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Jacobs Journal of Epidemiology and Preventive Medicine

Review Article

Effective Public Health Responses in Emerging Infectious Diseases: Lessons from the SARS Outbreak and Implemented in Ebola

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Received: 08-01-2015

Accepted: 11-06-2015

Published: 11-17-2015

Abstract

A preponderance of emerging infectious diseases have been witnessed in previous years. Of these Ebola and Severe Acute Respiratory Syndrome (SARS) are recent examples that readily come to mind. These rapidly spreading illnesses cross international within short periods, spread in epidemic proportions, causing numerous fatalities. The 2003 SARS outbreak saw an unprepared world make attempts towards controlling its spread. Ironically, some of these strategies have been shown to result in additional health problems. Instances include an observed increase in the incidence of acute stress disorder and post-traumatic stress disorders amongst quarantined suspects in certain studies. In this review of the SARS epidemic, we highlight national and multinational public health efforts that were deployed. Additionally, we examined the implementation of these strategies in the Ebola control in West Africa in 2014. Though these strategies proved to be quite useful, unique socioeconomic and regional challenges warrants improvements within the West Africa community.

Introduction

The world was informed in March 2003 by the World Health Organization (WHO) of an acute respiratory disease of unknown origin which had surfaced and was swiftly spreading in China and Viet Nam. The illness had a high probability of global spread, but the cause was undetermined [1]. The disease would later be identified as a zoonotic coronavirus (SARS-CoV), and named SARS [1]. It would in weeks after detection, be transmitted from China across continents to about 37 countries worldwide [2]. A second alert following additional probable cases caused global vigilance. A coordinated response to the outbreak made it possible for the disease to be managed and thus further spread was avoided [3]. In July 2003, four months after the world was first warned, the spread of SARS had been interrupted, and the outbreak contained. Public heath emergencies like SARS underscore the need for the national response teams to be trained and prepared. This ensures that threats are handled in a systematic and integrated manner [4].

A feature of the distribution of the 2003 SARS epidemic

was its preponderance among healthcare workers and in healthcare settings. This was because many lapses in the health care system made these healthcare workers less protected and therefore exposed. Because these health workers attend to other numerous patients, SARS was transmitted very rapidly, causing an explosive outbreak [5]. Furthermore, studies have shown possible long-term effects of the outbreak experience on the quality of life of affected persons. Bai et al [6]. Showed that 5% of 338 healthcare workers in an East Taiwan Hospital met DSM-IV criteria for Acute Stress Disorder (OR=4.677, CI=1.148-14.8) during the post-outbreak period. The risk was found to be higher among quarantined personnel.

Similarly, a survey looking at psychological effects of SARS exposure on healthcare workers in Beijing, China in a three year time frame following the outbreak found significant levels of post-traumatic stress disorder (PTSD) in about 10% of 549 randomly selected employees. These symptoms were significantly associated with a history of quarantine, history of exposure or a confirmed case of SARS among friends and relatives [7]. Isolated patients are more likely to have a lower perception of safety and quality of life and more likely to develop anxiety disorders and depression [8]. Conversely, isolation of individuals who meet case definition criteria and their secondary contacts has remained an essential component in the management of disease outbreak. Thus, the need for constant review and improvement of isolation practices and methods to protect the public as well as the quarantined. Studies on the outbreak are relevant, as outcomes of these outbreaks, would as expected, have grave implications for economies and health systems. Findings from these studies are expected to help ensure a dependable public health system in every nation, as well as identify what changes and development strategies are required.

Public health strategies, which are well-coordinated actions and policies utilized to achieve major health purposes, have been shown to be a quite effective means of providing lasting solutions to health problems [9]. Policies have been effective in controlling numerous diseases from tobacco use [10]. Therefore, similar policies should be effective in controlling the spread of newly emerging highly infectious diseases. However, besides scientific evidence to understand what type of policies is needed, numerous barriers have to be surmounted before this evidence could be successfully made into policies [11].

The primary objective of this manuscript is to review extensively, information on the SARS outbreak that relates to public health preparedness. This report presents an overview of the existing literature on SARS; the role played by public health and disaster management institutions in the response to the outbreak, and the challenges they faced. Furthermore, it evaluates how well these were implemented in the recent 2014 Ebola outbreak in West Africa. We also propose priorities for future research and policy formulation as well as recommendations for better response to the next infectious disease outbreak.

The primary literature search for this review was conducted on Medline and Google Scholar. Original research articles from the year 2000 through 2015 were examined. The term SARS was combined with 'disaster planning', 'international co- operation' or 'emergency response'. Articles that examined the emergency response to SARS outbreak were selected. The resulting studies were reviewed for relevance.

Review Information

Local origin & national spread: SARS emerged as the first new communicable disease at the dawn of the 21st century [12]. The initial cases occurred in November 2002 in Guangdong region, China but presented as atypical pneumonia. Poor response to conventional therapy for usual lung infections as well as a progressively worsening disease raised a red flag [13]. The infection was highly transmissible and readily progressed to respiratory distress and death, which was challenging for the health sector [14]. The disease spread to other regions outside the Guangdong province.

A small percentage of the total cohort of infected individuals-super-spreaders was found to be responsible for the majority of SARS transmission. This concept is not peculiar to SARS and has been described in other infectious diseases e.g. HIV, Ebola, Tuberculosis and Typhoid for which Typhoid Mary is a notable case. During the preliminary phase of the 2003 SARS outbreak in Singapore, contact tracing revealed that five infected persons were responsible for infections in 10 or more contacts. SARS super-spreaders accounted for 75% of transmissions while about 81% of those infected never transmitted the disease to secondary contacts. Similarly, an evaluation of the early phase of SARS infection in Beijing, China revealed that 14% of patients from a group of 77 initially infected individuals were responsible for most of the transmission while 86% never transmitted SARS to others [15]. To prevent further spread, the WHO issued urgent global alerts [1] and activated an influenza pandemic preparedness plan [13].

The SARS- CoV was shown to be the causative agent for SARS but is dissimilar to any identified human or animal virus in its family [1]. It is transmitted primarily through respiratory droplets from infected persons and has a fatality rate of 11% [1]. The clinical symptoms are non-specific [14]. Death appears to be higher with increasing age and presence of pre-existing co- morbidities [16]. There neither exists a vaccination nor curative treatment, so the disease is managed majorly through supportive care for the infected and controlled through epidemiologic interventions [1]. However, the exact manner in which the virus is transmitted has not been scientifically

established [17].

Regional & global spread: The first case outside China occurred in February 2003 in Hong Kong was a medical doctor who had arrived via air and had treated patients in China. He lodged in a hotel in Hong Kong and was credited to have transmitted it to 16 other guests on the same floor through uncertified mechanism [17]. An international spread of the infection occurred afterward [1].

Response: Global Outbreak Alert and Response Network (GOARN) were established as a result of the necessity of a global surveillance and intervention system in the face of emerging infectious disease outbreaks in the 20th century. GOARN's contribution was remarkable in the coordinated International response to SARS [3]. The network of experts and institutes that make up GOARN assisted WHO with information and intelligence throughout the outbreak. A response and preparedness team was established with primary objective goals of containing the outbreak, supporting public health infrastructure in affected regions, preparing vulnerable countries for response and updating public health officials and the world [1]. Two GOARN partners who played significant roles were the Global Public Health Intelligence Network (GPHIN) and the WHO Influenza Laboratory Network. The GPHIN uses the internet to analyze thousands of online news in different languages for early identification of disease outbreaks [18].

Expert teams were sent to high-risk regions in Asia to prepare and train health workers for response. Public health education and awareness campaigns ensured information dissemination in affected areas. The member states collaborated in assisting and supporting the framework. Hong Kong conducted an electronic contact tracing system. In China, several clinics were opened for patient monitoring and management. In the United States, the Directors Emergency Operations Center (DEOC) was activated by the Centers for Disease Control and Prevention (CDC) director. The National Center for Infectious Diseases (NCID) was then designated to lead the response. Nine teams were created, and each was charged with specific duties. The teams include the Epidemiology/Surveillance, Quarantine, Communications, IT, Operations, Domestic, Clinical, Lab, and WHO/International. Additional units were created within weeks. In all, there were 16 teams with specific groups for consultations. A majority of the groups were placed at the United States point of entry while some were deployed to affected regions and international locations. Deployment packs and all necessary equipment were made available. The operational procedure was timely and standardized [20].

Control measures: Schrag et al. [14] details the structure of surveillance used in the United States. Surveillance was based on WHO's case definition which was modified as the outbreak progressed. WHO's definition specified the clinical criteria for infection. An epidemiologic link, i.e. travel to an affected region completes the definition. The CDC made use of a website dedicated to SARS as the communications grid for all public health personnel and also connected with health departments through Epidemiologic Information Exchange. However, passive reporting by clinics was the means used by health departments to monitor respiratory illnesses. Patients who met the case definition were identified, hospitalized and monitored for outcomes.

Isolation was a critical component of the containment effort in affected countries. In Canada, following the identification of the first two SARS patients, 5000 people were placed under quarantine in a community hospital in Ontario. The measures used to identify and control the outbreak were respiratory isolation and surveillance. Personal Protection Equipment (PPE), Respiratory masks and barrier precautions were made available. However, because the PPE were not promptly available to health workers, and inadequate knowledge and communication, there was an explosive transmission to health workers [5]. Health workers were at the most risk even when there is inappropriate exposure [20]. As a result of extensive isolation practices, there was a decline in air travel, tourism, and many business operations [1]. According to Hanna & Huang [17], the WHO SARS-related travel advisory led to a decrease in travel and social interactions. The decrease had negative effects on tourism, business and subsequently, on GDPs with China and Hong Kong the most hit [5].

Due to globalization, it was initially feared that the outbreak would become pandemic. International effort coordination and information dissemination were among the most effective strategies used to contain SARS. However, extensive media coverage led to the high levels of perceived risk relative to actual risk. As expected, this had a widespread economic impact as commercial and retail activities were heavily affected [17,13].

In Singapore, strict control measures were used for the immediate containment of the disease. Mandatory use of personal protective equipment (PPE) for healthcare providers as well as screening via regular temperature monitoring was enforced once a nosocomial pattern was established or SARS. Also, compulsory temperature screening schools nationwide and thermal scanners at the airports to monitor travelers were introduced. Electronic bracelets were used to enforce quarantine in Singapore [17] to prevent people escaping quarantine during outbreaks. Surveillance and quarantine measures were very broad, and facilities were separated and used for all SARS cases to reduce transmission [22].

Employing Susceptible-Infective–Removal (SIR) model to measure the relative effect of several quarantine modalities on the outcomes of the 2003 SARS outbreak in Taiwan, Hsieh et

al. [23] concluded that active contact tracing and isolation of exposed secondary contacts (Level A Quarantine) significantly contributed to controlling the transmission and spread of SARS during the outbreak when compared to quarantining travelers arriving in Taiwan from regions with recorded confirmed cases of SARS (Level B Quarantine). They showed that Level B Quarantine led to a 5% reduction in cases and deaths. This pales in comparison with Level A quarantine that prevented 461(81%) and 62(63%) cases and deaths respectively, underlying the need for an early response. The mean daily isolation rate for Level A quarantine was estimated to be 0.047 (CI= 0.0280-0.0677). The SIR model predicted a case and fatality reduction of 88% and 86% if a perfect quarantine (mean daily rate=1) was achieved.

Discussion

Local & National: The SARS experience highlights the importance of a strong government commitment to control disease outbreaks. Singapore's rapid control of the infection was primarily due to strict legislations on assessment, quarantine, and isolation. They were innovative, firm and well-coordinated in their approach to identify cases and curtail the spread of the virus. Similarly in Nigeria, an immediate deployment of resources led to a successful Ebola disease containment in 2014. Swift contact tracing, continuous contact monitoring and prompt isolation of the high-risk contacts were shown to be effective. Governmental support and assurance of compliance proved effective as the disease was completely contained within a month [24]. The level of leadership which the Singaporean and Nigerian government exhibited demonstrates the importance of a robust and decisive political governance in countries as it is the government's burden to defend and evaluate public health strategies and regulations.

According to the WHO, [1], evidence-based decisions were made through instant and consistent information exchange between professionals and governments leading up to the progressive containment of SARS. In a likewise manner, laboratories linked securely shared and communicated findings that identified the coronavirus and as well, developed diagnostic tests for it. Hence, the importance of interoperability cannot be over emphasized.

Timely isolation, efficient screening at ports, and tracing and isolation of the contacts were found to be significant parameters in a model developed to better understand best approaches to interrupting the chain of spread between the diseased and susceptible individuals [25]. These parameters were similarly found to be significant in the control of Ebola in developing countries in 2014 [26]. In addition, Dhama et al. [26] included more parameters in their recommendations for Ebola control to cater for the unique challenges in developing countries viz: early laboratory diagnosis and proper hygiene practices. A high index of suspicion and early diagnosis prior to the development of specific clinical symptoms are critical in arresting the spread of viral diseases like SARS and Ebola. SARS and Ebola infections initially present with non-specific symptoms during the prodromal phase. The prodromal phase serves as an important rate-limiting determinant of transmissibility as infected individuals are most infective during this phase [26]. Thus, it is not surprising that West African countries that recorded a high number of cases and high transmissibility were those that relied primarily on diagnosis after susceptible individuals have developed specific clinical features and isolation. It's obvious that an opportunity to prevent further spread of SARS and Ebola was missed in these countries as they lacked the necessary resources for the early detection of diseases [26].

The high prevalence of illiteracy, superstitious and unhygienic practices in these countries, encouraged the widespread of Ebola. Limitations in border patrol, information dissemination, intimate home/family care of the diseased, surveillance, and late hospital presentations made the Ebola epidemic in West Africa harder to control. These limitations eased with increasing international efforts and support [19].

Regional & Global: The SARS experience also highlights the impact a single infectious outbreak could have, not only in the nation where it originated but in the world and thus the need for well-coordinated and concerted efforts on a global scale. The inability of any country to respond efficiently to such emergencies endangers world populations [3]. Development and increased movement across nations have highly increased the probability of any outbreak to become a pandemic, especially through air travel. The 2014/2015 Ebola outbreak in West Africa, which spread to other parts of the world via air travel, lend credence to this. In times of epidemics, airport officials should be alerted and trained to remain vigilant and help in identifying probable cases. Airport authorities in Germany were warned of probable cases aboard a flight en route Singapore but scheduled for a stop in Germany. This led to prompt isolation of the said cases upon their arrival, thus halting further spread in Europe [1].

The studies show that delayed response to disease outbreaks could cause even more disaster as was evident in the progression of the SARS outbreak. The first global alert on the presence of the outbreak was in March 2003 after over 100 new cases had appeared and four months after the first suspect cases were identified in Guangdong. If cases were promptly and urgently reported, the international spread could have possibly been averted. Though subsequent analysis puts the beginning of the 2014 Ebola epidemic at four months earlier, the index case of Ebola Viral Disease was confirmed in March 2014. The WHO declared the Ebola outbreak a Public Health Emergency of International Concern (PHEIC) on August

8, 2014, about 33 weeks later. PHEIC is an agreement by all WHO member countries to collaborate in controlling major international health hazards [27]. A remarkable reduction in global spread was noted after the WHO PHEIC report, with spread limited to within the borders of affected countries.

The WHO highlighted the extensive media coverage that amplified the capability of nations to achieve public health results like containing an outbreak of such magnitude without drugs and vaccines. The immediate activation of emergency response teams with specific goals detailed in the article by Posid et al. [20] portrays how successful a coordinated and unified approach to public health emergencies could be. The success recorded by the teams accentuates the importance of factors such as interoperability, accessibility, accountability and interaction within state and local health departments and any response organization.

A positive outcome and lesson learned from the risk that the level of preparedness and reporting on the 2003 SARS epidemic posed to the world is the ratification of International Health Regulation by the WHO. This framework provides a foundation for adequate assessment and reporting of diseases irrespective of the socioeconomic implications of such reports [28].

Remarkably, the assistance from international organizations such as CDC and WHO towards Ebola was quite prompt, commendable and efficient. Without this, the outbreak might have resulted to a pandemic. They provided home diagnostic kits for mobile and home-based screening of susceptible individuals. This resulted in a quicker identification of diseased individuals. Most importantly, they also provided quarantine centers [27]. Quarantining is central in communicable infectious disease control. However, it could also result in adverse health conditions [6]. This issue calls for better criteria for selecting, grouping and isolating cases and secondary contacts. To reduce these drawbacks of quarantining, a decision tree was recently developed to guide health care workers [29]. Quarantine laws should also be better implemented internationally. The Chinese and Singaporean government and health system employed strict quarantine laws in controlling the spread of SARS. Implementation and enforcement of such laws might have been helpful in preventing the Ebola spread to and within the USA and West Africa [30]. Furthermore, ensuring quarantined individuals do not leave the isolation facility without appropriate clearance is necessary. Hanna & Houng [17] noted that the use of electronic bracelets contributed to an effective quarantine program in Singapore. Unfortunately, such devices or alternatives were unavailable in West Africa during the Ebola outbreak. Thus, voluntary discharges from containment centers were rampant.

The lessons to be learned, therefore, are the importance of timely interventions and coordination of emergency response. Generally, the studies attributed the timely containment to the international collaboration of health organizations and countries, and to compliance on travel bans due to the media attention heaped on the outbreak, which is indeed commendable. Also, success was attributed to the epidemiological interventions that were useful in the timely control of the SARS outbreak.

Conclusion & Recommendations

Fortunately, the 2003 SARS outbreak was not as disastrous as feared and predicted. It was fast paced and ended on a note that left room for research and future preparedness. Unfortunately, there is still more to be done as 11 years down the lane; the world witnessed another outbreak -Ebola. The world needs to be more prepared to handle future unforeseen and unexpected health disasters. In addition to all the previous recommendations that have been extensively discussed above, we believe the strategies discussed below would also play a crucial role in the West Africa region.

Local & national directions: Effective communication of evidence-based health information via local media to the populace could discourage the numerous unhealthy superstitions among the majorly illiterate masses on more hygienic health practices. Mobile phone use in Sub-Saharan Africa has risen from 1% in 2000 to 54% in 2012. Countries such as Ghana, Tunisia and Morocco are over 100%. Not all of these mobile connections provide internet access, as Tunisia has just above 41% internet penetration [31]. Therefore mere increase in mobile connection is not a silver bullet to providing m-health services. M-health service would require a more coordinated information technology program through mobile internet to provide health services. Despite lacking m-health service, the young people of Sub-Saharan Africa have bridged healthcare gaps through making calls, sending text messages and pictures [32]. We believe that more information dissemination could have been achieved through a well-structured m-health service, and health social media. Social media in health have been shown to be efficient in promoting health information [33]. The information could be further disseminated via an active and regular social media. Local websites should be regularly maintained and updated especially during epidemics. GPHIN could also have access to such reliably structured health information, and incorporate this into their epidemic surveillance [18]. These websites should also have pictorial messages and short videos that are more beneficial than datasets and lengthy articles. Such pictures were already shared during the outbreak via Flicker and Instagram [34]. Similarly, Facebook has been used to create an increased awareness of breast cancer [35]. Though many such organizations have and maintain their websites, they could make use of other channels such as YouTube and

Instagram.

Emerging infectious diseases should be treated as though they have the potential for global spread; because they do. The public health system of every country should have an emergency preparedness mechanism that is trained and ready for activation should the need arise. The approach used to contain the SARS outbreak by WHO and CDC should be adopted by nations as response plans for future outbreaks. There should be prompt reporting on probable cases of unidentified or undetermined illnesses by national health authorities to international bodies regardless of political pressure. This is beneficial not just to the country but the world. An infection could easily be transmitted to another continent via air travel. Delay could swiftly cause an outbreak to become pandemic with disastrous consequences for populations and economies. Therefore, nations shouldn't hesitate to seek the aid of experts and bodies like WHO and GOARN, who have the capacity and strength required to spearhead international response.

Essential public health interventions like case identification, contact tracing, quarantine, isolation and surveillance were tools used to curb the spread of SARS and are regularly used in disease outbreaks. Ensuring that quarantined individuals are prevented from rejoining the population before medical clearance is needed. Health personnel and response teams should be trained on how best to conduct such interventions within their nations, in preparation for possible future occurrences. For every person quarantined, millions are saved. National surveillance should be seen as important as international surveillance as both are necessary to ensure protection at all levels.

Global directions: Finally, there should be more GOARN partners across continents with a stronger presence in developing countries with weak public health infrastructure. The network should be strengthened across the globe.

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