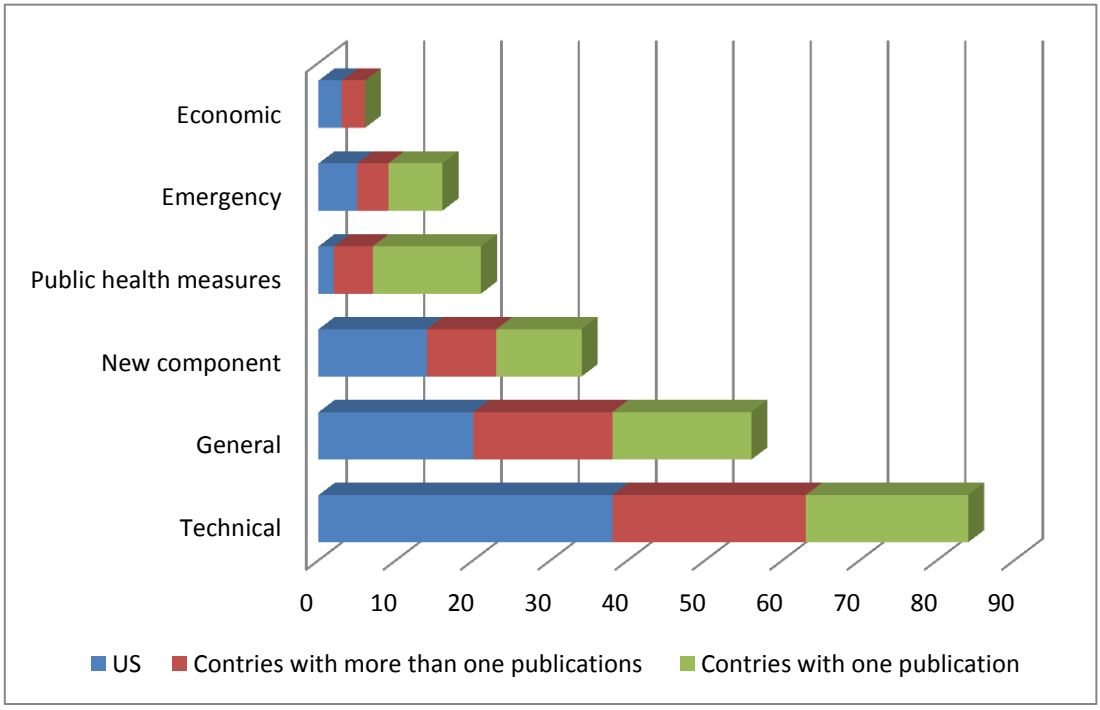

Figure 7. Triggers Stimulating Public Health Surveillance Evaluations, by Region, Systematic Literature Review, 2002 – 2012

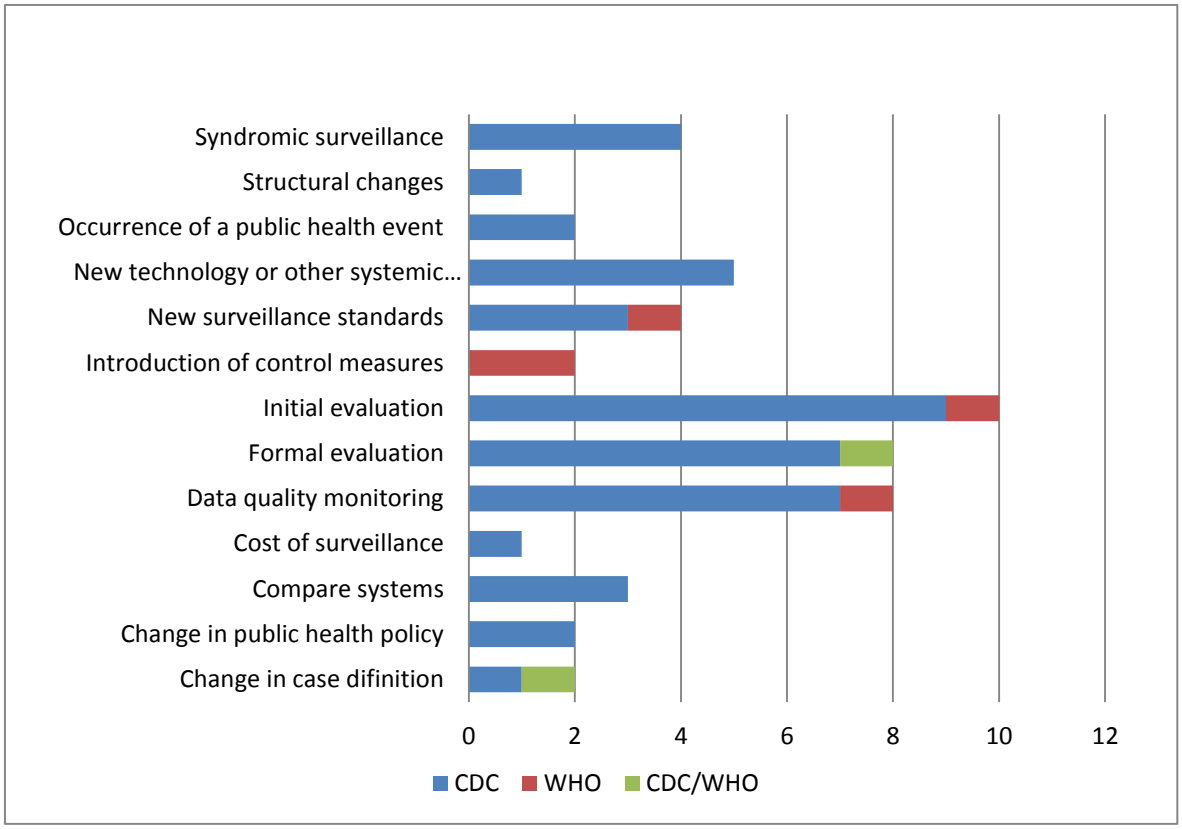

Figure 8. Triggers Stimulating Public Health Surveillance Evaluations, by Guideline, Systematic Literature Review, 2002 – 2012

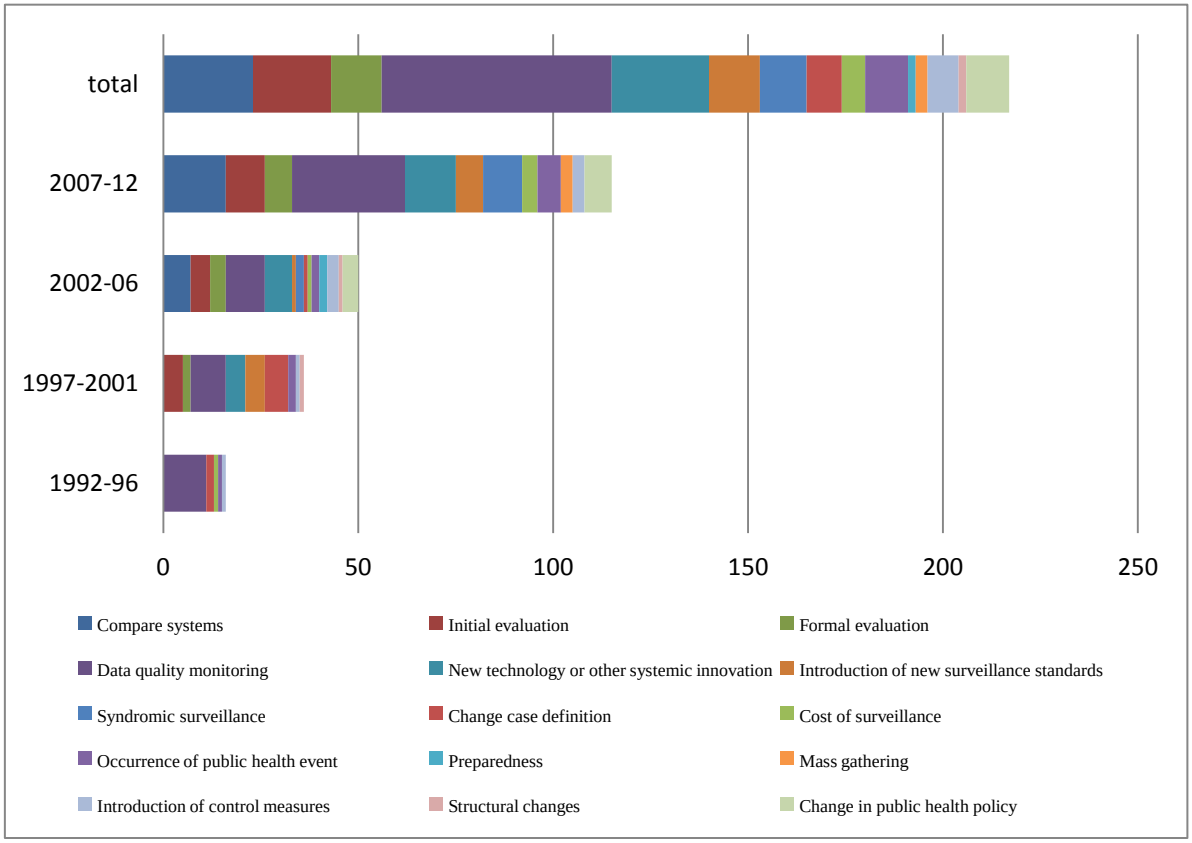

Figure 9. Triggers Stimulating Public Health Surveillance Evaluations, by Time Period, Systematic Literature Review, 2002 – 2012

Annex 1. Summary of Publications of Public Health Surveillance Evaluations, Systematic Literature Review, 2002 – 2012

Authors	Country	Health Outcome	Purpose	Trigger Category	Trigger
1992	Jamaica	Communicable disease	To get an accurate picture of existing surveillance system	Public health measure	Introduction of control measures
Rosenblum L et al. 1992	USA	Communicable disease	To evaluate the completeness of AIDS case reporting.	Technical	Data quality monitoring
Hickman M et al. 1993	UK	Communicable disease	To assess directly the extent of under-reporting of AIDS cases to the National AIDS surveillance system.	Technical	Data quality monitoring
Cardo DM et al. 1993	USA	HAI	To determine the sensitivity and specificity of standard infection control surveillance techniques for the identification of surgical wound infections.	Technical	Data quality monitoring
Webster LA et al. 1993	USA	Communicable disease	To summarize and to review the chlamydia surveillance data received by CDC from 1987 through 1991	Technical	Data quality monitoring
Greenberg AEet al., 1993	USA	Communicable disease	To assess the completeness of AIDS case reporting in New York City and to determine whether the completeness of reporting differs in various populations	Technical	Data quality monitoring
Prevots DR et al., 1994	USA	Communicable disease	To evaluate the completeness of the national poliomyelitis surveillance system	Technical	Data quality monitoring
Barchielli A et al. 1995	Italy	Communicable disease	To evaluate the completeness of AIDS cases reported and the quality of AIDS death certification	Technical	Data quality monitoring

Migliori GB et al., 1995	Italy	Communicable disease	To assess the coverage and validity of data collected by the national Compulsory Surveillance System; validity of diagnosis and risk factors for tuberculosis and tuberculosis incidence.	New component	Change case definition
Trepka MJ et al., 1995	USA	Communicable disease	To assess the completeness of tuberculosis disease reporting in Wisconsin and evaluates the usefulness of laboratory and hospital discharge data as supplemental case ascertainment sources	Technical	Data quality monitoring
Lenaway DD, Ambler A., 1995	USA	Communicable disease	To compare school-based influenza surveillance system with a preexisting sentinel communicable disease surveillance system	Emergency	Occurrence of public health event
CDC, 1995	USA	Communicable disease	To assess the accuracy and completeness of reporting using the new case definition and to determine the personnel costs associated with identifying and classifying congenital syphilis cases	New component	Change case definition
Rosenthal S, Chen R., 1995	USA	Adverse events	To assess the reporting sensitivities of two passive vaccine adverse event reporting systems	Technical	Data quality monitoring
Morris S et al., 1996	UK	Communicable disease	To assess the costs and cost-effectiveness of the PHLS AIDS Centre's epidemiological surveillance mechanisms for HIV and AIDS in England and Wales	Economic changes	Cost of surveillance
Davis Y et al., 1996	USA	Injuries	To assess the accuracy and completeness of National Electronic Injury Surveillance System for detecting gunshot wounds sustained as a result of the discharge of a firearm	New component	Introduction of new surveillance standards
Ackman DM, Birkhead G, Flynn M., 1996	USA	Communicable disease	To assess completeness of reporting of meningococcal disease in 1991	Technical	Data quality monitoring
Macarthur C, Dougherty G, Pless IB., 1997	Canada	Injuries	To assess the reliability and validity of proxy respondent information in the Canadian Hospitals Injury Reporting and Prevention Program surveillance system	Technical	Data quality monitoring

Singh J, Foster SO. , 1998	India	Communicable disease	To estimate the sensitivity of poliomyelitis surveillance in India	Public health measure	Introduction of control measures
Hedegaard H, Wake M, Hoffman R., 1998	USA	Injuries	Implementation and evaluation of a surveillance system for fatal and hospitalized nonfatal firearm-related injuries	New component	Introduction of new surveillance standards
Wiersema B et al., 1998	USA	Injuries	To evaluate the surveillance system's ability to ascertain cases in the absence of a standard for the true number of cases.	Technical	Data quality monitoring
Fox J et al., 1998	USA	Injuries	To evaluate the attributes of the Wisconsin Firearm-Related Injury Surveillance System	General	Initial evaluation
LeMier M et al., 1998	USA	Injuries	Develop and evaluate a system for surveillance of fatal and nonfatal gunshot injuries	General	Initial evaluation
Gazarian M et al, 1999	Australia	Communicable disease	To assess whether system fulfilled its objectives and satisfied criteria established by the Centers for Disease Control and Prevention for evaluating surveillance systems	General	Initial evaluation
Macarthur C, Pless IB., 1999	Canada	Injuries	To evaluate the quality of Canadian Hospitals Injury Reporting and Prevention Program	Technical	Data quality monitoring
Abraira GL, Martinez-Navarro JF., 1999	Spain	Communicable disease	To evaluate the National Disease Surveillance System for brucellosis in Galicia, Spain	Technical	Data quality monitoring
Reintjes R, Termorshuizen F, van de Laar MJ., 1999	The Netherlands	Communicable disease	To assess the sensitivity of two national sexual transmitted disease surveillance systems by applying the capture-recapture method	Technical	Data quality monitoring

Singleton JA et al., 1999	USA	Adverse events	To evaluated the Vaccine Adverse Event Reporting System	Technical	New technology or other systemic innovation
Barat LM et al., 1999	USA	Communicable disease	To determine the sensitivity of malaria surveillance in several large metropolitan areas	Emergency	Occurrence of public health event
Johnson RL et al., 1999	USA	Injuries	To evaluate the sources reporting hospitalized spinal cord injury cases to the statewide, population-based surveillance system	New component	Introduction of new surveillance standards
Solomon L et al., 1999	USA	Communicable disease	To decide whether an HIV surveillance system should be based on reports of the names of infected individuals or employ non-name-based data codes	New component	Change case definition
MacDonald JK et al., 1997	USA	Communicable disease	To develop and evaluate models for public health surveillance of illnesses among children in out-of-home child care facilities.	Technical	New technology or other systemic innovation
Schwarcz SK et al., 1999	USA	Communicable disease	To assess the impact of the 1993 change in the AIDS case definition on the completeness and timeframe of AIDS case reporting in San Francisco	New component	Change case definition
Alpers L et al., 2000	Botswana	Communicable disease	To assess the validity of the data in the Electronic TB Register with respect to missing pre-treatment sputum smear results in these two cities in order to improve the overall performance of the BNTP	Technical	New technology or other systemic innovation
Perron L, De Wals P, Milord F., 2000	Canada	Communicable disease	To evaluate the validity of information in the rubella surveillance system in Quebec	Technical	Data quality monitoring
Carrieri MP et al., 2000	Italy	Communicable disease	To evaluate the performance of SIMI after its first three years of activity	Technical	New technology or other systemic innovation

Velasco-Mondragón HE, Martin J, Chacón-Sosa F., 2000	Mexico	Communicable disease	To assess the feasibility of binational migrant health data exchange for epidemiological surveillance of migrant populations	Technical	Change in demography
de Chabalier F, Hassane A, Chippaux JP., 2000	Niger	Communicable disease	To assess the effectiveness of the method in the field	Technical	New technology or other systemic innovation
Mazurek J et al., 2000	Poland	Communicable disease	To evaluate hepatitis C surveillance in Poland during 1998	General	Initial evaluation
Chadee DD., 2000	Trinidad and Tobago	Communicable disease	To determine the sensitivity of the malaria surveillance system in Trinidad	Emergency	Occurrence of public health event
CDC, 2000	Uganda	Communicable disease	To assess IDS of the Uganda Ministry of Health	General	Requirements. Told to.
Nguyêñ GT et al., 2000	USA	HAI	To establish the current status of ISCPs in United States health care facilities	Public health measure	Structural changes
Jara MM, Gallagher KM, Schieman S., 2000	USA	Communicable disease	To determine the impact of the 1993 AIDS case definition on the completeness of AIDS case reporting to the state registry and to compare reported and unreported cases with regard to sex, race, and mode of transmission of the virus	New component	Change case definition
Yadon ZE et al., 2001	Argentina	Communicable disease	To estimate the number of new CL cases that occurred in four districts of the province Santiago del Estero, Argentina, during the period 1990– 1993, and to provide an indication of the completeness of reporting to the leishmaniasis surveillance system	Technical	Data quality monitoring

2001	Ethiopia	Communicable disease	To assess the number of syndromes of public health importance	New component	Introduction of new surveillance standards
Ajdacic-Gross V et al., 2001	Multi country	Communicable disease	To get an accurate picture of existing surveillance system	New component	Change case definition
Aavitsland P, Nilsen O, Lystad A., 2001	Norway	Communicable disease	To describe of the system, evidence of system attributes, estimation of resources for system operations, and documentation of the system's usefulness	New component	Change case definition
Butchart A et al., 2001	South Africa	Injuries	To evaluate the NMSS and illustrate its utility from sample findings	New component	Introduction of new surveillance standards
Curtis AB et al., 2001	USA	Communicable disease	Multistate evaluation of completeness and timeliness of reporting of TB cases in the United States during 1993 and 1994	Technical	Data quality monitoring
Sekhobo JP, Druschel CM., 2001	USA	Non communicable diseases	To evaluate the surveillance of congenital malformations in New York State using the CDC guidelines	General	Requirements. Told to.
Walker N et al., 2001	USA	Communicable disease	To analyze the quality of HIV/AIDS sentinel surveillance systems resulting quality of the data used to make estimates of HIV/AIDS prevalence and mortality	Technical	Data quality monitoring
Perz JF et al., 2001	USA	Communicable disease	To measure the alternative county-sponsored surveillance strategy against recognized standards	New component	Introduction of new surveillance standards
Klevens RM et al., 2001	USA	Communicable disease	To assess the completeness, validity, and timeliness of the AIDS surveillance system after the 1993 change in the surveillance case definition	New component	Change case definition

Wuhib T et al., 2002	Armenia	Communicable disease	To assess of the Armenian infectious diseases surveillance system	Public health measure	Structural changes
Finch CF, Mitchell DJ., 2002	Australia	Injuries	To identify of appropriateness of data collection methodologies in sports medicine clinics	General	Compare systems
Robotin M., 2002	Australia	Communicable disease	To assess the ability of the Registry to detect all cases of CJD in Australia, and in particular, to identify cases that may have public health importance	New component	Change case definition
2002	Georgia	Adverse events	To identify the ways to improve the VPD surveillance system in Georgia	Public health measure	Change in public health policy
Mester J et al., 2002	Hungary	Communicable disease	To summarize the results of the first year of the revised National Tuberculosis Surveillance System	General	Initial evaluation
Arscott-Mills S, Holder Y, Gordon G., 2002	Jamaica	Injuries	To conduct a comparative evaluation of two injury surveillance systems in operation in the Accident and Emergency departments of public hospitals in Jamaica	General	compare systems
Fujii H et al., 2002	Japan	Communicable disease	To compare school health surveillance system with national sentinel surveillance system	General	Compare systems
Biddle EA, Marsh SM., 2002	USA	Injuries	To compare two national surveillance system	General	Compare systems
Schwarcz S et al., 2002	USA	Communicable disease	To develop and evaluate a non-name-based HIV reporting system	Technical	New technology or other systemic innovation

Spicer RS et al., 2002	USA	Injuries	To evaluate the Utah experience in developing and administering the Student Injury Reporting System	Economic changes	Cost of surveillance
Zoutman DE et al., 2003	Canada	HAI	To assess the resources and activities directed toward the prevention and control of nosocomial infections in acute care hospitals across Canada	Technical	Data quality monitoring
Nardone A et al., 2003	France	Communicable disease	To estimate the total number of cases of Legionnaires' disease diagnosed in France in 1998 and thus the sensitivity of the mandatory notification surveillance system	Technical	Data quality monitoring
Benavides FG et al., 2003	Multi country	Injuries	To describe fatal work injury surveillance system characteristics, and to compare basic statistics between the U.S. and the E.U.	General	Compare systems
Foot B et al., 2003	UK	Non communicable diseases	To investigate whether this method of case ascertainment is appropriate and productive in an ophthalmological setting	General	Initial evaluation
Greenko J et al., 2003	USA	Communicable disease	To examine potential biases associated with ambulance dispatch-based surveillance	Emergency	Preparedness
2004	Sri Lanka	Communicable disease	To review the existing surveillance systems, in order To identify strengths, weaknesses, opportunities and threats for integrated disease surveillance	General	Regular periodic evaluation
Miller M et al., 2004	Australia	Communicable disease	To systematically and objectively evaluate the attributes of NNDSS and highlight areas for improvement	General	Initial evaluation
Grenier D et al., 2004	Canada	Injuries	To assess whether it fulfilled its objectives and satisfied the Centers for Disease Control and Prevention's surveillance evaluation criteria	General	Requirements. Told to.

Pyle DF et al., 2004	Nepal	Communicable disease	To examine the current performance of the Early Warning and Reporting System in the eight pilot districts, focusing attention on the reporting and response functions	Emergency	Occurrence of public health event
Jones NF, Marshall R., 2004	New Zealand	Communicable disease	To distinguish initial from follow-up visits, the definition of denominators, and the external validity of measured influenza-like illness trends	New component	Introduction of new surveillance standards
Graham PL 3rd et al., 2004	USA	HAI	To validate the New York Antimicrobial Resistance Project's data	Technical	New technology or other systemic innovation
McNabb SJ et al., 2004	USA	Communicable disease	To better evaluate the performance and measure the costs of TB surveillance	Economic changes	Cost of surveillance
Takahashi T et al., 2004	USA	Communicable disease	To assess the timeliness of the Salmonella surveillance system	Technical	Data quality monitoring
Clothier HJ, Fielding JE, Kelly HA, 2005	Australia	Communicable disease	To assess the utility of ILI surveillance conducted by ASPREN, in the context of the Biosecurity Surveillance System requirements	Emergency	Preparedness
Samaan G et al., 2005	Australia	Communicable disease	To reviews the process of gonococcal antimicrobial resistance surveillance in Australia and utility of WHO questionnaire	General	Regular periodic evaluation
Cretikos M,Telfer B, McAnulty J., 2005	Australia	Communicable disease	To evaluate the NSW enteric disease outbreak surveillance system	General	Initial evaluation
Bingle CL et al., 2005	Canada	Non communicable diseases	To examined the process effectiveness, collaboration, utility and cost-effectiveness of RRFSS during its first year of operation	General	Initial evaluation

Edmond M, Wong C, Chuang SK., 2005	China	Communicable disease	To identify areas for improvement	Emergency	Occurrence of public health event
Josseran L et al., 2005 []	France	Injuries	To evaluate the quality and utility of systems	New component	Syndromic surveillance
2005	Ghana	Communicable disease	To conduct semi-structured interviews with program staff from national, regional and district level and, where possible, the local zonal coordinators	Public health measure	Change in public health policy
200 5	Philippines	Communicable disease	To assess the Philippines National HIV/AIDS Sentinel Surveillance System	General	Regular periodic evaluation
Jansson A, Arneborn M, Ekdahl K., 2005	Sweden	Communicable disease	To evaluate the sensitivity of the Swedish system for statutory surveillance of communicable diseases and to form the basis for future comparisons	Technical	New technology or other systemic innovation
Klein S, Bosman A., 2005	The Netherlands	Communicable disease	To estimate completeness of malaria notification in the Netherlands from 1995-2003	Public health measure	Change in public health policy
Doroshenko A et al., 2005	UK	Communicable disease	To evaluate NHS Direct syndromic surveillance using the "Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks", published by CDC	New component	Syndromic surveillance
Comstock RD, Mallonee S, Jordan F., 2005	USA	Injuries	To compare violent injury death reporting by the statewide Medical Examiner and Vital Statistics Office surveillance systems in Oklahoma	General	compare systems
Wright MO, et al., 2005	USA	Communicable disease	To identify and evaluate of available systems	Technical	New technology or other systemic innovation

Ritzwoller DP et al., 2005	USA	Communicable disease	To identify an early and severe influenza A outbreak in Denver in 2003	General	Compare systems
Wilson JL, Carew MT, Strauss BA., 2006	Canada	Communicable disease	To determine the effectiveness of EPINATO as a Canadian Force deployment health surveillance system	Technical	New technology or other systemic innovation
Gastmeier P et al., 2006	Germany	HAI	To investigate whether participation in the German national NI surveillance system (Krankenhaus Infektions Surveillance System) resulted in reduced rates of NIs	Public health measure	Introduction of control measures
Oh HS et al., 2006	Korea	Communicable disease	To assess the status of infection surveillance and control programs and to analyze the trends associated with ISCP implementation since the first program	Technical	New technology or other systemic innovation
2006	Mozambique	Communicable disease	To assess the country's surveillance system and review the status of functions essential for IDSR implementation in regard to human resources, training, supervision and coordination	General	Regular periodic evaluation
Jani JV et al., 2006	Mozambique	Communicable disease	To assess the quality of the measles reporting system during two outbreaks	Public health measure	Introduction of control measures
Chotivichien S, Tharmaphornpilas P, Sinawat S., 2006	Thailand	Non communicable diseases	To describe the current practice on growth monitoring and promotion system in Thailand, identify its constraints and recommend appropriate solutions	Public health measure	Introduction of control measures
Averhoff F et al., 2006	USA	Communicable disease	To validate that the observed absence of rubella is due to the disappearance of disease rather than a failure of rubella surveillance	Technical	Data quality monitoring

Rodriguez SR et al., 2006	USA	Injuries	To describe the accuracy of death certificate surveillance for TBI mortality in 2002 in Oklahoma	Technical	Data quality monitoring
Sprinson JE et al., 2006	USA	Communicable disease	To systematically assess the validity and completeness of reported TB case surveillance data in California and to inform TB case report revision process	Technical	Data quality monitoring
Hall HI et al., 2006	USA	Communicable disease	To determine the completeness of reporting of HIV diagnoses to state surveillance systems	Technical	Data quality monitoring
Miller E., 2006	USA	Non communicable diseases	To assess the overall quality of data collection and to examine variations across regions of the state	Technical	Data quality monitoring
Vogt RL et al., 2006	USA	Communicable disease	To evaluate the completeness and timeliness of the Colorado statewide Web-based system for reporting notifiable diseases	General	Requirements. Told to.
Rosenman KD et al., 2006	USA	Injuries	To estimate the undercount in the existing national surveillance system of occupational injuries and illnesses	Technical	Data quality monitoring
Friedman ND et al., 2007	Australia	HAI	To measure the accuracy and determine the positive predictive value and negative predictive value of data submitted to a statewide surveillance system	Technical	Data quality monitoring
Gillam C et al., 2007	Australia	Injuries	To assess the validity of data collected by a new injury surveillance system in metropolitan public hospital ED in Western Australia	Technical	New technology or other systemic innovation
Gutierrez-Martinez MI et al., 2007	Colombia	Injuries	The methodology employed and lessons learned that may be applicable to similar settings	Public health measure	Change in public health policy

Huotari K, Agthe N, Lyytikäinen O., 2007	Finland	HAI	To compare of Surgical site infection rates as a measure of the quality of patient care	Technical	Data quality monitoring
Zuschneid I et al., 2007	Germany	HAI	To assess the accuracy of the data on primary bloodstream infections reported to the German nosocomial infections surveillance system	Technical	Data quality monitoring
Kaufman Z et al., 2007	Israel	Communicable disease	To assess the capabilities of a syndromic surveillance system in identifying early signals of a localized unusual influenza outbreak	New component	Syndromic surveillance
Jahn A et al., 2007	Malawi	Demographic surveillance	Describes and evaluates the first demographic surveillance system in Malawi	Technical	Change in demography
Betanzos-Reyes AF et al., 2007	Mexico	Communicable disease	To compare the costs and operative loads of the current surveillance program (malaria diagnosis through thick blood smears) with those of an alternative surveillance model	Public health measure	Change in public health policy
Tozzi AE et al., 2007	Multi contry	Communicable disease	To compare the characteristics and the performance of pertussis surveillance systems in 16 European countries	Public health measure	Change in public health policy
Weber IB., 2007	South Africa	Communicable disease	To describe the qualitative aspects of the notifiable diseases surveillance system of the Gauteng Province, South Africa	General	Initial evaluation
Burrows S, Laflamme L., 2007	South Africa	Injuries	To assess the accuracy of suicide data as recorded in the system	Technical	Change in demography
Tan HF et al., 2007	Taiwan	Communicable disease	To investigate the completeness of varicella reporting in Taiwan	Public health measure	Change in public health policy
Rumisha SF et al., 2007	Tanzania	Communicable disease	To gather specific information on the performance of IDSR systems in each of the districts selected	Technical	New technology or other systemic innovation

Manniën J et al., 2007	The Netherlands	HAI	To describe how continuous validation of data on surgical site infection is being performed in the Dutch National Nosocomial Infection Surveillance System to assess the quality and accuracy of the data, and to present the corresponding outcomes of the assessment	Technical	Data quality monitoring
Betancourt JA et al., 2007	USA	Communicable disease	To determine the accuracy of data in ESSENCE	Technical	New technology or other systemic innovation
Payne DC et al., 2007	USA	Adverse events	To analyze the agreement between electronically recorded anthrax vaccination data versus anthrax vaccination data abstracted from hardcopy medical charts	General	compare systems
Jhung MA et al., 2007	USA	Injuries	To describe and evaluate a new system for surveillance of outpatient adverse drug events treated in hospital emergency departments	New component	Introduction of new surveillance standards
Erhart A et al., 2007	Vietnam	Communicable disease	To assess the quality of the health information system in estimating malaria morbidity I mortality	General	Initial evaluation
Roberts-Witteveen AR, Patel MS, Roche PW, 2008	Australia	Communicable disease	To evaluate the program for its utility and capacity to monitor effectiveness of the rotavirus vaccines recently introduced into the Australian National Immunization Program	Technical	New technology or other systemic innovation
Galvão PR et al., 2008	Brasil	Communicable disease	To evaluate the SINAN software, quality of data input, the transfer of the computerized data from the municipality to state levels, human resources and other factors associated with the health information system infrastructure	Technical	Data quality monitoring
Macpherson AK et al., 2008	Canada	Injuries	To assess the sensitivity and representativeness of an injury surveillance system	Technical	Data quality monitoring

Laberge K, Galanis E., 2008	Canada	Injuries	To assess the sensitivity and timeliness of reporting methods in order to guide recommendations around reportability and surveillance of this syndrome in BC	Technical	Data quality monitoring
Daudens E et al., 2008	French Guiana	Communicable disease	To evaluate the knowledge, attitudes and practical experience of users concerning syndromic surveillance	New component	Syndromic surveillance
Jefferson H et al., 2008	French Guiana	Communicable disease	To evaluate a new military syndromic surveillance system (2SE FAG) set up in French Guiana	New component	Syndromic surveillance
Hahn S et al., 2008	Honduras	Injuries	To determine the major causes and outcomes of injuries presenting for emergency care and assesses the validity of the surveillance system	General	Initial evaluation
Mor Z et al., 2008	Multi country	Communicable disease	To compare surveillance system function across industrialized countries with low TB incidence and lays the collaborative groundwork for advanced and additional analyses	General	Compare systems
Safdar RM, Khan SA, Asghar RJ, 2008	Pakistan	Communicable disease	To identify key strengths and weaknesses to develop recommendations	Technical	Data quality monitoring
Ansari JA et al., 2008	Pakistan	Communicable disease	To evaluate the surveillance systems to determine strengths & weaknesses and analyze their roles in meeting public health objectives.	Technical	Data quality monitoring
Murad N, Zaheen M, Asghar RJ, 2008	Pakistan	Communicable disease	To assess the performance of the existing diarrhea surveillance system to identify strengths and weakness to make recommendation for improvement	Technical	Data quality monitoring

Soto G et al., 2008	Peru	Communicable disease	To identify and discuss challenges of implementation of new electronic surveillance system and the best methods to address them	New component	Introduction of new surveillance standards
Coleman M et al., 2008	South Africa	Communicable disease	To evaluate the performance of a novel malaria outbreak identification system in the epidemic prone rural area of Mpumalanga Province, South Africa, for timely identification of malaria outbreaks and guiding integrated public health responses	Emergency	Occurrence of public health event
Richard JL, Vidondo B, Mausezahl M, 2008	Switzerland	Communicable disease	To review the 1999-2003 measles surveillance data to compare the performance of the sentinel and the mandatory surveillance systems, and in particular to evaluate if the SSSN still provides reliable information for public health	General	compare systems
Kivi M et al., 2008	The Netherlands	Communicable disease	To evaluate the acceptability of the enhanced LGV surveillance in the Netherlands in 2004-2005 to provide recommendations for future surveillance	Technical	New technology or other systemic innovation
van Benthem BH, van Vliet JA, 2008	The Netherlands	Communicable disease	The most important results of a recent evaluation of the system	Economic changes	Cost of surveillance
Shipton D, Stone DH, 2008	UK	Injuries	To describe the processes involved in the running of Y-CHIRPP; to identify changes made; to determine the strengths and weaknesses of Y-CHIRPP	Technical	Data quality monitoring
Wilkins K et al., 2008	USA	Communicable disease	The Data for Decision Making project developed a conceptual model for a data-driven health system	New component	Introduction of new surveillance standards
Hebden JN et al., 2008	USA	HAI	To identify and evaluate of available systems	Technical	New technology or other systemic innovation

Lyerla R, Gouws E, Garcia-Calleja JM, 2008	USA	Communicable disease	To examine the quality of HIV serosurveillance systems and the gaps in data needed for reliable estimates of HIV prevalence and size of populations at risk for infection	Technical	Data quality monitoring
Davila JC et al., 2008	USA	Adverse events	To assess the nonanthrax vaccination data quality in the Defense Medical Surveillance System	Technical	Data quality monitoring
McBryde ES et al., 2009	Australia	HAI	To measure the interobserver agreement, sensitivity, specificity, positive predictive value, and negative predictive value of data submitted to a statewide surveillance system for identifying central line-associated bloodstream infection	Technical	Data quality monitoring
Watkins RE et al., 2009	Australia	Communicable disease	To evaluate the sensitivity of AFP surveillance for poliovirus infection in Australia	General	Regular periodic evaluation
Parrella A et al., 2009	Australia	Communicable disease	To assess the utility of ILI surveillance	General	Compare systems
Somda ZC et al., 2009	Multi country	Communicable disease	To analyze the incremental costs of establishing and subsequently operating activities for detection and response to the priority diseases under the IDSR	Economic changes	Cost of surveillance
Joseph KS, Fahey J, 2009	Canada	Injuries	To assess the accuracy of the Canadian Institute for Health Information data base	Technical	Data quality monitoring
Liu X, Li L, Cui H, Jackson VW, 2009	China	Injuries	To assess an emergency department-based injury surveillance project (S-EDISP) in China using WHO evaluation guidelines. To identify problems and make suggestions for improvement	New component	Introduction of new surveillance standards

Yoo HS et al., 2009	Korea	Communicable disease	To identify the timeliness of notifiable infectious disease surveillance in Korea	Technical	Data quality monitoring
Arana C, 2009	Multi country	Non communicable diseases	To assess and analyze the behavior surveillance systems of U.S., Canada and Italy, compare their strengths and weaknesses and provide recommendations that can be used as a guide for the design of new BRFSS systems or the assessment of existing systems	General	compare systems
Huaman MA et al., 2009	Peru	Communicable disease	To assess the effect of two interventions on such attributes in Alerta, an electronic disease surveillance system in the Peruvian Navy	Technical	New technology or other systemic innovation
Rocha C et al., 2009	Peru	Communicable disease	To compare the efficacy of distinct community-based (door to door) and school absenteeism-based febrile surveillance strategies in detecting active cases of dengue	General	Compare systems
Kadigi DM, 2009	Tanzania	Communicable disease	To determine whether the surveillance system is achieving its objectives, purposes and to assess its attributes	General	Requirements. Told to.
Paranthaman K et al., 2009	UK	Communicable disease	To assess the completeness and timeliness ofreporting of invasive meningococcal disease in Thames Valley in 2006-2007	Technical	Data quality monitoring
Jennings JM et al., 2009	USA	Communicable disease	To identify the major challenges for information integration across the primary computer-based infectious disease surveillance information systems during a 10-year period	Technical	New technology or other systemic innovation
Hwang J et al., 2009	USA	Communicable disease	To evaluate the existing systems for state-level reporting of malaria data to the CDC	General	Compare systems
Lesher L et al., 2009	USA	Communicable disease	To compared passive surveillance and International Classification of Diseases, 9th Revision, codes for completeness of staphylococcal toxic shock syndrome	General	Compare systems

CDC, CSTE, 2009	USA	Communicable disease	To assess the National Assessment of HIV Surveillance Capacity	General	Requirements. Told to.
Herasevich V et al., 2009	USA	Injuries	To determine the accuracy of computerized syndrome surveillance for detection of acute lung injury in hospitalized patients and compare it with routine clinical assessment	General	Compare systems
Guy RJ et al., 2010	Australia	Communicable disease	To assess the surveillance system and make recommendations to its improvement	General	Initial evaluation
Hope KG Guy RJ et al., 2010	Australia	Communicable disease	To assess usefulness of surveillance system	New component	Syndromic surveillance
Grills NJ Guy RJ et al., 2010	Australia	Communicable disease	To assess performance against evaluation system objectives, identify areas requiring improvement and inform a decision of whether Campylobacter infection should remain a notifiable infectious disease	Public health measure	Structural changes
Ahn S Guy RJ et al., 2010	Korea	Communicable disease	To compare the data from the emergency department in detection and reporting of acute diarrheal syndrome with the data from the Korea Food and Drug Administration	New component	Syndromic surveillance
Meynard JB Guy RJ et al., 2010	Kosovo	Communicable disease	To assess the feasibility of DSS functioning within a multinational task force in the field.	New component	Introduction of new surveillance standards
Meerding WJ Guy RJ et al., 2010	Multi contry	Injuries	To assess whether the emergency department (ED) injury surveillance systems in Europe are suitable for cross-country comparisons.	General	Compare systems
Socan M, 2010	Slovenia	Communicable disease	To explore the completeness of mandatory varicella reporting in Slovenia.	Public health measure	Change in public health policy
CDC, 2010	USA	Communicable disease	To evaluate the national acute hepatitis C surveillance system	Technical	Data quality monitoring

Li J Guy RJ et al., 2010	USA	Communicable disease	To characterize the complaint surveillance system in Minnesota and to evaluate its use for detecting outbreaks	Emergency	Occurrence of public health event
Iqbal S et al., 2010	USA	Injuries	To generate the first national estimates of CO-related hospitalizations and to evaluate the use of a Web-based query system for public health surveillance	Technical	New technology or other systemic innovation
Grota PG et al., 2010	USA	Communicable disease	To examine the utilization of Electronic SSs in acute care hospitals in California	Technical	New technology or other systemic innovation
Yih WK et al., 2010	USA	Communicable disease	To evaluate a real-time ambulatory care-based syndromic surveillance system	New component	Syndromic surveillance
Garcia Calleja JM et al., 2010	USA	Communicable disease	To assess the quality of HIV surveillance systems in low- and middle-income countries in 2009 compared with 2007	General	Regular periodic evaluation
Savage R et al., 2011	Canada	Communicable disease	To evaluate the role of syndromic surveillance in informing public health action	New component	Syndromic surveillance
Liu XQ et al., 2011	China	Communicable disease	To evaluate the quality and timeliness of hepatitis A surveillance data from Yunnan Province, China, and to evaluate the sensitivity of the system for reporting outbreaks	Emergency	Occurrence of public health event
Peragallo MS et al., 2011	Italy	Non communicable diseases	To assess completeness of cancer surveillance and incidence estimates for all malignancies, Hodgkin's lymphoma and thyroid cancer in the Italian army, for the years 2001-2007	Technical	Data quality monitoring
Baldissera S et al., 2011	Italy	HAI	To assess two years of activity	General	Initial evaluation
Tanihara S et al., 2011	Japan	Communicable disease	To evaluate underreporting in the measles surveillance system and to quantify the proportion of measles patients who undergo laboratory tests in order to confirm their measles diagnosis	General	Compare systems

2011	Nigeria	Communicable disease	To assess the sensitivity of the existing AFP surveillance network, situation in the structures outside the network and within the migratory population and to make recommendations	Technical	Data quality monitoring
Hajdu A et al., 2011	Norway	HAI	To gain knowledge primarily about the system's performance in practice and, if necessary, improve its utility and efficiency	General	Regular periodic evaluation
Al-Arabi Al-Ghamdi AM et al., 2011	Saudi Arabia	Communicable disease	To identify the epidemiology of notified measles cases and to review the surveillance system	Public health measure	Introduction of control measures
Heidebrecht CL et al., 2011	South Africa	Communicable disease	To evaluate the current system of tuberculosis surveillance in the Cape Metro region	General	Regular periodic evaluation
Riera-Montes M, Velicko I, 2011	Sweden	Communicable disease	To determine whether the current Ct surveillance system delivers relevant, accurate and timely information to those who need it in order to enable adequate prevention and control measures	General	Initial evaluation
Boehmer TK et al., 2011	USA	Communicable disease	To evaluate the sensitivity, timeliness, and data quality of reporting eight notifiable diseases to the Colorado Electronic Disease Reporting System	Technical	Data quality monitoring
Avchen RN et al., 2011	USA	Non communicable diseases	To conduct the first evaluation of a population-based autism spectrum disorders surveillance system	General	Initial evaluation
Matheny ME et al., 2011	USA	Injuries	To compare risk-adjusted sequential probability ratio testing implemented in an automated tool to Massachusetts public reports	Technical	New technology or other systemic innovation
Barr C et al., 2011	USA	Communicable disease	To evaluate a newly established active influenza surveillance program that utilized 6 sentinel hospitals to collect epidemiologic information for influenza-like illness admissions	Emergency	Occurrence of public health event

Vidi VD et al., 2011	USA	Adverse events	To review the design of the Data Extraction and Longitudinal Trend Analysis network study of the medical device safety surveillance.	Technical	New technology or other systemic innovation
Short VL et al., 2011	USA	Communicable disease	To evaluate this monitoring system	Emergency	Preparedness
CDC, 2011	USA	Communicable disease	To assess of ESSENCE performance for influenza-like illness surveillance after an influenza outbreak	New component	Syndromic surveillance
Sickbert-Bennett EE et al., 2011	USA	Communicable disease	To estimate disease-specific reporting proportions, describe changes to reporting over time, and examine the variability of reporting completeness between health care facilities.	Technical	Data quality monitoring
Nair HP et al., 2011	USA	Communicable disease	To discuss the usefulness of HIV incidence surveillance in the ongoing effort to reduce HIV transmission in NYC	Technical	New technology or other systemic innovation
Reeder B et al., 2011	USA	Communicable disease	A pilot utility evaluation and information needs assessment of the Distribute Project	New component	Introduction of new surveillance standards
Estes CR, Marsh SM, Castillo DN, 2011	USA	Injuries	To assess four surveillance systems for their utility in characterizing firefighter fatalities and informing prevention measures.	General	Compare systems
Paterson BJ et al., 2012	Australia	Communicable disease	To identify strengths and weaknesses of the system, ease of use and possible points for improvement	New component	Introduction of new surveillance standards
Teixeira MG et al., 2012	Brazil	Communicable disease	To evaluate Brazil's public health surveillance system, identifying its core capacities, shortcomings, and limitations in dealing with public health emergencies, within the context of the International Health Regulations 2005	General	Requirements. Told to.
CDC, 2012	Multi country	Communicable disease	Meningitis surveillance data were analyzed, stakeholders were consulted, and surveillance databases, reports, and registers were examined	Public health measure	Change in public health policy

Vong S et al., 2012[]	Cambodia	Communicable disease	To determine disease under-recognition to the National Dengue Surveillance System	Technical	Data quality monitoring
Tadrous M, 2012	Canada	Adverse events	To assess the sensitivity of the Canadian Adverse Event Following Immunization Surveillance System	Technical	Data quality monitoring
Savage R et al., 2012	Canada	Communicable disease	To describe the use of syndromic surveillance systems in Ontario and users' perceptions of the value of these systems within the context of other surveillance systems	New component	Syndromic surveillance
Takla A, Velasco E, Benzler J, 2012	Germany	Communicable disease	To develop a strategy to tailor an event-specific enhanced surveillance for this smaller-scale mass gathering.	Emergency	Mass gathering
Englund H, Hautmann W, 2012	Germany	Communicable disease	To describe the *E. coli* cases (both EHEC and non-EHEC) notified when the notification rate peaked and compare them to the cases notified before and after the HUS/EHEC-outbreak to assess the sensitivity of the surveillance system in order to guide interventions for improvements	Technical	Data quality monitoring
Jasem J et al., 2012	Iraq	Communicable disease	To identify the risk factors for measles and low vaccination rates, to evaluate the performance of surveillance, and to calculate vaccine effectiveness and failure in Iraq for the years 2005 to 2010	Public health measure	Introduction of control measures
Melosini L et al., 2012	Italy	Communicable disease	To assess the quality of surveillance at the University Hospital in Pisa, Italy, and TB incidence rates over a ten year period	Technical	Data quality monitoring
O'Brien SF et al., 2012	Multi country	Communicable disease	To compare examples of surveillance programs in five developed countries to describe the similarities and differences in approach, function, and application	General	Compare systems
CDC, 2012	Pakistan	Communicable disease	This report summarizes surveillance results early after implementation, describes system usefulness, and identifies areas for strengthening	Emergency	Occurrence of public health event

Huang WT et al., 2012	Taiwan	Adverse events	To evaluate the completeness of spontaneous reporting, cases of death, Guillain-Barré syndrome (GBS), convulsion, Bell's palsy, and idiopathic thrombocytopenic purpura (ITP) after 2009 H1N1 vaccination	Technical	Data quality monitoring
Whelan J et al., 2012	The Netherlands	Communicable disease	To describe – from the perspective of the system user – experiences of using pandemic case register systems developed before and during the pandemic, whether the systems were used as intended during the pandemic and what problems, if any, were encountered	Emergency	Occurrence of public health event
Boisson EV, Imana M, Roberts P, 2012	Trinidad and Tobago	Communicable disease	To describe the development and implementation of, and major findings and recommendations from, a regional mass gathering surveillance system (MGSS) in support of the International Cricket Council Cricket World C up West Indies 2007	Emergency	Mass gathering
Knowles RL et al., 2012	UK	Communicable disease	Formal evaluation to examine system effectiveness commenced.	General	Requirements. Told to.
Heinsbroek E et al., 2012	UK	Communicable disease	To discuss the establishment of the new USII surveillance system and the results from a pilot study undertaken during the first six months of surveillance	Emergency	Mass gathering
Salemi JL et al., 2012	USA	Non communicable diseases	The purpose of this study was to evaluate the capacity of the Florida Birth Defects Registry (FBDR) to identify infants with birth defects by comparing and contrasting the two birth defects surveillance approaches	General	Compare systems
Iqbal K, Klevens RM, Jiles R, 2012	USA	Communicable disease	To assess and compare CDCEIP-funded and non-funded surveillance mechanisms, with a focus on three core attributes of viral hepatitis surveillance: completeness of demographic data (i.e., sex, age, and race/ethnicity) and risk behavior/ exposure information; adherence to the CDC; timeliness of reporting to the health department	Economic changes	Cost of surveillance
Dailey NJ et al., 2012	USA	Injuries	To describe and evaluate the quality, timeliness, and usefulness of the system	Public health measure	Change in public health policy

Lindsey NP et al., 2012	USA	Communicable disease	We assessed the perceived utility of data collected through ArboNET, the national arboviral surveillance system, and evaluated state health department user satisfaction with system function	General	Initial evaluation
Peterson KE et al., 2012	USA	Communicable disease	To validate electronic tools for MRSA healthcare-associated infection trending that can replace manual medical record review	General	compare systems
CDC, 2012	USA	Communicable disease	To determine whether ABCs estimates of the number of cases of meningococcal disease were far lower than NNDSS counts and the contribution of polymerase chain reaction (PCR) to that difference	General	Compare systems
Kang J et al., 2012	USA	HAI	To evaluate the cost-effectiveness of three alternative active screening strategies for methicillin-resistant Staphylococcus aureus: universal surveillance screening for all hospital admissions, targeted surveillance screening for intensive care unit admissions, and no surveillance screening.	Economic changes	Cost of surveillance
Palumbo AJ et al., 2012	USA	HAI	To evaluate the usefulness of these systems in reducing HAIs.	New component	Introduction of new surveillance standards

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