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Applying Historical Responses to Infectious Disease for Future Disease Control

Christiana R Dallas and Curtis H Harris

Institute for Disaster Management, College of Public Health, University of Georgia, United States of America

Corresponding author: Christiana R Dallas, Institute for Disaster Management, College of Public Health, University of Georgia, United States of America, Tel: 34976553790; E-mail: crd83038@uga.edu

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Abstract

The control of infectious disease has been a concern of human populations throughout the record of human history. The more recent historical events of severe acute respiratory syndrome- coronavirus (SARS) and the Ebola Virus Disease (EVD) highlighted the need for public health efforts which could effectively control the spread of infectious disease in the increasingly globalized contemporary environment. To prevent future epidemics of this kind, more effective disease controls must be identified and included in future preparedness efforts. The SARS and EVD epidemics not only accentuated the weaknesses of public health response, but also resulted in the discovery of interventions with promise in providing benefit to future infectious disease responses. Specifically discussed here are two forms of intervention: Global Disease Surveillance and Isolation and Quarantine. Using quarantine without isolation and vice versa may do more harm than good. Response in the future to events like the SARS and EVD outbreaks should not consist of only using these individual disease controls as solitary tools, but together as a cohesive system, also utilizing local expertise. Quarantine and isolation can be beneficial to both the individual and the community when properly implemented. Utilizing local cooperation in quarantine, isolation, and surveillance is imperative to any successful response. Understanding how these relationships work in concert will aid in the future better implementation of these disease control measures.

Keywords: Infectious diseases; Quarantine; Tuberculosis

Introduction

The control of infectious disease has been a concern of human populations throughout the record of human history. The more recent historical events of severe acute respiratory syndrome- coronavirus (SARS) and the Ebola Virus Disease (EVD) highlighted the need for public health efforts which could effectively control the spread of infectious disease in the increasingly globalized contemporary environment. To prevent

future epidemics of this kind, more effective disease controls must be identified and included in future preparedness efforts. The SARS and EVD epidemics not only accentuated the weaknesses of public health response, but also resulted in the discovery of interventions with promise in providing benefit to future infectious disease responses. Specifically discussed here are two forms of intervention: global disease surveillance and isolation and quarantine.

Global Disease Surveillance

Challenges of global disease surveillance

Global disease surveillance is an information-based activity involving the collection, analysis, and interpretation of large volumes of data originating from a variety of global sources. The information collected is then used to evaluate the effectiveness of control and preventative health measures on a global scale. While the modern scientific movement has given us many forms of effective disease surveillance, a complete, and efficient, system of those methods has yet to be conglomerated and utilized on the large scale [1]. The call for better surveillance systems has been made repeatedly in the past decade, but there has been too little effective change on the ground [2]. As the response to EVD and other subsequent responses have reported, instances of actual change resulting from the SARS epidemic regarding disease surveillance have been few and far between [3]. SARS highlighted innovative surveillance methods, the need for change was voiced and recognized, but the momentum behind reform lost traction quickly after the epidemic was brought under control [4].

Any response to an infectious disease outbreak, and especially a coordinated international effort, is contingent not just on the presence of functional national surveillance systems but also on the rapid information sharing between countries and international agencies. The revolution in information and communications technology that has occurred over the past 20 to 30 years has removed virtually all technological barriers to this process, even in remote, resource-poor settings. Moreover, as the responses to SARS and EVD illustrate, it is now routine to integrate and analyze data from multiple sources, such as public health, demographics, location (for example, with global positioning

system), movement, animal distribution, remote sensing, and genome sequence data [2].

Greaves et al. argue that the ideal surveillance system for infectious disease would be, among other things, accurate, timely, continuous, electronic, and easily used in follow-up monitoring of cases and contacts of the exposed [5].

Solution: Information and communications technology

In regards to infectious disease, information and communications technology (ICT) is the modern system of technology which inherently has the ability to strengthen interoperability and communications on a broad scale in the event of a disaster. If properly organized and managed, information and communications technologies such as cell phones, computers, and databases of information could be utilized to create a system which has the capacity to strengthen the workforce, enhance real-time data surveillance, expedite case management, improve community engagement, and facilitate the improvement of infection prevention and control. The idea behind the use of ICT in infectious disease control is to encourage cooperation and involvement on all levels of government, from the local level to the international level [3]. Effective ICT systems have most commonly been created by public health officials, and managed by both health officials and local government bodies [3]. Mobile phones are one very common form of ICT, and if combined with GPS technology and information databases are a very effective public health tool that can be utilized across the globe [6]. In Africa alone there are an estimated 1 billion mobile phones, or more than one per person on the continent. During the recent EVD outbreak, mobile health tracking applications (apps) for mobile phones, also known as “mHealth apps”, combined GPS capabilities, information databases, and social networks into one tool which anyone with a mobile phone could utilize to report new or suspect cases of EVD [7]. mHealth apps were credited by Nigerian health officials as a primary player in the swift containment and eradication of the EVD outbreak in Nigeria. Nigeria, a much more populous country than Sierra Leone, Liberia and Guinea, contained and eradicated the outbreak much faster and with far fewer cases and fatalities than these neighboring nations. Nigeria had only 19 cases in total, with 7 of those fatal for the entirety of the outbreak, which is a noteworthy difference from the other countries’ thousands of cases [8]. Nigerian health workers applied the usage of ICT through utilizing mobile phones loaded with mHealth apps soon after the first cases were recorded. This led to a significant reduction in the reporting time of EVD cases from 12 hours to 6 hours, and eventually mHealth was able to track reports made in real time. This use of ICT enabled health workers to both visit individuals suspected of being exposed to the virus, and to map these visits in GPS coordinates. Data from the Ebola Emergency Operation Centre in Lagos showed that more than 800 people were traced from known EVD cases, and roughly 18,500 houses and workplaces were visited during the EVD campaign.

The case for ICT was not solely made in Nigeria during the EVD outbreak. The United States Agency for International Development's (USAID) Africa Bureau also reported the use of ICT in the form of cell phones and information databases in its response to the EVD outbreak in Liberia and West Africa. Its use was credited for eventual containment and prevention of the exacerbated spread of the disease [9].

The World Health Organization (WHO) has since spoken out regarding EVD and the use of ICT, highlighting the need for better utilization of this tool in the event of infectious disease outbreaks. WHO speaks of ICT’s use not only in Africa, but worldwide [10].

As Greaves et al. mentioned, effective containment of any disease outbreak relies on timeliness, which ICT has the ability to provide. This is true regarding early detection and rapid response, both of which are critical to successful control, as well as prompt and effective coordination and communication across various interventions. The truth of this theory was seen in practice during the EVD outbreak of 2014. The early discovery of new EVD cases and promptness in response was quickly recognized as imperative to empower the response team members with technologies and solutions which would enable smooth and rapid data flow. Thus, while implemented minimally, the use of ICT in active surveillance proved itself effective when used in the response to EVD. Remarkable improvement was recorded in the reporting of daily follow-up of contacts in the event of the integrated real time technology’s deployment. In the spirit of timeliness, turnaround time was also a serious issue. The time required for the identification of symptomatic contacts, evacuation to isolation facilities, and receipt of laboratory results were all reduced with the ICT system. This time reduction allowed for quicker and better informed decisions to be taken by all concerned. Further, accountability in contact tracing was ensured by the use of a Global Positioning System (GPS) enabled device. The use of innovative technologies in the response of the EVD outbreak in Nigeria contributed significantly to the prompt control of the outbreak and containment of the disease by providing a valuable platform for early warning and guiding early actions [9].

Solution: Local involvement

Local involvement in infectious disease surveillance: Federal and international disaster response resources are stretched very thin on a daily basis: this fact has alarmed enough scholars for many of them to warn that “federalizing” disasters is a hazardous practice. Scholars such as Matt Mayer et al. argue that local and state governments have come to rely on the federal government in the event of disaster so much that they divert their preparedness funds to other areas in need. This creates a dangerous lack of preparedness and therefore high vulnerability on the very level at which the disaster will occur: locally [11]. An infectious disease epidemic’s source is always a specific local area. Identifying that area and knowledgeable individuals in that area is critical to quickly and effectively mitigating the further spread of disease.

Local expertise and community support: Concentrating on shipping people in and out of disease-ridden areas overlooks the wealth and potential of local expertise in disaster response. Instead of endlessly rotating personnel and spending useful logistical resources to do so, investing in local expertise is critical for a local element's independent long term recovery [12] and community resilience. Since disaster management is a cycle, with resiliency as its foundation, the elements of the community already in place which lend to recovery, adaptation, and future preparedness should be considered. Local expertise is necessary for understanding the actual resilience of the community, and thus its' chances of recovery in the absence of outside support in the event of similar disasters in the future [13].

The International City/County Management Association (ICMA) recognizes the value of local expertise in recovery. This Association aids in all-hazards disaster mitigation and preparedness for vulnerable communities. It assists in recovery and restoration of basic municipal services after initial response efforts have stabilized the areas. ICMA not only draws from the experience and knowledge base of practitioners, but also utilizes an extensive network of well-qualified local practitioners and experienced international consultants. ICMA emphasizes sustainability, capacity-building, and institutional strengthening to help communities become more disaster-resistant. ICMA consults, trains, and collaborates with local government leaders in the U.S. and around the world to establish sound, innovative management and leadership practices. Partnerships are created with federal agencies, foundations, other international donors, universities, and private-sector organizations to provide research, resources, training, and technical assistance across a wide range of areas of expertise [14]. Thus, local perspectives are intertwined with the resources, knowledge and experience of the international entity, creating a much more effective recipe for long-term mitigation.

In Liberia, during the 2014 EVD outbreak, the influence of the local government was utilized nation-wide by the international response teams. This cooperation between local and international spheres aided in the realization of contact tracing and surveillance methods which ensured the containment and effective mitigation of the initial outbreak [15]. Sadly, this cooperation between local officials and outside aid was not enough to combat EVD forever. Community resistance to necessary protocols enforced by outside entities has historically been detrimental to the efficacy of public health interventions [16]. The fear and stigma that occurred during the EVD outbreak of 2014-2016, combined with a distrust of outside aid caused a severe lack of cooperation, and even violence to occur between the local population and global public health professionals. This lack of support from the local populace is hypothesized to have been the root cause behind Liberia's three consecutive outbreaks after the initial outbreak was controlled [16]. The subsequent outbreaks were tied to instances of hiding the bodies of victims of EVD from cremators, and an unwillingness of locals to visit hospitals. This was due to fear of stigma and two commonly held beliefs: first, that EVD was either a myth or conspiracy by the government,

and second that the hospitals were the source of the infection [17].

Unfortunately, distrust in Liberia did not end only in a lack of cooperation, but also violence. The range of violence included incidents of rocks being thrown at Red Cross vehicles, and the much more serious case of the massacre in Womey, Guinea, resulting in 8 deaths [18]. The massacre occurred after an "Ebola Health Team" from the international non-profit Search for Common Ground organization entered the village of Womey. Due to the common belief in this village that EVD was "nothing more than an invention of white people to kill black people" [19], 8 of the 9 members of the team were brutally murdered with clubs and machetes, the lone 20 survivor escaping to tell the story [20].

While most of the nation rejected cooperation, the Mawah Village stood out as an example of effective public health disease containment in Liberia. This community quarantined itself by utilizing household quarantine to stay the spread of infection. While the Mawah Village was a singularity in Liberia, community initiated containment was also practiced in Eastern Sierra Leone. Villages in the Nimiyama Chiefdom of Sierra Leone instituted their own isolation techniques, with each household devising a strategy on how to deal with infected family members. Further, people in these areas used available materials such as plastic bags for makeshift, but often ineffective, protection [12]. A likely element to the success of these interventions was the involvement of village leadership in the EVD response. An active surveillance approach and well-informed population are also credited for the success of this household quarantine. The Nimiyama chiefdom established its own "Ebola Taskforce", where village leaders and representatives of civil society groups proposed and discussed solutions to the current situation. Aiming to mobilize all community members, this Ebola Taskforce embodied local, collective ownership in the fight against the disease [12].

Cooperation between the local population and the intervening entity is imperative to successful disease surveillance and containment. Distrust of government and public health response entities is prevalent across the globe. If distrust exists, involving locals in the foundational strategy for disease containment measures could aid in combating suspicion and engendering trust, cooperation, and ultimately a much more effective response [21]. Especially in the event of an international response to infectious disease, miscommunication and a lack of cultural understanding can have severely negative impacts on efficiently containing the disease. The 2013 EVD outbreak in Liberia rendered an infamous case on this subject [22].

The burning of bodies is taboo in Liberia. The international public health response protocol for those who fell victim to EVD was to burn the bodies. This protocol led to shunning of local Liberians tasked with incinerating the bodies [23]. The Liberian Government recruited local Liberians with the promise of wages at 250 dollars a week. Due to Liberia's high level of poverty, 30 men signed up for the job despite the cultural taboo. These men were, one by one, rejected by their families and villages and put out of their homes by landlords.

Interviews with these men reveal that they assumed their fellow countrymen would see them as heroes once the EVD epidemic was controlled, partially due to their efforts. Regardless, there are no reports of these men being accepted back into society, but rather turning to drugs and alcohol to assuage the pain of their sacrifice [23]. This deviance between the cultures of Liberia and those contributing from foreign aid further led to a general lack of cooperation from locals who held public health officials suspect. There were even theories held by many Liberian communities which proposed that the EVD outbreak was a staged event by the elite meant to allow greater control of those of lower socioeconomic status [15]. Surveillance interventions, specifically contact tracing, is much easier if local trust has been established. This has been recognized by the WHO, which established in its Response Programme that local surveillance and appropriate community health workers or staff should be utilized in the “follow-up” portion of contact tracing. While local resistance has been observed in the past, this has not always been the case: the key to successful disease surveillance in a disaster is local involvement. In 2002, Georgia Annas wrote about local involvement with public health concerning bioterrorism. While the academic consensus held that locals were likely to not cooperate with public health efforts in an emergency, history records that locals and first responders have been very cooperative in helping higher level authorities respond to emergencies [24].

Isolation and Quarantine

Challenges of isolation and quarantine

The words “isolation” and “quarantine” are often used interchangeably. This mistake occurs not only in common society but, regrettably, is easily found in scholarly works [25]. The misunderstanding of this definition is important due to the serious nature of any event requiring the use of either intervention. Isolation separates the diagnosed from the healthy, while quarantine separates the undiagnosed from the healthy [26]. Many protests to the use of quarantine during the EVD outbreak argued that quarantine was being misused when undiagnosed and asymptomatic individuals were separated from their friends and family [27]. This kind of rhetoric, especially in the media, not only misleads the general public, but can also cause unwarranted distrust of public health and government officials. For instance, Kaci Hickox, a nurse for Doctors without Borders, received a mandatory quarantine order upon her arrival in New Jersey after her humanitarian efforts treating EVD patients in Sierra Leone. Hickox refused to follow this order, not only appearing in public but travelling in public transportation across state lines to Maine which has more lenient quarantine laws [28]. U.S. public health officials reported signs of fever upon her arrival, but Ms. Hickox refuted those claims: in the end she was never diagnosed with the virus [29]. Her exposure and interaction with EVD patients induced the U.S. government to take the precaution of attempting to quarantine Ms. Hickox to protect the public from any possible infection, and to ensure any initial

signs or symptoms of EVD could be detected and treated as soon as possible. Many newspaper articles and scholarly works were written about the “unfair” quarantine, with harsh judgements against the “paranoia” of the government and public health officials attempting to implement it [30,31]. If quarantine were properly understood, however, many of these arguments would lose their virility. Ms. Hickox had been repeatedly exposed to EVD, and was to be separated by New Jersey health officials from the healthy population until the 21-day incubation period passed [28]. Most of the arguments against her quarantine were based on the fact that she claimed to be feeling healthy, and ultimately was never diagnosed [29]. This argument would only stand against the action of isolation, since quarantine is for the undiagnosed [32].

It is imperative that the public be properly educated on the matter so that individuals can respond constructively to any threats to their health. Often these measures are seen as sacrifices of the individual to benefit the group [33]. However, when properly implemented, quarantine and isolation are also beneficial to the individual, which a proper understanding of these efforts will reveal [34].

Solutions: Isolation

Isolation restricts the movement of persons who have been positively diagnosed with a disease and separates them from the healthy to control the spread of a disease [35]. The SARS outbreak in Toronto is a prime example of the importance of isolation to contain infectious disease. In most cases, SARS transmission was driven by exposure to infected individuals [36]. This outbreak began with the index case for the Toronto outbreak being placed in a general observation area, not in isolation even after his severe respiratory symptoms were made known [37]. Once he was tentatively diagnosed with Tuberculosis, he was isolated, but 18 hours had already passed, with the index case contacting numerous other hospital personnel and patients. As with the index patient, transmissions in Toronto occurred primarily within health care settings or in circumstances where close contact occurred. Ultimately, the containment of SARS in Toronto and the restoration of safe conditions for hospital staff and patients was not achievable until strict adherence to precautions and regulation regarding isolation was correctly implemented [38].

Isolation was also imperative to the success of the mitigation of the EVD outbreak in 2014. EVD is spread through contact with bodily fluids from the infected individuals, or contact with objects contaminated with such bodily fluid [39,40]. An example of an effective isolation strategy was the Rapid Isolation and Treatment of Ebola (RITE) in response to the epidemic in Liberia [41]. RITE targeted remote areas, proactively coordinating with the Liberian Ministry of Health and Social Welfare (LMHSW) to respond as quickly and effectively as possible to the EVD outbreak in the area. RITE was so successful that it was subsequently used in Sierra Leone and Guinea for their battle with EVD [42].

RITE was developed bilaterally by the U.S. Centers for Disease Control and Prevention (CDC) and the LMHSW. The

strategy utilized “boots-on-the-ground” response teams in the form of “RITE teams”. These teams investigated and maintained a response-ready status, poised to deploy to remote areas as soon as a report of a suspected EVD case was received [43]. RITE teams would take the lead in coordinating the assistance from the LMHSW and international partners, such as the CDC, to plan, manage, and track the response efforts. The main focus of these teams was to rapidly isolate and treat EVD patients, either by establishing facilities in the community or safely transporting patients to existing Ebola Treatment Units (ETUs). Statistics gathered after the EVD outbreak was officially declared to be controlled in 2016 spoke of the efficacy of this isolation technique. Compared to six outbreaks in Liberia that began before RITE was implemented, six outbreaks after RITE lasted less than half as long. Furthermore, the later six had a lower death rate and shorter chains of transmission, all while nearly three times as many EVD patients were recorded to have entered isolation and received treatment [43].

Solutions: Quarantine

Quarantine is the separation and/or restriction of movement of persons who are not ill but, because of recent exposure, are suspected to be carrying an infection [38]. The use of quarantine has been reported as particularly successful in the case of SARS. Hsieh et al. even propose in their retrospective modelling study that quarantine can be credited with reducing both the case number and number of deaths from SARS by half in Taiwan [44]. This is a common theme in after-action reports for SARS response efforts. Due to the nature of the virus being communicable from person to person, limiting that contact was found to be a particularly effective tactic.

When considering the future of quarantine, especially regarding social resistance, a shift in cultural acceptance of quarantine is needed. At this time, quarantine is seen as solely an infringement upon the rights of citizens. However, if this focus could be moved to be realized as a social duty like, jury duty, then wider acceptance might be more readily found [45]. Therefore, rebranding of the term “quarantine” is imperative to the practices’ successful implementation in the future. Branding is recognized by public health officials as a highly influential element in the success or failure of an intervention [46]. Quarantine today is seen as largely negative in the public perception. It is imperative to rebrand the term to support the beneficial elements of quarantine, and remove the negative stigma that surrounds the method. Public health agencies should aim to improve the experience and help shift perceptions of quarantine from punishment to social responsibility [33]. Efforts, such as working to make quarantine seem as a beneficial social limitation to the community as opposed to frightening totalitarianism [47] could aid in this rebranding. The idea of making quarantine more agreeable to society and less like imprisonment has been taken into account by many states in the United States. Katz et al. suggest that a government should institute quarantine in a manner that is respectful to its population. They further suggest that quarantine be rebranded as a social responsibility in a way

which eases the process of trading civil liberties for the security of the community. Methods of doing this include not only new regulations and laws, but more importantly focuses on changing public perception through use of monetary support or compensation during or after the period of quarantine, along with proper education as to how quarantine benefits that individual and the community [45]. For instance, a person placed in quarantine might be compensated for lost salary, and the reward of their sacrifice explained in how their friends and family are kept safe from any possible disease he or she might have. Further, under the surveillance of quarantine, any signs or symptoms of the disease in the quarantined individual will be noticed and thus treated earlier than if that person were to continue with their life as usual [33].

When considering the EVD outbreak in 2013, it is important to note that other interventions besides quarantine such as contact tracing, experimental pharmaceutical interventions, and improved infection control practices were all attempted to no avail in Sierra Leone and Liberia [48]. However, once quarantine was added to the suite of treatments the outbreak began its downward trend.

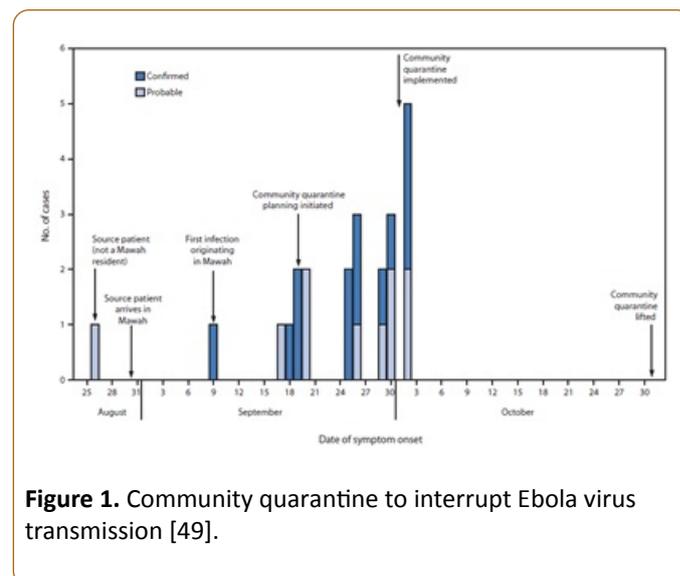


Figure 1. Community quarantine to interrupt Ebola virus transmission [49].

This could, of course, be attributed to the natural history of the disease. Considering the relatively extreme case of the Mawah Village in Liberia is helpful for shining light on the situation. The Mawah Village utilized community quarantine, or complete separation of the community from outside communities [49]. Upon viewing **Figure 1**, we can see that as soon as Source quarantine was implemented, the rate of infection had an astonishing drop. This epidemiological curve showing a severe downward trend after the introduction of quarantine is hard to argue as pure chance.

Solution: Effective combination

A combination of isolation and quarantine is credited by many for the swift containment of the SARS outbreak. Conversely, there were many recorded instances of quarantine and isolation being used improperly in the response to EVD,

which led many to believe that the practices themselves were ineffective. Upon consideration of the available resulting data, it can be argued that it was the execution that handicapped the mitigation, not the tool. Leaders must recognize that if applied inappropriately, actions of isolation and quarantine themselves may cause harm to both individuals and society [50].

First, isolation and quarantine must always be used together, and used properly. Disease transmission may increase in the quarantined population if symptomatic persons are not isolated immediately upon the early recognition of symptoms [51]. EVD and SARS were both only contagious after the onset of symptoms: however, looking forward, the question of what can be done with asymptomatic but simultaneously contagious individuals remains. If persons with clear evidence of infection are placed in cohorts together with persons with no evidence of infection, increased transmission may result. Furthermore, discriminating between people with the disease of interest and individuals with similar symptoms is incredibly difficult. When considering a disease with flu-like symptoms, such as EVD or SARS, a significant portion of non-infected individual may be introduced to the disease if placed in isolation with truly infected individuals [50].

Many scholars discuss the necessity of containing a disease at the source in order to mitigate its spread. They argue that this should be the focus of disease response, not quarantine or isolation [30]. It is important to focus on controlling the source, yet these arguments overlook the fact that quarantine and isolation techniques, especially whole community quarantine, have been recorded as being particularly successful at controlling outbreaks [50]. Further, each infected individual has the ability to become the source of a new outbreak. Therefore, utilizing quarantine and isolation at the source may be the most effective way to contain the disease at the source.

Dr. Drazen et al. argue that aid workers returning from administering foreign aid to countries with EVD should not be quarantined [50]. Rather, these scholars argue that these aid workers should be trusted to self-quarantine and report themselves to the proper authorities in the event of symptom onset. The main reasoning behind this suggestion is a fear of the harmful effects of stigma. During the EVD outbreak, a great deal of negative stigma surrounded anyone who had been in any form of contact with the virus [31]. One particularly sad example of this is the case of Salome Karwah. Salome survived two civil wars in Liberia and the EVD outbreak in her nation, and was never even diagnosed with EVD [51]. She was a voluntary aid worker who was recognized as a person of the year by Times in 2014 [52]. While the international realm recognized her a hero, the severe discrimination in her community forced her to move several times. The fear of EVD was so severe that upon complications with her pregnancy, she died after being refused aid [52].

While isolation is a more stringent structure, the concept of quarantine should not be seen as a strictly structured system, but rather as a flexible tool that is tailored to match the disease for which it is used [53]. Drazen et al. suggest in their

essay that quarantining aid workers only encourages the stigma that these people are to be feared, when in fact they should be celebrated for their charity, hard work, and sacrifice [30]. Of course, aid workers should be properly honored for their work and public health practices should reflect that. However, the social acceptance of aid workers is not the main responsibility of public health protocol. The health of the public is the focus, and while the mental and social health of aid workers is important, the primary focus in this instance must be on protection of the public from infectious disease [54]. Further, there is fallacy in assuming that self-quarantine is a reliable form of disease control. EVD is not contagious until symptomatic. However, this is not true for all infectious diseases. This is where tailoring of quarantine must come into play. Human Immunodeficiency Virus (HIV) [55], Chlamydia [56], Epstein-Bar Virus (EBV) [57] and even some forms of Middle East Respiratory Virus (MERS) [58] are all examples of infectious disease that notoriously show delayed and even no sign of disease in many infected individuals. Voluntary quarantine or voluntary isolation would have little benefit for infection control in the case of an outbreak of any one of these diseases. Public Health officials must consider that quarantine for these types of diseases will be more difficult to implement than those which are only infectious upon symptom onset. Thus far, when observing existing policy for quarantine, it is focused on "worst case scenario". Taking care to alter these policies to match the disease can greatly aid in encouraging public adherence and support in the implementation of quarantine.

The proper education of the public would be a wise effort on the part of public health leaders. Not only does this fight stigma and encourage respect of the sacrifices of those undergoing quarantine for the good of the community, but further supports public health through knowledge. If people understand the disease, how it is spread, how to prevent infection, and why certain protocols need to be followed, they will be much more likely to comply with the necessary steps towards mitigation [59]. It is imperative that this education is complete and understands the realities of long term recovery. This was not the case in the Liberia EVD outbreak. Most public education messages neglected the community's capabilities or lack thereof to recover [60-62]. These messages were more notifications of the EVD outbreak and less of education on how people could protect themselves without a functioning healthcare system [22]. Efforts to ensure we do not repeat this unfortunate history could save much time, resources, and most importantly, lives in future disease outbreaks.

Conclusion

Recorded history dictates that global disease surveillance, quarantine and isolation have aided in creating a more effective response to infectious disease outbreaks. Response in the future to these kinds of events should not consist of only using these individual disease controls as solitary tools, but together as a cohesive system utilizing local expertise.

Regarding quarantine and isolation, using one without the other often does more harm than good. This can be true of

many disease controls. Despite common misconception, quarantine and isolation can be beneficial to both the individual and the community when properly implemented. Others disease controls, such as contact tracing, are better used alone than not at all, but can create confusion and chaos if not used as part of the larger system. Overall, if any of these methods are utilized with others in an organized system, they will be much more effective.

Local involvement is imperative to a successful response. Utilizing local cooperation in quarantine, isolation, and surveillance is imperative to its success. If the individuals in need of help are cooperating in an official capacity, providing what they need will be a much simpler process. Local cooperation with implementing commonly unpopular interventions such as quarantine or contact tracing has, in the past, been conducive to more successful implementation. In the case of quarantine and isolation, as a rule local citizens trust local authorities more than outside aid, lending to greater adherence. Likewise regarding disease surveillance, especially contact tracing, using familiar, trusted faces to make inquiries into people's personal lives and connections is imperative to success.

Properly implemented disease surveillance is vital to public health decision making, especially when considering community quarantine. Knowing which areas are in such dire straits as to require quarantine, and when such measures should be applied are imperative to disease control and the public's trust of the aid they are receiving. If the wrong community is quarantined, or if a community is not quarantined when it should be, efforts to contain the disease will suffer. Again, this is when having community cooperation is so vital.

All of these elements have roles within or in support of the other. Understanding how these relationships work in concert will aid in the future better implementation of these disease control measures.

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