



## History and evolution of surveillance in public health

Varun Kumar,\* Deepak Raut<sup>1</sup>

### ABSTRACT

The modern concept of surveillance has evolved over the centuries. Public health surveillance provides the scientific database essential for decision making and appropriate public health action. It is considered as the best public health tool to prevent the occurrence of epidemics and is the backbone of public health programs and provides information so that effective action can be taken in controlling and preventing diseases of public health importance. This article reviews the history of evolution of public health surveillance from historical perspective: from Hippocrates, Black Death and quarantine, recording of vital events for the first time, first field investigation, legislations that were developed over time and modern concepts in public health surveillance. Eradication of small pox is an important achievement in public health surveillance but the recent Severe Acute Respiratory Syndrome (SARS) and Influenza pandemics suggest still there is a room for improvement. Recently new global disease surveillance networks like FluNet and DengueNet were developed as internet sites for monitoring influenza and dengue information. In spite of these developments, global public health surveillance still remains unevenly distributed. There is a need for increased international cooperation to address the global needs of public health surveillance.

**Keywords:** history, evolution, surveillance, public health

### INTRODUCTION

Public health surveillance is considered to be an essential public health function. Surveillance data are a result of continuous monitoring of the occurrence of a disease or condition. The term 'surveillance' is derived from the French word meaning 'to watch over'. Public health surveillance provides the scientific database essential for decision making and appropriate public health action.<sup>1</sup> Public health surveillance is considered as the best public health tool to prevent the occurrence of epidemics.<sup>2</sup>

The modern concept of surveillance has evolved over the centuries. World Health Organization (WHO) in 2012 defined Public health surveillance as the continuous, systematic collection, analysis and interpretation of health-related data needed for the

planning, implementation, and evaluation of public health practice<sup>3</sup>. Recent disease outbreaks like the Severe Acute Respiratory Syndrome (SARS) pandemic, the avian influenza pandemic and the alleged threats of deliberate epidemics like anthrax in the wake of bioterrorism have brought together the countries in the field of public health to plan for a comprehensive surveillance agenda.

All outbreaks cannot be predicted or prevented. However, precautionary measures can be taken within the existing health infrastructure and service delivery to reduce risks of outbreaks and to minimize the scale of the outbreak, if it occurs. The effectiveness with which national programs are implemented and monitored, the alertness for

GJMEDPH 2014; Vol. 3, issue 1

<sup>1</sup> Deepak Raut, Director Professor, Department of Community Medicine, VMMC and SJH, New Delhi, India.

\*Corresponding Author

Post Graduate student

Junior Resident

Department of Community Medicine

VMMC and SJH

New Delhi, India

Email: drvarunkumar17@gmail.com

Conflict of Interest—none

Funding—none

identification of early warning signals and the capacity for initiating recommended specific interventions in a timely manner are important to achieve the above objectives.

Surveillance is the backbone of public health program and provides information so that effective action can be taken in controlling and preventing diseases of public health importance. In some cases like cholera and food contamination, the action must be immediate, within hours in order to prevent large scale epidemics and deaths. In others, control and prevention activities are long term response to information about disease such as tuberculosis and Non Communicable Disease risk factors, for which action may be taken in weeks, months or even years.

Surveillance data also can be used to detect changes in health practices, monitoring changes in infectious

and other environmental agents, evaluation of control measures, and to describe the natural history of a health event in a community that will generate hypotheses and stimulate applied research<sup>4</sup>. In short, public health surveillance is the foundation for decision making in public health and empowers decision makers to lead and manage more effectively by providing timely, useful evidence<sup>5</sup>. This article describes the evolution of surveillance from historical perspective.

#### Historical origins of surveillance:

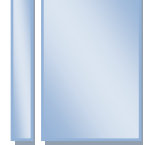
The first recorded epidemic in history was the great pestilence in Egypt during 3180 BC. This was the starting point of collecting and organizing data. Some of the major epidemics<sup>6</sup> in the history of public health are summarized in table 1.

**Table 1. Major epidemics in the history of public health**

S. No	Year	Places affected	Disease
1	3180 BC	Egypt	The great pestilence
2	166 AD	Rome	Small pox
3	541 – 549 AD	Constantinople	The Justinian Plague
4	664 – 689 AD	England	Relapsing fever
5	1348 – 1351 AD	Asia and Europe	The Black Death (Bubonic Plague)
6	1494 AD	Europe	Syphilis
7	1500 – 1600 AD	Americas	Small pox
8	1600 – 1650 AD	South America	Malaria
9	1665 AD	London	The Great Plague of London
10	1817 – 1875 AD	Worldwide	Pandemics of cholera
11	1918	France, England, China, United States	The Spanish Flu
12	1940 – now	Worldwide	Lung cancer epidemic
13	1957	Worldwide	The Asian Flu
14	1983	Worldwide	AIDS (Acquired Immune Deficiency Syndrome)
15	1997 – now	Worldwide	Obesity pandemic
16	2003	Worldwide	SARS (Severe Acute Respiratory Syndrome)
17	2007	Worldwide	Influenza

The idea of collecting data, analyzing them, and considering a reasonable response stems from Hippocrates, a Greek physician who lived between 460 – 370 BC. In his book, 'On Airs, Waters and

Places', when writing on disease occurrence, Hippocrates made a distinction between the endemic state as the steady state of the disease, and the epidemic as the abrupt change in incidence of



disease.<sup>7</sup>

### Development of isolation as a public health tool

After the fall of Roman Empire in 476 AD, Europe experienced a period of social and political disintegration. There was a decline of hygiene and sanitation and physical body became less important than the spiritual self. Many epidemics occurred, the notable ones being small pox, plague, leprosy, measles and tuberculosis. So this period, approximately from 500 – 1500 AD is called as, 'Dark ages of medicine'.

The concept of isolation as a tool in public health was developed during this period. Leprosy was the most important disease of this period, manifested by a continent-wide epidemic which began in 6<sup>th</sup> century and lasted till 15<sup>th</sup>.<sup>7</sup> Rules and regulations were made to diagnose the disease and isolate cases. Leper houses (leprosaria) were established isolate cases of leprosy in medieval times and it represents the earliest application of a public health practice still in use. Of the plague epidemics of this period, two were devastating – the Justinian plague of 541 AD and the Black Death from 1348 – 1351 AD.

### The Black Death and Quarantine

The first public health action that can be attributed to surveillance began in 1348 AD during the bubonic epidemic plague, infamously called as, 'The Black Death'. Quarantine measures were initiated to stop the entry of plague from outside regions. In 1348, the public health authorities in a port near the Republic of Venice prevented passengers from coming ashore during the time of epidemic bubonic plague in Europe. Quarantine as a means to control the spread of infectious diseases was used again in 1377 in Marseilles to detain travelers from plague infected areas for 40 days. This was expanded in 1423 when a pest house or 'lazaretto' (houses and institutions of quarantine) was constructed in Venice to hold detained individuals suspected of harboring infections.<sup>8</sup>

By the middle of the fifteenth century, the major cities in Europe had established permanent boards of health that were responsible for identifying cases of

plague, establishing quarantine, issuing health passes, arranging for the burial of plague victims and the fumigation of their residences, and the management of lazarettos. The boards worked in coalition with the local physicians who provided medical care and prophylactic advice. As time passed, the boards took control over markets, sewage systems, water supplies, cemeteries, and the cleanliness of streets; and they took jurisdiction over the professional activities of physicians and surgeons, the preparation and sale of pharmaceutical drugs, and it also kept an eye on activities of beggars and prostitutes. With the disappearance of plague at the end of the seventeenth century, the boards of health disappeared but, they provided a model for nineteenth century organization of public health activities.<sup>8</sup>

### Recording of vital events:

Records of vital events were preserved in numerous European towns at the beginning of sixteenth century. The first London Bills of Mortality were prepared by an unknown person in 1532 as a consequence of fear of a plague epidemic although their use for health and scientific purposes did not begin until 100 years later.<sup>7</sup>

Comprehensive analysis and interpretation was introduced by John Graunt in 1662. He analyzed the weekly bills and published in his book *Natural and Political Observations Made upon the Bills of Mortality*. Graunt was the first to quantify the patterns of disease and to understand that numerical data on a population could be used to study the cause of disease. He was the first to estimate the population of London and to count the number of deaths from specific causes. He laid the basis for the modern use of statistics for the planning and evaluation of public health activities.<sup>7</sup> This early surveillance system illustrates the main principles of surveillance which are still used-data collection and analysis, interpretation to provide information, and dissemination of that information for action.

### First field investigation

During the industrial revolution of seventeenth century in Europe, London was overcrowded with

poor sanitary conditions. The great plague of London struck the city in 1665 which caused nearly 8000 deaths. Samuel Pepys recorded the number of deaths due to plague each day from August to November 1665 in his personal diary with personal revelations and eye witness reports of many events. He also introduced the term, 'proportionate mortality', the proportion of total deaths resulting from the index disease. The epidemic of plague was ended by natural interventions in 1666, by winter frost and the great fire of London which destroyed and cleansed the overcrowded neighborhood.<sup>6</sup>

### Legislations for surveillance

In 1741, the legislation for surveillance was first introduced in America, when Rhode Island passed an act requiring tavern keepers to report contagious disease among their patrons. Regular reporting of smallpox, yellow fever, and cholera was made an act.<sup>9</sup> France was the first country to make health of people as the responsibility of state.<sup>10</sup>

In 1776 Johann Peter Frank advocated a more extensive monitoring of health in Germany that would support public health efforts related to the health of schoolchildren, prevention of injuries, maternal and child health, and public water and sewage disposal. Frank formulated and presented a coherent, comprehensive, and very detailed health policy which had considerable impact both within Germany and in countries such as Hungary, Italy, Denmark and Russia that had close cultural contact with Germany. This was the first link of surveillance to health policy.<sup>10</sup>

In 1834, Sir Edwin Chadwick, Secretary of the Poor Law Commission in England, conducted a Survey into the sanitary Condition of the laboring classes in Great Britain and was the first health administrator to demonstrate, through surveillance, that poverty and disease were closely related. This led to poor law amendment act in 1834 and constitution of general

board of health in 1848 and first public health act was passed in the same year.<sup>7</sup>

The need for more accurate and complete mortality data in the United Kingdom led to the establishment of the General Register Office in 1836 and the introduction of medical certification of death and universal death registration in 1837. William Farr was appointed as the first Compiler of Abstract (medical statistician) and created a modern surveillance System. He is recognized as the founder of modern concept of surveillance.<sup>11</sup>

In 1850, Lemuel Shattuck published 'Report of the Massachusetts Sanitary Commission', in United States. This was a landmark publication that related death, infant and maternal mortality, and communicable diseases to living conditions. In this report, Shattuck proposed the creation of a permanent statewide public health infrastructure and recommended establishing health offices at state and local levels in order to gather statistical information on public health conditions.<sup>12</sup>

### John Snow's study

John Snow is regarded as the father of modern epidemiology for his work during an epidemic of cholera in London during 1854. John Snow mapped cholera cases using a spot map and identified the source of outbreak as the public water pump at Broad Street in London. This led to formulation of Public health act of 1875 in England.

### Notification of diseases

Following the theory of contagion as a cause of disease, due to discovery of various bacteria during the latter part of nineteenth and early part of twentieth century, many countries passed laws for periodic reporting of infectious diseases. Major milestones in disease notification are given in table 2.

**Table 2. Major milestones in disease notification**

S. No	Year	Place	Event
1	1874	United States	The Massachusetts State Board of Health inaugurated a plan for weekly voluntary reporting of prevalent diseases by physicians
2	1888	Italy	Mandatory reporting of eleven communicable diseases and death certificates
3	1893	United Kingdom	Publication of international list of causes of death by the International Statistical Institute
4	1911	United Kingdom	Use of national health insurance data for surveillance
5	1935	United States	First national health survey
6	1943	Denmark	First registry, the Danish cancer registry
7	1943	United Kingdom	First sickness survey
8	1966	Geneva	First publication of communicable disease surveillance report by World Health Organization (WHO)
9	1967	United Kingdom and Netherlands	Development of General Practitioners' Sentinel Systems

### Modern concepts in surveillance:

The twentieth century saw the expansion of the concept of surveillance and the development of many different surveillance systems. Until 1950 surveillance, meant the specific but limited function of watching contacts of certain serious diseases such as plague, smallpox, typhus and syphilis. The obvious purpose was to detect first symptoms so that prompt isolation could be instituted. It was considered as a more ethical practice than the quarantine.<sup>11</sup>

The current concept of surveillance as the monitoring of disease occurrence in populations was promoted by Alexander D. Langmuir in 1950. He defined surveillance as, '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'. He explained that the data and their interpretations must be disseminated to all who have contributed and to all others who need to know. But his definition did not include direct responsibility for disease control activities.<sup>10</sup>

In 1968, the Technical Discussions of the 21st World Health Assembly made a full examination of surveillance as an established and essential function of public health practice. The concept of population surveillance was adopted and its three basic characteristics were systematic collection of data; consolidation and analysis of the collected data; and dissemination of information by means of narrative epidemiological reports.<sup>13</sup>

In 1986, Centre for Disease Control (CDC) redefined public health surveillance as the ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control. CDC concept of surveillance differentiates surveillance from occasional surveys and from planned comprehensive research programs.<sup>8</sup>

In 1988, Thacker and Berkleman defined surveillance as the ongoing systematic collection, analysis, and interpretation of outcome-specific data, closely integrated with the timely dissemination of these

data to those responsible for preventing and controlling disease or injury. This however contains two very different activities. Case surveillance focuses on individuals, to identify those with certain diseases and take action. Statistical surveillance, on the other hand, focuses on populations, to identify differentials and trends that can inform public health policymaking, including the allocation of resources.<sup>14</sup>

WHO in 2012 has defined Public health surveillance as the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.

### Surveillance: the present scenario

Historically, surveillance focused on infectious disease, then broadened to other topics, including chronic diseases, such as cancer and then diabetes. During 1980s and 1990s surveillance concepts were applied to occupational health, environmental health, hazard surveillance (toxic chemicals and physical and biological agents), emerging infectious diseases, injury control, behavioral risk factors, events following disasters and pharmaco surveillance.<sup>15</sup>

The International Health Regulations are the only binding international agreements on disease control. The regulations provide a framework for preventing the international spread of disease through effective national surveillance coupled with the international coordination of response to public health emergencies of global concern by using the guiding principle of maximum protection, minimum restriction. The current regulations apply only to cholera, plague, and yellow fever; they require WHO member states to notify WHO of any cases of these diseases that occur in humans within their territories and then give further notification when the territory is free of infection. Programs established to improve the capacity of both epidemiologists and laboratories to collect, use, and interpret surveillance and outbreak data are also important components in developing global surveillance networks.<sup>5</sup>

The outbreak of SARS in 2003 demonstrates the economic impact of not having an effective global public health surveillance system in place, with estimated income losses in the range of US\$12.3 billion to US\$28.4 billion for East and Southeast Asia as a whole.<sup>16</sup>

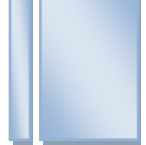
### Uses of public health surveillance

Public health surveillance serve as an early warning system in identifying new emerging health problems, it assesses the impact and trend of new emerging health problems, helps in developing public health interventions and allocating health resources, evaluation of interventions, identifying risk factors and high risk populations, and also supports public health research.<sup>17</sup>

### CONCLUSION

The global public health surveillance networks are transforming the public health through International Health regulations (IHR) and emergence of new global disease surveillance networks like FluNet<sup>18</sup> and DengueNet<sup>19</sup> as internet sites for monitoring influenza and dengue information. In spite of these developments, global public health surveillance still remains unevenly distributed.

At present, the boundary between global security and global public health surveillance system is blurred.<sup>20</sup> Developing nations share surveillance needs with the rest of the world, but they have to overcome their economic limitations along with weak public health infrastructure, and challenges of poverty and disease. So their contributions on research are less and often depend on developed countries, or collaborate with them to conduct the research necessary for their surveillance needs. Surveillance should be used as a scientific method for solving critical problems in public health practice. There is an emergent need for increased international cooperation to address the global needs of public health surveillance.



## REFERENCES

1. Berkelman RL, Stroup DF, Buehler JW. Public health surveillance, Oxford Textbook of Public Health, 4<sup>th</sup> edition Oxford University press 2002; 6:16:1545-1546.
2. Disease Control Priorities Project, "Public Health Surveillance, the Best Weapon to Avert Epidemics." Available from: <http://www.dcp2.org/file/153/dcpp-surveillance.pdf>
3. World Health Organization, "Public health surveillance," 2012. Available from: [http://www.who.int/topics/public\\_health\\_surveillance/en/](http://www.who.int/topics/public_health_surveillance/en/)
4. Thacker SB. Editorial. *Sentinelles* 1992;2:1-4
5. Nsubuga P, White ME, Thacker SB. Public Health Surveillance: A Tool for Targeting and Monitoring Interventions. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK11770/>
6. Choi BCK, Pak AWP. "Lessons for surveillance in the 21st century: a historical perspective from the past five millennia," *Soc prev med* 2001; 46:361-368.
7. Eyles W, Noah ND. "Historical aspects," in *Surveillance in Health and Disease*, Oxford University Press, Oxford, UK, 1988; 166-182.
8. Nelson KE, Sifakis F. "Chapter 4. Surveillance," in *Infectious Disease Epidemiology: Theory and Practice*, Jones & Bartlett Learning, Sudbury, Mass, USA, 2nd edition, 2007.
9. Thacker SB, Berkelman RL. "Public health surveillance in the United States," *Epidemiologic Reviews*, 1988; 10:164-190.
10. Declich S, Carter AO. "Public health surveillance: historical origins, methods and evaluation," *Bulletin of the World Health Organization*, 1994; 72(2):285-304.
11. Alexander D. Langmuir. William Farr: Founder of modern concepts of surveillance. *International journal of epidemiology* 1975; 5.
12. Thacker SB, Berkelman RL. History of public health surveillance, *Public Health Surveillance*, 1992; 1:1-15.
13. Van Nostrand Reinhold, New York, NY, USA, 1992; 1:1-15.
14. Lucas AO. The surveillance of communicable diseases. *WHO Chronicle*, 1968; 22:439-444.
15. Stoto MA. Public Health Surveillance: A Historical Review with a Focus on HIV/AIDS, RAND, Santa Monica, California, USA, 2003.
16. Choi BCK. The past, present and future of public health surveillance. *Scientifica* 2012. Available from: <http://dx.doi.org/10.6064/2012/875253>
17. Fan EX. SARS: Economic Impacts and Implications. ERD Policy Brief Series 15 Manila: Asian Development Bank, 2003.
18. Garcia-Albreu A, Halperin W, Danel I. Public Health Surveillance Toolkit: A Guide for Busy Task Managers, World Bank, Washington, DC, USA, 2002.
19. World Health Organization, Global Influenza Program (Flu Net), World Health Organization, Geneva, Switzerland, 2009. Available from: [http://www.who.int/influenza/gisrs\\_laboratory/flunet/en/](http://www.who.int/influenza/gisrs_laboratory/flunet/en/)
20. World Health Organization, DengueNet, World Health Organization, Geneva, Switzerland, 2009. Available from: <http://apps.who.int/globalatlas/default.asp>
21. Calain P. Exploring the international arena of global public health surveillance. *Health Policy and Planning* 2007; 22:2-12.