Planning for large epidemics and pandemics: challenges from a policy perspective

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Purpose of review
Less than two decades into the 21st century, the world has already witnessed numerous large epidemics or pandemics. These events have highlighted inadequacies in both national and international capacity for outbreak prevention, detection, and response. Here, we review some of the major challenges from a policy perspective.

Recent findings
The most important challenges facing policymakers include financing outbreak preparedness and response in a complex political environment with limited resources, coordinating response efforts among a growing and diverse range of national and international actors, accurately assessing national outbreak preparedness, addressing the shortfall in the global biomedical workforce, building surge capacity of both human and material resources, balancing investments in public health and curative services, building capacity for outbreak-related research and development, and reinforcing measures for infection prevention and control.

Summary
In recent years, numerous epidemics and pandemics have caused not only considerable loss of life but also billions of dollars of economic loss. Although the events have served as a wake-up call and led to the implementation of relevant policies and counter-measures, such as the Global Health Security Agenda, many questions remain and much work to be done. Wise policies and approaches for outbreak control exist, but will require the political will to implement them.

Keywords
epidemics, outbreaks, pandemics, policy, preparedness, response

INTRODUCTION

Although global health goals are realigning to match the growing burden of noncommunicable disease, the perennial threat posed by large infectious disease epidemics and pandemics remains. Less than two decades into the 21st century, the world has already witnessed numerous large epidemics or pandemics, three of which the World Health Organization (WHO) declared Public Health Emergencies of International Concern (PHEIC; Table 1). The PHEIC declaration means that WHO will help coordinate an immediate response with the affected country and with other countries around the world, and is an important designation in terms of mobilizing human, material and financial resources. Population growth, globalization, climate change and growing antibiotic resistance are among the factors that increase the risk of disease outbreaks.

The frequency of large outbreaks and epidemics, and the effectiveness of the response to them, is largely reliant on emergency preparedness. Being adequately prepared for large epidemics and pandemics requires a combination of political will, financial investment and public health expertise. Unfortunately, recent events, most notably the epidemics of Ebola virus disease (EVD) in West Africa in

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KEY POINTS

- Less than two decades into the 21st century, numerous epidemics and pandemics have caused not only considerable loss of life but also billions of dollars of economic loss.
- Recent events have served as a wake-up call and led to the implementation of relevant policies and countermeasures, including the Global Health Security Agenda.
- Despite this, major policy challenges still exist for both international organizations, such as the World Health Organisation, as well as national governments and nongovernmental organizations working to prevent, detect and respond to large outbreaks of infectious disease.
- These challenges can be addressed, but will require significant political commitment, strategic leadership and effective health system strengthening efforts.

2013–2016 and of Zika virus disease in Latin America in 2015–2016, have highlighted inadequacies in both national and international emergency preparedness and response [1▪]. To further improve infectious disease outbreak prevention, detection, and response, it is essential to identify the most important challenges facing policy makers, based on past evidence, existing knowledge and future projections. Although some challenges may be linked to specific outbreaks and pathogens, many are common to the broader objectives of emergency preparedness and health systems strengthening. Here, we discuss some of the major challenges to epidemic and pandemic preparedness from a policy perspective, drawing examples from the large epidemics and pandemics noted to date in the 21st century (Table 2).

Table 2. Key policy challenges in planning for epidemics and pandemics

Ensuring global security and health as a human right
Financing outbreak response
Coordinating outbreak response
Assessing outbreak preparedness
Establishing a global health workforce
Establishing and maintaining surge capacity
Balancing investments in public health and curative medical services
Outbreak-related research and development
Establishing and maintaining proper infection prevention and control

GLOBAL SECURITY AND HEALTH AS A HUMAN RIGHT

Although it is perhaps self-evident, it must nevertheless first be emphasized that large outbreaks often take place in low-and-middle-income countries (LMICs), often at the zoonotic interface, and often in settings where prolonged civil unrest has destroyed or prevented the development of capacities for disease surveillance and response [2]. Not only do these sites of physical insecurity provide

Table 1. Large epidemics and pandemics in the 21st century

Year of onset	Event[a]	Region	Reported cases	Reported deaths (case fatality)
2003	Severe acute respiratory disease (SARS) coronavirus pandemic	Asia and selected countries in Europe and North America	8098	774 (9.6%)
2006	Chikungunya epidemic	India	>1.25 million	≥61 (<0.001%)
2009	Meningitis (*Neisseria meningitidis*)	West Africa	13,516	931 (6.9%)
2009	H1N1 influenza pandemic[a]	Global	~200 million	~6 million (0.03%)
2010	Cholera epidemic	Hispaniola	>700 000	>9000 (1.3%)
2011	Measles epidemic	Democratic Republic of the Congo	294 455	5045 (1.7%)
2012	Middle East respiratory syndrome (MERS) coronavirus epidemic	Saudi Arabia and Middle East	2189	782 (35.7%)
2013	Chikungunya pandemic	Latin America	>2.9 million	296 (0.01%)
2014	Ebola virus disease epidemic[a]	West Africa	28 616	11 310 (39.5%)
2016	Zika virus disease epidemic[a]	Latin America	223 477	20 (<0.001%)
2016	Yellow fever epidemic	Central Africa (Angola, Democratic Republic of the Congo, and Kenya)	964	137 (14.2%)
2016	Cholera epidemic	Yemen	>1.1 million	≥2255 (0.2%)
2017	Yellow fever epidemic	Brazil	723	237 (32.8%)

[a]Indicates event declared a Public Health Emergency of International Concern by the World Health Organization.

fertile ground for disease introduction and spread, but they also prevent effective outbreak response; for example, the cholera outbreak that started in Yemen in 2016 continued largely unfettered to become the largest cholera outbreak on record – over a million cases (Table 1) – as the violence from warring factions prevented a coordinated response from both government and international stakeholders [3]. Thus, the first policy challenge is to ensure health as a human right, and the physical security for its implementation. Most often the biomedical and public health community counts on political leaders for this service, but the need for continued advocacy cannot be under-estimated. In this regard, new WHO Director General Tedros Adhanom Ghebreyesus' recent call for universal health coverage is a welcome and important initiative.

FINANCING OUTBREAK RESPONSE

Since its founding in 1948, the world has generally looked to WHO to coordinate and assist member states to provide health services to their populations and to lead global emergency preparedness efforts. However, the organization was heavily criticized for their perceived slow and disorganized response to the West Africa EVD outbreak [4].

One of the more serious challenges faced by WHO in their global mission is the relative lack of flexibility in funding. In 1951, over 50% of the WHO budget came from fully flexible, assessed contributions (i.e. funds that can be spent as deemed appropriate by WHO, rather than earmarked to a particular activity by the donor), a proportion that has fallen to just 29% in 2015 [5]. Such a budgetary profile hampers the organization's ability to rapidly funnel resources wherever needed to respond to outbreaks. Many have pointed to this financial straitjacket as the source of the inadequate WHO response in the early phases of the West Africa EVD outbreak [6–8].

In an effort to overcome this major impediment to outbreak response, in 2016, the WHO established a contingency fund for emergencies (CFE), but questions remain on how best to maintain the fund to ensure its success. Over 3 years since the fund's creation, WHO has received only $53.3 million of a targeted $100 million in flexible donations [9]. Furthermore, questions persist as to whether this target is appropriate, how it was calculated, and whether it can be sustained. The perpetual policy issue of how to ensure member states finance international health activities in proportion to their economic ability remains unsettled. As of March 2018, Germany and the United Kingdom have been by far the greatest contributors to the CFE, donating $16.6 and $16.1 million, respectively [9]. The United States has yet to donate to the fund. Furthermore, the United States' commitment to global health appears to have recently wavered, with significant cuts to the global health security agenda and US overseas programs [10].

In addition to the need for a CFE, two major policy challenges relating to funding have come to the fore since the West Africa EVD outbreak. First, can and should WHO further diversify the organization's financial income portfolio beyond government support through partnerships with NGOs and private companies? In 2010, WHO raised a meagre 6% of its total income from private sources [11]. However, acceptance of private sources may come at the risk of undue influences on health policy [12]. Second, how to limit the proportion of funds earmarked for activities specified by a donor, permitting a more flexible budget [13]? Until these problems are overcome, permitting a stable and well functioning CFE, it may be difficult for WHO to effectively plan and prepare for a large outbreak or pandemic.

WHO has adopted a 'no regrets' policy – meaning that, at the onset of emergencies, a rapid commitment of human and financial resources will be made to counter the perceived threat, even if it is later realized that a smaller contribution was required. However, limited resources may inevitably force WHO to balance liberal use of the CFE for a robust outbreak response with the potential waste of valuable resources for outbreaks that turn out not to be major threats. Although challenging, there is considerable interest in developing accurate forecasting through modelling during outbreak response, which could help WHO and other responders match resources to the need [14].

COORDINATING AND STREAMLINING OUTBREAK RESPONSE

In addition to the creation of the CFE, the WHO has recently undertaken a broad reform designed to streamline its capacity for outbreak response, creating the WHO Health Emergencies Programme – a 'single programme, with one workforce, one budget, one set of rules and processes and one clear line of authority' and 'an independent mechanism of assessment and monitoring of the performance of the Organization, reporting to the governing bodies' [15]. Although most observers herald this as a positive step, questions remain whether the reorganization is significant enough to fundamentally change WHO's long-entrenched ways of working and, again, whether donor contributions will be sufficient to provide long-term support for the new organizational structure.

In addition to prompting reforms at WHO, the challenges of responding to the EVD and Zika outbreaks have motivated a broad range of international agencies, national governments and nongovernmental organizations to create or reinforce their capacity for outbreak response. These include the creation of Africa Centers for Disease Control and Prevention (CDC) [16] (conceived prior to the EVD outbreak, but the outbreak was a driving force in ultimate funding and implementation), national or international rapid response teams [17,18], the Collation for Epidemic Preparedness Innovations (CEPI), and the Global Research Collaboration for Infectious Disease Preparedness (GLOPID-R), to name but a few. Although these initiatives are certainly welcome, the entry of so many diverse organizations onto the global outbreak response scene brings questions regarding how they would be coordinated, especially with a large outbreak on the scale of West Africa EVD. Arguments could also be made that, in some cases, funds for these initiatives divert support away from WHO, fragmenting rather than advancing the goal of a unified system for outbreak response. WHO and their contracted primary implementing partner for outbreak response – the Global Outbreak Alert and Response Network – are faced with the challenge of drawing out the best from this broad array of well meaning partners, finding the delicate balance of convening and facilitating without adding bureaucratic obstacles.

INTERNATIONAL HEALTH REGULATIONS AND ASSESSING OUTBREAK PREPAREDNESS

The 2005 International Health Regulations (IHR) is a binding international legal instrument encompassing 196 countries [19]. The objective is to aid the prevention, detection and response to acute public health risks that have the potential to threaten global public health. Ensuring implementation of IHR capacities through technical and financial assistance has remained a focus of international global health security work since the revised IHR in 2005 [20]. The Joint External Evaluation (JEE) tool is a collaborative process to assess a country's capacity under IHR to prevent, detect and rapidly respond to public health threats [21]. It is intended to identify strengths and weaknesses, providing countries with a way of identifying the most urgent needs within their health security system in the context of emergencies.

The JEE tool looks at various areas of a national health system, including emergency preparedness plans, surveillance and laboratory systems and antimicrobial resistance. Although the concept of evaluating IHR capacity is commendable, the current JEE tool allows a limited assessment of IHR capacity; for example, there is a dearth of collected data on health financing, access to medicines and clinical management of disease, all of which are highly relevant indicators of susceptibility to infectious disease outbreaks. To be of maximum benefit to policymakers, the JEE must be refined to more comprehensively assess these areas, and used in conjunction with existing local knowledge on health systems. The subsequent policy challenge for WHO and national governments will be to facilitate the translation of identified weaknesses in national emergency preparedness and health system capacity into measurable improvements in those same areas. Success will bring benefits with regard to limiting both communicable and noncommunicable disease.

GLOBAL HEALTH WORKFORCE

One of the biggest challenges to outbreak control is having a skilled workforce with the requisite expertise in public health, epidemiology, clinical management, laboratory and social sciences and other relevant disciplines. Very often, large outbreaks occur in areas with drastically inadequate human resources. For example, before the West Africa EVD outbreak, Guinea, Liberia and Sierra Leone had less than one doctor per 1000 population, amongst the lowest health worker coverages in the world [22]. The ranks were then further thinned by the estimated 518 health worker deaths because of EVD [23]. Furthermore, the diseases and situations encountered in large outbreaks require experience and resources that most healthcare systems and health workers do not routinely possess. Lastly, implementation of research during outbreaks can create a conflict when the limited pool of skilled health workers are needed for both the research and public health control efforts.

With insufficient numbers of trained health workers in many areas of the world, confronting large outbreaks almost invariably requires international support, which has traditionally come from a relatively small group of organizations with the necessary expertise and resources, including WHO, the US CDC, Médecins Sans Frontières (MSF) and the International Federation of the Red Cross. Other national and international rapid response teams have also recently come on to the scene. However, these organizations also have their limitations because of financial, political and other constraints, sometimes also with limited experience with a given epidemic-prone disease. In some cases, significant turnover of personnel between outbreaks, with

consequent loss of institutional memory, may limit effectiveness.

This limited health worker workforce has led to calls for a global reserve of health professionals to be assembled for future emergencies [24▪]. Although this may be a short-term solution to fill gaps during epidemics of limited scale, a global reserve would be rapidly depleted in the context of a large pandemic. Military personnel could be deployed to complement the health worker pool, although this often creates some complicated geopolitical tensions, and such personnel may often not have experience with epidemic-prone diseases. Deployment of international workers may also be complicated by questions of legal and financial liability if an international health worker becomes infected, as well as restrictive, and not always evidence-based, quarantine policies upon return, as was seen in the United States during the West Africa EVD outbreak [25].

In addition to the number of skilled health workers, the geographic distribution of health workers may also pose challenges. Although many outbreaks start at the zoonotic interface in remote rural settings, in most developing nations, most of the health infrastructure and workforce is intensely concentrated in urban areas, with rural areas containing only on average 23 and 38% of a country's doctors and nurses, respectively [26,27]. Similar urban–rural disparities can also be seen in the skills mix of available health workers. Quality of clinical training, and therefore patient care, varies widely within developing countries [28▪] and is an imperative consideration when planning for an epidemic. Following the EVD outbreak, WHO formed an expert working group to develop methods for measuring the quality of clinical care in such a situation. This group of clinicians and public health experts came up with an initial proposal of over 100 clinical indicators to assess the quality of clinical management of EVD – for example, the percentage of severely ill patients with vital signs systematically recorded [29]. As this list of indicators is refined, the challenge for policymakers will be to successfully implement the regular use and evaluation of such quality measures in areas that may not currently meet many of the desired standards. The development of networks enabling health workers to rapidly share expertise on unusual cases or events, such as the WHO Emerging Diseases Clinical Assessment and Response Network [30], could serve as valuable tools to enhance quality care and also to rapidly implement enhanced infection prevention and control (IPC) measures to limit transmission in the early phases of an outbreak. Lastly, although it is important to generate a global workforce and develop communication networks for shared international response, these measures can never be a substitute for building a national frontline workforce with the skills and tools to rapidly detect and respond at the local level.

SURGE CAPACITY

Planning for a large epidemic or pandemic is contingent on having the requisite surge capacity to scale up resources when required. This includes not only human resources, but physical infrastructure, including numbers of functional hospital beds and requisite medical equipment and supplies. Although surge capacity to confront a major pandemic, such as the 1918 'Spanish flu,' would pose a challenge to all countries, the task is especially serious for LMICs [31]. Oshitani *et al.* [31] estimated that, in Bangladesh, for example, in an outbreak of pandemic influenza with an incidence rate of 15%, over 100% of beds would be required for patients with this disease.

The trouble for policymakers is that it is difficult to predict how much resource to keep in reserve before an outbreak, and how best to direct that extra resource when the time comes. In most hospitals, policies exist for temporarily expanding patient bed capacity in disease outbreak or disaster situations, such as cancelling elective procedures and admissions, discharging inpatients early and clearing emergency departments. Nevertheless, statistical modelling suggests that restricting elective hospital admissions alone would be ineffective in maintaining an adequate surge capacity to prepare, for example, for a SARS outbreak [32]. Limiting elective surgery would likewise be inadequate in areas where the majority of admissions are medical. Nevertheless, developing uniform guidelines, including definitions of urgency and how patients can be safely deferred, could prove useful in outbreak situations. Influenza assessment centres [33] and telephone services, such as the National Pandemic Flu Service in the United Kingdom during the 2009 H1N1 influenza virus outbreak [34], have also been useful when acute services have been overwhelmed. Emergency credentialing of volunteer health professionals from regions unaffected by the outbreak has also been proposed as a way to augment clinical staff capacity [35].

Although the aforementioned policy ideas are viable, they are not necessarily sustainable, and may come at a significant long-term financial cost for hospitals, and health cost for the population unaffected by the infectious disease outbreak. The question of which of these measures would prove most cost-effective in a large infectious disease outbreak is a crucial dimension to consider, and remains to be

answered [36]. For certain diseases, stockpiles of particular medicines (i.e. influenza therapeutics), equipment (i.e. mechanical ventilators for severe influenza) or materials (personal protective equipment for EVD) may be needed, most of which are not readily kept on hand and may not even be readily procurable because of limits in routine manufacturing capacity.

INVESTMENTS IN PREVENTIVE PUBLIC HEALTH VERSUS CURATIVE MEDICAL SERVICES

LMICs with weak health systems are often most susceptible to epidemics. To effectively plan for outbreaks in such settings, an investment in preventive public health services is required, including establishing sensitive epidemiologic surveillance and early warning systems with the requisite laboratory diagnostic support. These systems must be integrated into an overarching public health model that includes a reporting network involving nonhealth-sector stakeholders to enable a proportional response when an outbreak occurs. This also means having appropriate mechanisms in place at designated airports, ports and certain ground crossings, all of which were challenges during the West Africa EVD outbreak [37].

The most obvious barrier to developing such systems lies in the political pressure and preference to invest in curative medical services at the expense of preventive public health services (a general trend that holds true not just for developing countries [38,39] but also high-income settings such as the United Kingdom [40]). In many sub-Saharan African countries, WHO has led and funded disease surveillance efforts to plug the chasm left by resource-poor national governments [41]. From a policy perspective, the challenge lies not only in the decision to invest in robust epidemiological surveillance systems but also in how to overcome the practical obstacles of implementation. Only once surveillance systems have been successfully implemented will policy makers be able to collate epidemiological data, with the necessary social, political and ethical considerations, to respond effectively when an outbreak occurs.

RESEARCH AND DEVELOPMENT

The West Africa EVD and 2015–2016 Latin American Zika virus epidemics underscored the need to advance research and development as an integral component of the global emergency preparedness and response agenda. Although outbreaks are obviously unwelcome, they may provide an important opportunity and obligation for prospective research. High case numbers during outbreaks may provide the only opportunity for studies of sufficient statistical power to arrive at definitive conclusions on efficacy of experimental therapeutics, vaccines and diagnostics. Important information can also be garnered regarding, for example, the efficacy of various epidemiologic and community messaging approaches with regard to case finding and contract tracing. In addition to prospective trials, a vast amount of information can be generated from informal observations and empiric experience with the large number of cases [42].

Conducting research, however, during outbreaks usually requires rapid navigation of a complex web of scientific, logistical, ethical and sociocultural challenges that are difficult to overcome quickly, especially in the heat of an outbreak. Although a few efficacy trials were undertaken during the West Africa EVD outbreak, with some successes, most notably an efficacy trial of an EVD vaccine [43] by the time most trials were implemented case counts had fallen to a level insufficient to meet clinical endpoints. There was also a missed opportunity to enroll more patients in clinical trials in resource-rich settings. Nevertheless, numerous drug candidates progressed through Phase I–III clinical trials at an unprecedented pace and the recognition that some agents are ineffective, along with promising interim results for a few, provides a starting point for prioritization in future outbreaks.

Much work remains to capitalize on the lessons learned from the West Africa EVD outbreak and make the accelerated pace of clinical trials during outbreaks the norm, including advance prioritization of drug candidates, working out trial designs, prepositioning protocols and ethics committee reviews and setting logistical frameworks for rapid operationalization [44]. A 2016 United Nations high-level panel on global response to health crises recommended a priority list of pathogens to be developed by experts at the WHO [45], thereby serving as a framework to guide financial investment. WHO responded with the development of the WHO R&D Blueprint [46▪] – a global strategy and preparedness plan that allows the rapid activation of research and development activities during epidemics to fast-track the availability of effective tests, vaccines and medicines and including a list of priority pathogens. Part of the R&D Blueprint has entailed development of Target Product Profiles designed to orient and engage the private sector in therapeutics and vaccine development for selected outbreak-prone diseases [47]. The WHO Global Outbreak Alert and Response Network has created a Taskforce for Operational Research during

Outbreaks, although the precise methods for implementation, and dedicated resources, have yet to be elaborated. In addition to WHO, a number of public–private partnerships, such as CEPI and the European & Developing Countries Clinical Trials Partnership have been created to foster research and development on outbreak-prone diseases and have been able to garner significant resources for the cause. Research has also been integrated into the mission statements of the various rapid response teams that have been created in the wake of the West Africa EVD outbreak [16,17].

Although all the aforementioned initiatives represent important advances, significant questions and challenges remain regarding sustainable funding and coordination for research during outbreaks. The aforementioned United Nations panel found that overall investment in medical research and development for communicable diseases is deeply inadequate [45]; of the $214 billion invested in health research and development globally in 2010, less than 2% was allocated to neglected diseases [45]. In light of this, the panel recommended that WHO oversee the creation of a fund (of at least $1 billion per year) to support existing medical research and development for infectious diseases, and advocate for increased national investment in research and development.

If such funding for research and development can be procured, a major policy challenge for national governments will be to decide specifically where to direct the investment. Despite the R&D Blueprint, there is no 'one size fits all' solution. Each government will be required to carefully examine available epidemiological and scientific data on potential burden of disease, risk of emerging threats and economic forecasts, including cost-utility analyses, to ensure that resources are allocated in an evidence-based manner as possible to fit the needs of each country or region.

Lastly, even if research and development during outbreaks can be routinely and successfully implemented to produce the desired efficacy data, these advances will be largely futile if the resultant medical products remain inaccessible or unaffordable to vulnerable populations, as has often been the case in LMICs [48]. Thus, if international organizations and national governments are to be prepared for large-scale outbreaks, they must implement specific policies to broaden access to affordable medicines and vaccines in the emergency context.

INFECTION PREVENTION AND CONTROL

Rapid implementation of robust IPC measures is essential during outbreaks of diseases spread directly person-to-person. Not only are proper IPC practices essential to limit transmission in the community but also failure to implement healthcare facility IPC measures may result in health worker infections, further depleting the already limited workforce. The detrimental effect on the morale of health workers and community alike may discourage other health workers to join the response efforts and has, at times, elicited fearful and violent reactions from the community, with an overall result of impeding control of transmission [49]. Unfortunately, sufficient IPC programs are lacking in many LMICs. Inadequate investments in training and distribution of IPC practitioners remain major deficiencies in many outbreak responses, although the West Africa EVD outbreak, in which over 500 health workers were infected with Ebola virus, has placed renewed emphasis on the importance of IPC in outbreak response [50].

CONCLUSION

Although noncommunicable diseases may have over taken communicable ones as the biggest causes of global mortality and morbidity, because of their potentially explosive nature, epidemics of infectious disease remain perhaps the most major global threat. Less than two decades into the 21st century, numerous epidemics and pandemics have caused not only considerable loss of life but also billions of dollars of economic loss. Although the events have served as a wake-up call and led to the implementation of relevant policies and counter-measures, such as the Global Health Security Agenda, many questions remain, and much to be done. The challenges can be addressed, but will require significant political commitment, strategic leadership and effective health system-strengthening efforts.

The 2013 West Africa EVD outbreak fomented doubts about WHO and the United Nation System's leadership for outbreak response, prompting a host of players, and some major donors, increasingly from the private sector, to initiate independent programs for outbreak control. It remains to be seen if and how these diverse partners can be effectively coordinated when the next large outbreak or pandemic strikes, and whether WHO can retain and solidify its leadership role, regaining the world's faith, and with it the much needed resources to realize their mandate.

Ultimately, preparedness for control of large epidemics or pandemics is only a stopgap measure, implemented while creating resilient regional, national, and local health, surveillance, and response systems to ultimately stop outbreaks in their early stages, or prevent them from occurring

altogether. Success of the Global Health Security Agenda is inherently linked and dependent on longer term health systems strengthening, in which detection and response capabilities become a core part of service provision, rather than a never-ending emergency function. Policies and processes, such as the JEE, are being developed to promote this goal, but the political will, including donor commitment, must be maintained to see them broadly implemented and maintained. This will require bucking the generally fickle nature of public health financing, which often quickly dissipates once an outbreak is no longer news and the last case fades from memory. Wise policies and approaches for outbreak control exist. The question is whether we will have the wisdom and will to implement them.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

1. Bausch DG. West Africa 2013 Ebola: from virus outbreak to humanitarian
■ crisis. Curr Top Microbiol Immunol 2017; 411:63–92.

A detailed review of the underlying causes and challenges in responding to the 2013–2016 outbreak of Ebola virus disease in West Africa.

2. Bausch DG, Clougherty MM. Ebola virus: sensationalism, science, and human rights. J Infect Dis 2015; 212(Suppl 2):S79–S83.
3. World Health Organization. WHO Annual Report 2017 – Yemen. 2018. Available at: http://www.who.int/emergencies/crises/yem/yemen-annual-report-2017.pdf?ua=1 [Accessed 05 June 2018]
4. Kamradt-Scott A. WHO's to blame? The World Health Organization and the 2014 Ebola outbreak in West Africa. Third World Quarterly 2016; 37:401–418.
5. World Health Organization. WHO Mid-Term Programmatic and Financial Report for 2016–17. 2017. Available at: http://apps.who.int/gb/ebwha/pdf_files/WHA70/A70_40-en.pdf?ua=1. [Accessed March 2018]
6. Horton R. Offline: solving WHO's 'persisting weaknesses' (part 2). Lancet 2015; 385:213.
7. Clift, C. What's the World Health Organization for. London: Chatham House. 2014. Available at: http://archive.wphna.org/wp-content/uploads/2015/04/2014-05-Chatham-House-Charles-Clift-WHO-ca pacity-governance1.pdf. [Accessed 16 May 2018]
8. Jain V, Jain M. The response to global emergencies–how can the WHO re-establish itself as a leader? J Public Health Policy 2015; 36:369–371.
9. World Health Organization. Contigency fund for emergencies income and allocations. 2018. Available at: http://www.who.int/about/who_reform/emergency-capacities/contingency-fund/contribution/en/. [Accessed 28 April 2018]
10. Henry J Kaiser Family Foundation. Breaking Down the U.S Global Health Budget by Program Area. 2017. Available at: https://www.kff.org/global-health-policy/fact-sheet/breaking-down-the-u-s-global-health-budget-by-program-area/. [Accessed 28 April 2018]
11. Global Humanitarian Assistance. Private Funding - an emerging trend in international donorship. 2012. Available at: http://www.globalhumanitarianassistance.org/wp-content/uploads/2012/04/Private-funding-an-emerging-trend.pdf. [Accessed 1 February 2017]
12. Lawrence F. Health policy: extent of corporate influence revealed. 2010; Available at: https://www.theguardian.com/politics/2010/dec/09/health-policy-extent-corporate-influence. [Accessed 29 April 2018]
13. Gostin LO, Friedman EA. A retrospective and prospective analysis of the west African Ebola virus disease epidemic: robust national health systems at the foundation and an empowered WHO at the apex. Lancet 2015; 385:1902–1909.
14. Bausch DG, Edmunds J. Real-time modeling should be routinely integrated into outbreak response. 2018.
15. World Health Organization. WHO Health Emergencies Programme (WEP). 2016; Available at: http://www.who.int/health-cluster/about/structure/Emergencies_programme.pdf. [Accessed 29 April 2018]
16. Africa CDC. Africa CDC Centres for Disease Control and Prevention. 2018; Available at: https://au.int/en/africacdc. [Accessed 30 April 2018]
17. London School of Hygiene & Tropical Medicine. UK Global Health team ready to respond to disease outbreaks within 48hours. 2016; Available at: https://www.lshtm.ac.uk/newsevents/news/2016/uk_public_health_rapid_response.html. [Accessed 29 April 2018]
18. Centers for Disease Control and Prevention (CDC). Centers for Disease Control and Prevention. 2018; Available at: https://www.cdc.gov. [Accessed 20 April 2018]
19. World Health Organization. International Health Regulations. 2015; Available at: http://www.who.int/topics/international_health_regulations/en/. [Accessed 2 April 2017]
20. Katz RL, Fernandez JA, McNabb SJ. Disease surveillance, capacity building and implementation of the International Health Regulations (IHR [2005]). BMC Public Health 2010; (10 Suppl 1):S1.
21. World Health Organization. Joint External Evaluation Tool: International Health Regulations (2005). 2016; Available at: http://apps.who.int/iris/handle/10665/204368. [Accessed 2 January 2017]
22. Shoman H, Karafillakis E, Rawaf S. The link between the West African Ebola outbreak and health systems in Guinea, Liberia and Sierra Leone: a systematic review. Global Health 2017; 13:1.
23. World Health Organization. Ebola Situation Report - November 2015. 2015; Available at: http://apps.who.int/ebola/current-situation/ebola-situation-report-4-november-2015. [Accessed 28 April 2018]
24. World Health Organization. Building a global emergency workforce ready to
■ go. 2015. A description of the WHO efforts to build a global emergency workforce through a Global Foreign Medical Teams Registry. Available at: http://www.who.int/features/2015/vanuatu-emergency-response/en/. [Accessed 19 September 2016]

A description of the WHO efforts to build a global emergency workforce through a Global Foreign Medical Teams Registry.

25. Drazen JM, Kanapathipillai R, Campion EW, *et al.* Ebola and quarantine. N Engl J Med 2014; 371:2029–2030.
26. Anyangwe SC, Mtonga C. Inequities in the global health workforce: the greatest impediment to health in sub-Saharan Africa. Int J Environ Res Public Health 2007; 4:93–100.
27. World Health Organization. Factors that contributed to undetected spread of the Ebola virus and impeded rapid containment. 2015; Available at: http://www.who.int/csr/disease/ebola/one-year-report/factors/en/. [Accessed 20 September 2016]
28. Peabody JW, Taguiwalo MM, Robalino DA, Frenk J. Improving the quality of
■ care in developing countries. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, *et al.,* editors. Disease control priorities in developing countries, 2nd ed. Washington (DC): The International Bank for Reconstruction and Development/The World Bank Group; 2006.

A description of the Emerging Diseases Clinical Assessment and Response Network, established by the WHO to provide technical expertise to help set and implement standards for quality management of patients with emerging infectious diseases.

29. Walimu. Quality Indicators for Ebola Clinical Management. 2016. Available at: http://walimu.org/indicators/ebola/. [Accessed 02 January 2018]
30. World Health Organization. The WHO Emerging Diseases Clinical Assessment and Response Network (EDCARN). 2018. Available at: http://www.who.int/csr/edcarn/en/. [Accessed 22 April 2018]
31. Oshitani H, Kamigaki T, Suzuki A. Major issues and challenges of influenza pandemic preparedness in developing countries. Emerging Infect Dis 2008; 14:875–880.

32. Schull MJ, Stukel TA, Vermeulen MJ, *et al.* Surge capacity associated with restrictions on nonurgent hospital utilization and expected admissions during an influenza pandemic: lessons from the Toronto severe acute respiratory syndrome outbreak. Acad Emerg Med 2006; 13:1228–1231.

33. Ontario Ministry of Health and Long Term Care. Ontario Health Plan for an Influenza Pandemic. 2013; Available at: http://www.health.gov.on.ca/en/pro/programs/emb/pan_flu/docs/ch_06.pdf. [Accessed 05 January 2017]

34. Rutter P, Mytton O, Ellis B, Donaldson L. Access to the NHS by telephone and Internet during an influenza pandemic: an observational study. BMJ Open 2014; 4:; e004174.

35. Schultz CH, Stratton SJ. Improving hospital surge capacity: a new concept for emergency credentialing of volunteers. Ann Emerg Med 2007; 49:602–609.

36. Schultz CH, Koenig KL. State of research in high-consequence hospital surge capacity. Acad Emerg Med 2006; 13:1153–1156.

37. Kouadio KI, Clement P, Bolongei J, *et al.* Epidemiological and surveillance response to Ebola Virus Disease outbreak in Lofa County, Liberia (March-September, 2014); lessons learned. PLoS Curr 2015; 7:; pii: ecurrents.outbreaks.9681514e450dc8d19d47e1724d2553a5.

38. Machado CV, Lima LD, Andrade CL. Federal funding of health policy in Brazil: trends and challenges. Cad Saude Publica 2014; 30:187–200.

39. Welcome MO. The Nigerian healthcare system: need for integrating adequate medical intelligence and surveillance systems. J Pharm Bioallied Sci 2011; 3:470–478.

40. Ismail N. The increase to NHS budget is at the cost of preventive healthcare. 2015. Available at: http://eprints.lse.ac.uk/64864/1/__lse.ac.uk_storage_LIBRARY_Secondary_libfile_shared_repository_Content_LSE%20British%20Politics%20and%20Policy%20Blog_2015_December_Cure%20over%20prevention%20boost%20to%20NHS%20funding_2015.pdf. [Accessed 20 November 2017]

41. Steffen C, Debellut F, Gessner B, *et al.* Improving influenza surveillance in sub-Saharan Africa. Bull World Health Organ 2012; 90:301–305.

42. Bausch DG, Rojek A. West Africa 2013: re-examining Ebola. Microbiol Spectr 2016; 4:; EI10-0022-2016. doi:10.1128/microbiolspec.EI10-0022-2016.

43. Henao-Restrepo AM, Longini IM, Egger M, *et al.* Efficacy and effectiveness of an rVSV-vectored vaccine expressing Ebola surface glycoprotein: interim results from the Guinea ring vaccination cluster-randomised trial. Lancet 2015; 386:857–866.

44. Bausch DG, Sprecher A, Jeffs B, Boumandouki P. Treatment of Marburg and Ebola hemorrhagic fevers: a strategy for testing new drugs and vaccines under outbreak conditions. Antiviral Res 2008; 78:150–161.

45. United Nations. Protecting humanity from future health crises, report of the high-level panel on the global response to health crises. 2016. Available at: http://www.un.org/News/dh/infocus/HLP/2016-02-05_Final_Report_Global_Response_to_Health_Crises.pdf. [Accessed 02 January 2017]

46. World Health Organization. R&D Blueprint. 2018. A description of the WHO ■ R&D Blueprint–a global strategy and preparedness plan that allows the rapid activation of R&D activities during epidemics. Available at: http://www.who.int/blueprint/about/en/. [Accessed 30 April 2018]

A description of the WHO R&D Blueprint – a global strategy and preparedness plan that allows the rapid activation of R&D activities during epidemics.

47. World Health Organization. Zika virus vaccine product development. 2016. Available at: http://www.who.int/immunization/research/development/zika/en/. [Accessed 14 November 2016]

48. Peters DH, Garg A, Bloom G, *et al.* Poverty and access to healthcare in developing countries. Ann N Y Acad Sci 2008; 1136:161–171.

49. Shultz JM, Althouse BM, Baingana F, *et al.* Fear factor: the unseen perils of the Ebola outbreak. Bull At Sci 2016; 72:304–310.

50. Centers for Disease Control and Prevention (CDC). Infection Prevention and Control for Ebola in Healthcare Settings - West Africa and United States. 2016; Available at: https://www.cdc.gov/mmwr/volumes/65/su/su6503a8.htm. [Accessed 30 April 2018]