One Health 2 (2016) 99–102

Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

A brief historical overview of emerging infectious disease response in China and the need for a One Health approach in future responses

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ARTICLE INFO

Article history:
Received 26 October 2015
Received in revised form 8 July 2016
Accepted 8 July 2016
Available online 9 July 2016

In 1952, under the guidance of Chairman Mao, China's central government established an epidemic prevention system that focused on the principle of "putting prevention first" [1]. This approach greatly strengthened public health infrastructure and capacity in China. Chinese society has changed dramatically over the last 60 years, characterized by rapid economic and population growth. Intensification of animal production to accommodate population growth and increasing personal wealth have driven what appears to be a seemingly unceasing series of emerging infectious disease (EID) events [2]. The emergence of pandemic strains of influenza from high risk areas of China seems an almost seasonal occurrence and, in the wake of this and a number of other globally important public health emergencies, China is moving from a passive approach to EID surveillance and response to a more proactive one. This change has not occurred spontaneously; it is a process that has occurred through a number of distinct stages. China, however, appears to be in a transitional period again.

1. Maintaining social stability

At the time of the Severe Acute Respiratory Syndrome (SARS) outbreak, China's approach to EID surveillance was built on the principle of "maintaining social stability". Surveillance systems were predominantly passive and hysteresis. The 2003 SARS pandemic demonstrated clear weaknesses in this approach [3]. Government agencies were stunned by the speed of disease transmission and the philosophy of "maintaining social stability" produced conflict between science and politics, obstructing the release of epidemic information. The first case of "atypical pneumonia" occurred in Guangdong province on November 16, 2002. The Chinese public (and international community) were, however, not informed of developing events. This was resultant from a combination of poor policy and poor management. The initial cases of SARS occurred in Guangdong province, with the earliest case recorded to have occurred in Foshan city on November 16, 2002; this was followed by index cases in Heyuan (December 10), Jiangmen (December 21), Zhongshan (December 26), Guangzhou (January 2, 2003), Shenzhen (January 15) and Zhaoqing (January 17) [4]. Health officials in Guangdong province were, however, not required to notify the Ministry of Health of the emerging crisis. At the time, the provincial health departments were only legally mandated to notify for these diseases listed on National Infectious Disease Reporting System; as atypical pneumonia was not listed notification was not mandatory. Despite this, it appears that authorities were notified and investigations were conducted early in the outbreak [3]. The effectiveness of the response was, however, hobbled by bureaucracy. A team of health experts was sent to Guangzhou by the Ministry of Health on January 20, 2003 and a report was produced and delivered to the provincial health bureau on January 27, 2003. This report was, however, marked "top secret" and it was not read until three days after receipt as there was no official present who was authorized to open the report [3]. Upon opening, the provincial health bureau disseminated an alert to the hospitals. This act in itself was, however, counterproductive; under the legislation of the time, until

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http://dx.doi.org/10.1016/j.onehlt.2016.07.001

announced by the Ministry of Health, the occurrence of an infectious disease outbreak was classified as a state secret [3]. This prohibition of reporting/sharing of information resulted in the spread of rumors of circulating anthrax, bird flu or other diseases in the community.

Effectively the legislation that was designed to maintain social stability did the opposite; it created a bureaucracy that slowed response and, through the lack of clear information and communication, created fear and drove speculation. It was not until February 11, 2003 that the Guangzhou Municipal Government and Guangdong Provincial Health Department responded to these fears and held a press conference, at which the public were informed that Guangdong province was free of anthrax, the plague, and avian influenza. On February 18, 2003 the China Centre for Disease Control and Prevention (CDC) announced *Chlamydia* to be the cause and provided authoritative instructions to hospitals regarding treatment based on this. Over the next two months official Government media reported cases to be increasing, but maintained their assertion that the outbreak was under control. The Chinese government, however, continued to be resistant to transparency. Information continued to be controlled and reporting was again restricted on February 23, 2003 in response to criticism to the Government's handling of the outbreak. There was a clear political motive; restrictions on reporting continued in the lead up to the March National People's Congress [3]. On March 24, 2003 US CDC and Hong Kong scientists announced that a novel coronavirus had been isolated from samples and proposed this to be the etiological agent. Despite this evidence, the Chinese Government and CDC maintained that Chlamydia was the cause of the outbreak until as late as mid-April 2003; any dissenting voice was silenced through procedure that required findings to be reported to the Ministry of Health [5]. On April 16, 2003, the WHO declared the previously identified, novel coronavirus to be the etiological agent of SARS; this was supported by studies that demonstrated the coronavirus to fulfil Koch's postulates [6]. The WHO criticized reporting of SARS by the Chinese Government and finally, on April 20, 2003 the Chinese government complied with demands for complete, accurate and timely reporting of SARS cases; up until this point, little information had been shared with the WHO. The government reported that 339 confirmed cases and 402 suspected cases of SARS had occurred in Beijing, contradicting the statement of Health Minister Zhang Wenkang only days before, which reported only 22 confirmed cases [7].

This lack of operational transparency fed rumors, speculation and misinformation which were amplified by the media; furthermore, it invoked international fear and, in some cases resulted in inappropriate courses of action being followed. Rather than maintaining stability, this approach had the opposite effect [8]. To the credit of the Chinese government, through much introspection, considerable reform to the public health system was made, including: the development of public health legislation and regulations to improve government response; and transformation of the Sanitation and Anti-epidemic Stations into Centers for Disease Control and Prevention with dramatically improved infrastructure and technical capabilities. The SARS epidemic lead to a revolution in China's approach to infectious disease surveillance and response. Emphasis was shifted back to “Prevention First” and the utility of this approach improved China's handling of a number of subsequent EID events, including: H5N1 avian influenza, *Streptococcus suis* infections, severe fever with thrombocytopenia syndrome virus, and the 2009 H1N1 influenza pandemic. Despite the shift in approach, there were still concerns; the Chinese Government appeared to conceal cases during the 2004 H5N1 outbreak and criticized publications that indicated otherwise [9].

2. Preserving local economic interests

There was, however, a divergence from this approach during the 2013 H7N9 avian influenza outbreak. Since 2004, China CDC has conducted surveillance for pneumonia of unknown etiology. This system confirmed three human cases of influenza A (H7N9) on March 29, 2013 [10]. Health authorities responded aggressively with rapid diagnosis and treatment, enacting a number of plans that had been developed in response to identification of systematic failures during the SARS outbreak; agricultural authorities culled sick birds and closed live poultry markets; and, in contrast to the SARS outbreak, H7N9 epidemic information was published expediently and disease information shared openly with the international community. The Chinese government reported the outbreak to the WHO on March 31, 2013. These interventions were effective and the process significantly more transparent than that of the SARS outbreak. However, this approach came with a significant economic cost. H7N9 was estimated to cost the poultry industry ¥7.75 billion (US$1.24) in direct losses in the first three months alone [11]. The National Association of Poultry Industry in China and some poultry enterprises jointly submitted appeals to local governments in order to secure their economic interests. Unlike H5N1, H7N9 does not cause overt signs among poultry and in addition to industry concerns, Chinese agriculture authorities did not fully appreciate the immediate threat posed. These concerns precipitated a less-aggressive response to subsequent sporadic human cases and economic preservation was prioritized. Response was often limited to searches for H7N9 affected birds in the immediate geographical regions associated with human cases. As the birds were not obviously sick, mass euthanasia of poultry flocks was not embraced or supported. The response was inadequate; effective daily monitoring and control of H7N9 among poultry markedly lagged behind the dynamic geographical spread of human cases. The response mounted was performed under the pretext of “preserving local economic interests”; the economically-focused, passive responding patterns, however, drove continued transmission and further outbreaks [12].

3. The next stage: a more proactive approach

EID events have risen since the early 1940s, peaking in the 1980s [2]. EIDs have a tendency to originate from lower-latitudes, particularly for areas with poor reporting mechanisms, and it has been estimated that ~70% of EIDs are zoonotic. Areas such as Guangdong Province constitute, by all measures, a high risk environment for the emergence of novel and/or globally-relevant infectious diseases. Guangdong Province is a major nexus for national and international commerce; densely populated and located within the subtropics making it susceptible to mosquito-borne diseases. It has already been the center of a number of globally significant outbreaks beyond SARS and H7N9, including one of the largest epidemics of dengue fever seen in China [13]. EID surveillance in China has undergone a revolution since the advent of SARS. The Government has implemented a number of changes to EID detection and control and through this they have established systems that are among the most efficient worldwide. The changes implemented by China in its approach to public health emergencies has been built on four pillars [14]: (1) the development and implementation of effective legislation and contingency planning; (2) the establishment of an effective command and coordination structure to facilitate cross-sectorial response to emerging public health emergencies; (3) the development of a highly effective notification system for infectious diseases and public health emergencies; and (4) the establishment of professional public health emergency response teams. Once such example of changes that have been made is the development the China Infectious Disease Automated Alert and Response System (CIDARS). This early warning system for EIDs, developed by the China CDC in 2008, provides real-time reporting and automated analysis of data collected through the electronic National Notifiable Infectious Diseases Reporting Information System; any aberrant signal identified by the system is passed on to CDCs at the county level by short message service [15]. The changes implemented by the Chinese government have undoubtedly improved response to EID events in China and should be recognized for this. There is, however, a need not just for improved surveillance for high risk areas such as Guangdong Province, but also for a shift in thinking, away from the parochial approaches that have

previously been of applied. It is imperative to engage other sectors of the community, such as our veterinary colleagues and business, in order to develop a comprehensive response; it requires recognition that just as EIDs are driven by many factors and compounded by the complex interactions of these, they cannot be addressed exclusively from the human health domain. Coordinating such an approach is difficult, both politically and practically; the One Health approach, however, presents a means to deal with such complexities.

One Health has been defined "as the collaborative efforts of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals, and our environment" [16]. The concept of One Health is increasingly accepted as it presents the most comprehensive approach to addressing a vast range of complex health problems, not just at the point of effect, but also at the root cause of the problem [17]. On November 2014, an International Symposium for One Health Research was successfully held in Guangzhou, hosted by Sun Yat-sen University, South China Agricultural University, State Key Laboratory of Pathogen and Biosecurity and Duke University to promote One Health practice in China and beyond. The symposium demonstrated the utility of dynamic One Health approaches for use in EID surveillance and response. There is a clear need for China to develop systems that can better anticipate and respond to the emerging, complex public health problems. We believe that One Health will emerge as the fourth developmental stage in China's public health system to fill this need.

China is a country with unique challenges; it is a rapidly developing country with a very large population and expanding economy. Through this, China faces a number of complex challenges with regards to health, the economy and the environment. A number of infectious diseases of significant global concern have emerged from China over the past 20 years; many of which have been associated with production animals or live animal markets. Despite this, response to EID events in China has had a primary focus on human health and economic factors. It is becoming apparent that such approaches do not adequately address the root causes of the emergence of these diseases. EID events are highly complex in nature and cannot be merely reduced to a simple "cause and effect" model; adequate response requires a broader perspective. It is through this perspective that a One Health approach can be used to better address emerging and complex health issues affecting China, such as EIDs. One Health allows more proactive, systems based approaches to be developed to address complex issues.

Whilst the One Health approach in concept, has been endorsed by a number of significant international organizations, including but not limited to the Food and Agriculture Organization of the United Nations (FAO), World Organization for Animal Health (OIE), WHO, United Nations Children's Emergency Fund (UNICEF) and the World Bank [18], there is still much work required if it is to be effectively implemented. Adoption of a One Health approach in China has the potential to create tension between stakeholders. Enacting change will require both leadership and political will. Broadly, it will require action on four fronts: legislation, communication, education and investment.

Firstly, legislation need to be strengthened for activities in non-health sectors that are identified to contribute to the development and spread of infectious diseases, such as farming practices, animal movement and livestock markets. Such changes need to be supported with positive and negative incentives to ensure compliance, such as compensation for those adversely affected by shifts in practice and fines or more serious deterrents for those who are intentionally uncompliant. This will require the development of a comprehensive understanding of the motivations and needs of stakeholders.

Secondly, coordination during EID events needs to be improved through enhanced communication capabilities. As has been discussed above, China has made significant progress with regards to transparency around EID events and in reporting of emerging situations to the international community. Communication between government ministries and between the public and private sectors, however, needs improvement. Namely, better mechanisms need to be developed for sharing of information related to EID events between departments (such as the Department of Health, Department of Agriculture and Department of Forestry), dissemination of reports (within China and to the international community) and for linking of data.

Thirdly, One Health should be formally included in the curricula of medical, veterinary, public health and epidemiology courses. Improved understanding of the core principles of One Health by stakeholders is instrumental and currently appears lacking. Education opportunities, such as workshops, conferences and professional development courses needs to be developed. It is also imperative to recognize the need to extend education on the One Health approach beyond professionals in the health sciences field. Further efforts are required to educate all stakeholders, from primary producers through to legislators.

Finally, these activities need to be supported with investment. In order to successfully shift to a One Health approach investments are required in two key areas: research and implementation. Further research is required into novel surveillance approaches for identifying and addressing EID events [19]. Findings, however, also need to be translated to action, policy and practice. It is acknowledged, the successful implementation of a One Health system will require marked changes in the *status quo*, and significant investment. However, this shift has the potential to significantly improve EID surveillance and response in China and beyond.

Contributions

Structure of the manuscript was developed by JL, GJM and WH. JL drafted the original manuscript. The final version is approved by all authors.

Conflicts of interest

We declare that we have no conflicts of interest.

Acknowledgements

This work was supported by National Natural Science Foundation of China [grant number 81473034 to J.L.]; Science and Technology Planning Project of Guangdong Province, China [grant number 2013B051000033 to J.L]; Science and Technology Program of Guangzhou [grant number 201508020062 to J.L]. W.H was supported by an Australian Research Council Future Fellowship (FT140101216).

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