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## JOHN SNOW AND CHOLERA - THE BICENTENARY OF BIRTH

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### ABSTRACT

The bicentenary of John Snow's birth, a legend in his field, for his research on epidemiology and the prevention of cholera, constitutes a unique opportunity to commemorate this iconic figure. In the article, his spectacular achievements in this discipline are presented, including his epidemiological investigation during cholera epidemic and the well-known Broad Street intervention in Soho, in 1854, as well as his methodologically elegant experiment "on the grandest scale" in which he compared the cholera fatality rates in households served by two different water supply companies. Having referred to Snow's research, the cholera outbreak in Haiti in 2010 is also discussed.

**Key words:** *John Snow, epidemiology, cholera, outbreak, Haiti*

### INTRODUCTION

The year 2013 was the 200th anniversary of the birth of John Snow, a prominent English physician considered to be the father of modern epidemiology. Due to this fact, the London School of Tropical Hygiene organized a series of meetings in March and April, entitled "The Legacy of John Snow" with the objective of commemorating his achievements (1,2). The lectures held by eminent epidemiologists such as Neal Pearce, a former president of the International Epidemiological Association (IEA), Patricia Butler, president-elect and Shah Ebrahim, co-editor-in-chief of the International Journal of Epidemiology, focused on Snow's pioneering achievements regarding the identification of the source of the cholera epidemic and an explanation of epidemic transmission based on analysis of incidence and distribution of cases. The present cholera outbreak in Haiti was also discussed. The programme included a lecture on the role of epidemiology in modern medicine delivered by Cesar Victoria, the present president of the IEA, as well as lectures on future development directions. Kenneth Rothman, the author of epidemiology-oriented books, presented the theory of aetiology and Sir Richard Peto, an epidemiologist from the University of Oxford and a former collaborator of Richard Doll, discussed the large-scale randomised clinical trials.

### JOHN SNOW – OBSERVATION OF THE FIRST CHOLERA EPIDEMIC

Having been awarded a medical diploma, Snow focused his professional interest on the physiology of respiration. After the introduction of ether in general anaesthesia in Great Britain, he began his pioneering research on the proper monitoring of anaesthesia process and equipment used to administer ether and chloroform. In order to better understand the course of Snow's scientific interest and his path to discover scientific truth, the beginning of the 1830s should be analysed where the first epidemic of cholera in Great Britain was observed. Having stayed in the vicinity of Newcastle, in the village Killingworth, Snow worked among the patients collecting experience as a young medicine apprentice from which he benefited while studying the transmission of disease (3).

In Snow's time the miasmatic theory held sway, according to this theory, epidemic infectious diseases, such as cholera or plague, were caused by contaminated air arising from decaying animal or plants and transmitted over long distances if accompanied by favourable weather conditions (4,5). Snow's experience gained while combating cholera in 1831 as well as long-standing work regarding the effects of gases on the respiratory system resulted in his negation of miasmatic

\* The author participated in the symposium entitled "The Legacy of John Snow", which was held in *London School of Tropical Hygiene* on the day of 11-12<sup>th</sup> April 2013.

theory. He demonstrated that the disease was caused by the structured agent which was present in the patients' faeces and then transmitted orally, usually — but not only — through contaminated water. Having considered that this agent had to be living organism and capable of proliferation, he called it "special cholera poison". He also determined the incubation period of cholera, i.e. 24-48 hours, when the agent having the structure "most likely that of a cell" was reproducing (5). It should be noted that much later, 25 years following the death of Snow, Robert Koch discovered *Vibrio cholerae* as the causative agent of the disease (6).

With an objective to confirm the theory of faecal-oral transmission of cholera, Snow, during the successive epidemic in 1848, developed a map illustrating the distribution of cases and deaths in Soho, a district of London, in relation to 13 wells from which the local population drew their water. Snow was acquainted with the vicinity where he held his observations as he lived at Frith Street (1838-1842) and then at Sackville Street (1842-1845) (4). He had noticed that within 250 yards of the Cambridge Street and Broad Street intersection, several hundred fatal cases of cholera were reported in 10 days. When he became familiar with the situation and epidemic extent, he supposed that water from the pump at Broad Street could be contaminated (4,5). To justify this hypothesis, he gathered data from hospitals, schools, stores and pubs and interviewed local citizens. The genius of Snow was exemplified not only by collecting data on cholera cases, but also by analysing the persons who had not suffered from cholera. He reasoned that the employees of the nearby brewery, factory and the inmates of a local prison who had not contracted cholera, drank water from the pumps localized on the premises of these institutions. Irrespective of the fact that Snow could not identify the cause of cholera by means of microscopic and chemical analysis, his research results were sufficient to convince the local authorities to disable the pump at Broad Street by removing its handle on the day of 7th September 1848. This contributed to termination of the epidemic and today constitutes a symbol of successful public health action. Snow was the first practitioner to formulate a theory explaining the spread of cholera among the poor social classes (no access to clean water) or in mines (lack of toilet facilities) (5). His scientific considerations were described in a book entitled "On the Mode of Communication of Cholera" which was published in 1849 (7).

It should be noted that a replica of the well-known pump with a plaque commemorating Snow's achievements is located in London near Broad Street (today known as Broadwick Street). The pub bearing his name is also located on this street where the memorials may be viewed. To commemorate the bicentenary of Snow's birth in April 2013, a replica was also placed in front

of the lecture room of the London School of Tropical Hygiene.

## RESEARCH DURING THE EPIDEMIC OF CHOLERA IN 1853

An epidemiologist working in the 21<sup>st</sup> century could only be impressed by Snow persistence and determination in proving his hypotheses. During the successive epidemic of cholera, which was reported in 1853 in Great Britain, Snow again prepared statistical analysis of deaths and usage of particular water sources. At that time, it was not constrained to one London district and one pump, but various parts of city provided with water by different water supply companies (5,8). According to the present epidemiological nomenclature, this research was of cohort study nature with different

exposure groups. Snow referred the absolute numbers of deaths to the number of persons using the particular water sources. From his detailed analysis it transpired that cholera fatality rates were 14 times higher among persons supplied by the Southwark and Vauxhall water supply company. The latter obtained water from the sewage-polluted part of the Thames (Battersea Fields) whereas the population of south district was provided with water by the Lambeth Company which drew it from a sewage outfall. The provision of convincing data resulted in moving the water intake to a safe area which contributed to the gradual termination of the epidemic. Snow proved that the elimination of transmission routes results in the end of an epidemic. He correctly predicted high cholera fatality rates not only in London but also in Glasgow (where drinking water was obtained from sewage-contaminated river water), contrasting it with low fatality rates in the vicinity where water was drawn from rural areas (Birmingham, Leicester, Bath) (5,8,9).

## CHOLERA OUTBREAK IN HAITI IN 2010

In October 2010, nine months following an earthquake, a cholera epidemic occurred in Haiti affecting 650,000 people and killing more than 8,000 (10, 11). Prior to the earthquake, the island had no public water and sanitation system. A WHO/UNICEF report of 2008 revealed that only 68% and 17% of Haiti citizens, respectively, had access to drinking water and sanitation facilities (11,12). The faecal contamination of drinking water was a commonly observed phenomenon and diarrheal diseases were the major cause of deaths in children less than 5 years old (12). The disaster of 2010 deepened these earlier existing problems.

It is considered that the occurrence of the cholera epidemic should be accompanied by two factors: 1) significant negligence regarding drinking water supply, an inadequate number of sanitation facilities and low hygiene standards, which favoured the exposure to food and water contaminated with the *Vibrio cholerae*; 2) the pathogen must be present in the population (12). The cholera epidemic has not been observed in Haiti for more than a century.

The first cases of cholera were reported nearby a contingent from Nepal participating in The United Nations Stabilization Mission in Haiti (10,13, 14). Prior to the departure, the soldiers have not been screened for the carriage of *Vibrio cholerae*, which is endemic in Nepal. An epidemiological investigation revealed that the pipes discharging sewage from the camp in Mirebalais were broken and there could be leakage into the nearby Artibonite, the largest river in the country. The river is used for bathing, washing, cleaning as well as a source of drinking water by tens of thousands of

citizens. The canal system at the delta flavoured the rapid proliferation of *Vibrio cholerae*. Having employed DNA sequencing technique, independent groups of epidemiologists compared the strain present in Haiti (serogroup O1, serotype Ogawa) with the strain which is endemic in Nepal (13-15).

DNA sequencing, i.e. determining the order of nucleotides in the analysed fragment of nucleic acid meant it was possible to identify the genomes of the pathogens. Thus, a molecular analyses in the diagnosis of infectious diseases, including epidemiological investigations, began the tests of choice (16). It is worth mentioning that although molecular techniques are of increasing significance in epidemiological investigation, they respond to the 19th century understanding of cholera as a disease spread by means of trade routes, soldiers returning from front lines or commonly observed migration. They confirm Snow's observation of 1848, at the time of the Soho epidemic, when he linked disease occurrence with seamen who came to London from Hamburg, struck by the epidemic, i.e.: infectious diseases do not respect borders (7-9). This concept is especially applicable in the light of the events in Haiti.

In November 2011, the Institute for Justice and Democracy in Haiti filed a claim on behalf of 5,000 cholera victims in which they summoned the United Nations to install a national water and sanitation system to compensate the losses caused by the epidemic (10,13,17). In the statement issued in February 2013, the United Nations by virtue of immunity covering its actions covered by the Geneva Convention of 1946 refused to meet the request (8,18) In the report, the UN stated that the cholera outbreak was caused by the series of events resulting from poor sanitary standards and not the isolated, imported case of *Vibrio cholerae*.

In the report it was mentioned that this isolated strain is not typical only for Nepal, but also is present in some other countries of South Asia.

The pioneering achievements of Snow are beyond the epidemiology framework and have become a part of broadly defined public health. Unfortunately, the involvement of local authorities, NGOs and international organizations aimed at improving the sanitary conditions would not be enough to control the outbreak in Haiti. From the 10-year plan to combat cholera, which was published in 2012, it transpires that a remarkably high finding is vital, especially for the investment in the water and sanitation system (11). Irrespective of the fact that two sewage treatment plants were built, which are the first plants in the country's history, due to the shortage of funds for their running, they are periodically closed.

It is not simply the lack of sanitary infrastructure which is noticeable in Haiti, but also the absence of epidemiologists and public health officers who could calculate successive cholera cases, establish the source of infections and initiate actions aimed at improving the health status of the local population (19). There is also a deficiency of high quality data, which if used appropriately, could support the planning of a health care system and stimulate legislative actions.

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