Key Strategies to Address Emerging and Reemerging Infectious Diseases: A Systematic Analysis

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Research article

Keywords: emerging infectious diseases (EID), strategies, points of intervention, effective EID preparedness and response framework

Posted Date: September 24th, 2019

DOI: <https://doi.org/10.21203/rs.2.14861/v1>

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Abstract

Background: Given their unpredictable nature, their direct impact on human health, as well as their wider environmental, economic, and societal impacts, emerging and reemerging infectious diseases (EIDs) require ongoing and sustained attention, funding, and response from the global community. The purpose of this paper is to understand the institutional capacities necessary to effectively respond to EIDs and highlight key strategies and potential points of intervention.

Methods: We undertook a systematic analysis of the existing literature to understand what an effective preparedness and response framework for EIDs would look like. Using the Lancet Infectious Disease Journal and PubMed, we selected all relevant results that described possible epidemic preparedness interventions or EID prevention and control strategies. We included any results published in English and within the last ten years. The different interventions and/or prevention and control strategies were grouped together into larger categories to develop an effective preparedness and response framework for EIDs.

Results: An ideal emerging disease preparedness and response environment should center on collaboration between all impacted sectors and a fiscal and social commitment to strengthen the capacity on all levels of the country to respond to threats as they emerge. The potentially impacted sectors are numerous, but many that have been traditionally excluded from disease preparedness activities.

Conclusions: When considering how best to participate in emerging disease response activities, it is important to identify these critical points and how interventions might work to strengthen the system in entirety. While these breakdown points are common across many settings, it is imperative that the preparedness and response activities be contextualized to specifics of the disease and setting.

Introduction

Emerging and reemerging infectious diseases (EID) have an important role in the modern world and leave long-lasting legacies. There is a long history of EIDs in humans, and they have varied greatly in type, transmission method, fatality rate, and cost. Most EIDs are zoonotic, meaning they originated in wildlife (typically in mammals), and have found their way into the human population. 70% of the 300 emerging infectious disease events between 1940 and 2004 were zoonotic in nature.[1] Furthermore, it is estimated that 25–44% of all zoonotic events have been due to viruses.[1] Viruses are particularly challenging due to their wide diversity and tendency to genetically mutate—making EID response strategies moving targets. The costs associated with EIDs are numerous and can be enumerated in many ways: in terms of lives lost (both among healthcare workers and the general population), the financial cost of response, social costs, and higher economic costs. The costs are both direct in the short-term and indirect over the long-term. The global cost of the 2003 outbreak of severe acute respiratory syndrome (SARS) is estimated to be between US\$13 billion and US\$50 billion.[2] More recently, the Centers for Disease

Control (CDC) reports that the Ebola virus outbreak response in West Africa of 2014 cost roughly US\$3.6 billion in total.[3] It is difficult to ascertain the true financial revenue lost as a result of an infectious disease outbreak, but history demonstrates that disease results in reductions in tourism, livestock value, exports, food production, and beyond.[4] EIDs also have devastating effects on health systems, resulting in reductions in preventive care due to reprioritization of resources toward outbreak response, declines in vaccination rates, loss of trained health care workforce members, and the additional burden of providing long-term care to survivors with chronic symptoms.[4]

Due to the inherent uncertainty in predicting the next infectious disease to emerge, the global community has shifted its focus and prediction efforts away from the general question of *why is this disease emerging?* to the question, *why is this disease emerging at this time in this location?* Four domains have been identified as central to estimating EID threats: 1) genetic and biological factors of pathogens and hosts; 2) physical and environmental factors; 3) ecological factors; and 4) social, political, and economic factors.[5] First, the nature of the infectious agent and the source from where it emerges are important. This domain is difficult to ascertain due to the need for disease identification and more detailed biologic understandings. There are programs actively working on testing large populations of wildlife for the presence of pathogens. Second, the physical environment, in particular weather and climate patterns, is seasonal and subject to change as a result of global climate change. This has led to recent expansion and movement in disease vector range. Third, the ecological factors in a setting, (i.e., land-use make-up, presence of large agricultural operations, and deforestation) are resulting in species movement and increased human-animal interactions. Finally, numerous social, political, and economic factors impact how humans interact with animals, the source of proteins, and sanitation availability. It is important to incorporate each of these factors when trying to predict the location of the next emerging disease. Some researchers believe that the reasons behind disease emergence should be disaggregated and described in more specific terms as “drivers” of disease.[6,7] Such drivers of disease include microbial adaptation and change, human susceptibility to infection, climate and weather, changing ecosystems, human demographics and behavior, economic development and land use, international travel and commerce, technology and industry, breakdown of public health measures, poverty and social inequality, war and famine, lack of political will, and intent to harm. Most of the disease outbreaks of international concern can be attributed to a single driver—lack of public health infrastructure. This has been amply evident from the Ebola outbreak in some of the Western African countries during this decade. EID prediction capabilities have improved drastically in recent years and are now monitoring additional “drivers” of disease emergence. However, there remains a challenge of establishing real-time data collection and processing at the ground level in most countries.

While there are numerous disease prediction programs and methods in use globally, there have been regions with significant histories of disease emergence that are under increased scrutiny to ensure continued political commitments and capacity building on many levels. It is important to exhaust all potential avenues to understand, predict, and respond to emerging infections. Furthermore, strategic development efforts can target specific drivers of disease emergence (i.e., public health infrastructure) through surveillance and system strengthening activities to ensure efficient and effective use of monies.

There is an opportunity to learn from past outbreaks and work to develop an inclusive preparedness network with the ability to tweak and respond to any potential threat to arise. While emerging diseases are each unique, there are some control efforts, namely communication/collaboration and preparedness steps that are universal. The universality of some preparedness activities has already been acknowledged by international agencies that have worked to strengthen the International Health Regulations (2005) to respond to emerging disease threats.[8] Furthermore, some countries have made significant progress towards the achievement of the International Health Regulations and the establishment of strong disease surveillance and response plans. There is still an immense opportunity to assess capacities, develop policies, and plans to fill gaps and improve the operational quality of these systems around the world. Given their unpredictable nature, their direct impact on human health, as well as their wider environmental, economic, and societal impacts, EIDs require ongoing and sustained attention, funding, and response from the global community. The purpose of this paper is to understand the institutional capacities necessary to effectively respond to EIDs and highlight key strategies and potential points of intervention. We undertook a review of the literature to understand what an effective preparedness and response framework for EIDs would look like.

Methods

We undertook a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[42]

Search Eligibility and Criteria

The search was conducted through the two databases, PubMed and The Lancet Infectious Disease Journal. The search was limited to all resources published in English and within the last ten years from August 1, 2009, to August 1, 2019. Article types accepted in the search included systematic reviews, review, observational studies, meta-analysis, journal article, editorial, comparative study, comment, case report, case study, and correspondences. We applied the Boolean research method. For consistency, we employed the same set of search terms on all databases. The search terms or phrases used were [emerging infectious disease" OR "EID response framework" AND "epidemic response" AND "interventions" OR "prevention and control strategies" OR "epidemic preparedness"]. Only studies discussing possible epidemic preparedness interventions and/or EID prevention and control strategies using a case or country context were included. The search protocol for this review is provided as supporting information (*Additional File 1*).

Data Collection & Synthesis

A total of 264 records were identified using the two databases and the search criteria (Figure 1). Of these 264 results, only 46 of the results had titles/abstracts that matched the search criteria. After a full-text analysis of the 46 results, 16 were excluded for not fitting the search criteria. Finally, 30 studies were included in this systematic review. The studies were reviewed, and a list of EID preparedness interventions and prevention and control strategies were developed. Individually, the studies were assessed for risk of bias. Any studies considered biased will be excluded from the review.

Results

The data shows that an ideal EID preparedness and response plan must incorporate interventions and strategies over a variety of categories (*Figure 2*). Considering that this literature review only included possible epidemic preparedness interventions and/or EID prevention and control strategies using a case or country context, the included studies were found to present no risk of bias. The data highlights that an ideal emerging disease preparedness and response environment should center on collaboration between all impacted sectors and a fiscal and social commitment to strengthen the capacity on all levels of the country to respond to threats as they emerge. A truly comprehensive EID response system requires system-wide coordination, ongoing surveillance systems throughout the world, strengthening healthcare resources (personnel, medications, facilities, etc.), social, behavior, and change interventions, and the integration of appropriate diagnostics into prevention and control plans [14, 15, 18]. Ten different results (33.3%) stressed the importance of tailored EID surveillance strategy that would prevent and mitigate EID outbreaks [11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. Strengthening the collaboration between multiple stakeholders to improve existing healthcare systems and encourage the sharing of resources to improve EID response and help mitigate the damage was outlined in 12 results. Social, behavior, and change interventions (including educational interventions for the public) and the integration of appropriate diagnostics into prevention and control plans were highlighted as significant factors to an ideal EID preparedness and response plan in 20 studies. The potentially impacted sectors are numerous, but many that have been traditionally excluded from disease preparedness activities (*Figure 3*). The multi-sectoral approach is further expanded upon in the One Health framework [9] and highlight the importance of the interconnectivity between numerous sectors integral to disease response [28, 13, 16]. The fact that we do not know with any certainty where, when, and how a disease will emerge is the critical challenge. Funding for prevention and mitigation efforts are limited due to the lack of obvious return on investment and the uncertainty associated with emerging diseases. Due to globalization and travel patterns around the world, EIDs are a legitimate threat for all people of the world, even those not identified as hot-spots of disease emergence. The poverty burden in many EID hot-spot countries puts them at an additional disadvantage—the system and infrastructure are not adequate to respond to a novel infectious disease.

Both the Ebola and Zika virus outbreak instances demonstrate the significant long-term health impacts that can result from a little-understood pathogen. While there have been more outbreaks of Ebola in history than Zika, the natural host of the virus is yet to be fully ascertained. Similarly, studies amongst survivors of Ebola in West Africa are showing residual viral presence in bodily fluids for up to 12 months after recovery.[10] These knowledge gaps make a comprehensive response difficult, and there are no

curative medications or widely-applied vaccinations available. The case of Zika is even less clear. Health agencies continue to update recommendations due to the changing understanding of the virus. The temporality of infectious diseases results in extreme highs in interest (during the large outbreak) and significant drops in interest (after the deaths stop) leaving the impacted community to address indirect and long-term sequelae independently.

Discussion

Our proposed overall approach to EIDs centers around the emergency response cycle. The emergency response cycle is made up mitigation, prevention, response, and recovery phases. Each component of the cycle is a necessary part of the overall response; they are displayed in sequence but can occur concurrently or in quick succession depending on the scope and type of emergent risk. The goal of each component of the cycle is unique but complementary (*Table 1*).

Table 1: The Emergency Response Cycle

Cycle Phase	Goal	Examples
Mitigation	Minimizing the effects of the disaster	Building codes and zoning, vulnerability analyses and public education
Preparation	Planning how to respond	Preparedness planning, emergency exercises/training, warning systems
Response	Efforts to minimize the hazards created by a disaster	Search and rescue and emergency relief
Recovery	Return the community to normalcy	Temporary housing, medical care and grants for recovery activities

The emergency response cycle works to guide a response, and there are critical points along the cycle where interventions can strengthen the entirety of the cycle. When considering how best to participate in emerging disease response activities, it is important to identify these critical points and how interventions might work to strengthen the system in its entirety. While these breakdown points are common across many settings, preparedness and response activities must be contextualized to specifics of the disease and setting. Communication and capacity are constant across this cycle—an area that requires constant engagement and learning [14, 35, 40, 27, 39]. Communication strategies should also be tailored to fit local context and cultural settings [13]. If there are successful interventions at the beginning of the cycle, subsequent stages are more effective and efficient.

In order to expedite implementation and ensure the effectiveness of interventions, surveillance and response systems can be built on-top-of existing platforms or grown out of successful programs. The same can work in reverse - a functional surveillance system can be applied to a multitude of health issues to facilitate ongoing monitoring and community engagement. The harmonization of any new systems can help to ensure sustainability and uptake of novel approaches.

In light of the interest in EID response and preparedness, there have been novel approaches deployed for community use. Some of the previously identified applications of technology and system strengthening are provided in *Table 2*.

Table 2: Novel Approaches for Addressing Emerging and Reemerging Infectious Diseases

Area of Response	Example Approaches
Surveillance/Vector Control	App to report potential sources of mosquito breeding for community use
	Apps for community health workers to report potential illness
	Systems for laboratories and doctors to report results up the chain of command
	Systems for veterinarians to report large animal illnesses (and in their associated human population)
Behavior Change Communications	App to provide educational information regarding disease identification and prevention for general public
	Continued learning modules for trained healthcare workers to receive disease recommendation updates
Health Systems Strengthening	Establishment of public-private coordination system to keep up-to-date info available for decision making
	Capacity building for the implementation of new technologies (diagnostic tools, mosquito control efforts, vaccine deployments, personal protective equipment)
	Creation of real-time maps of available services and disease cases
	Establishment of ongoing monitoring system for Zika pregnancies and children with microcephaly

The range of technological applications is vast, but each was created for a particular context and outbreak. It is important to ensure that any innovations are realistic for the setting, and the technology works to fill the identified gap in capacity. Additionally, it will be important to understand how each of the relevant sectors can address issues on the system, community, provider, family, and individual levels. To identify some of these potential breakdown points and how-to response to identified needs, a more detailed description of EID response activities and required inputs is provided in *Figure 4*. This figure outlines the progression of an outbreak from initial consideration and planning stages to post-emergency responses.

There were clear strengths and limitations to our review. A strength of the review was that the use of the specific eligibility criteria and search process made narrowing down relevant articles efficient and straightforward. A limitation of the review was that the search could have been more comprehensive with the inclusion of other databases. However, for the two databases used—scaling the search to the past ten years provided a significant amount of relevant search results.

Conclusions

Emerging infectious diseases represent an ongoing challenge to the global community and bring with them the ongoing threat of grave health, environmental, economic, and societal impacts. An ideal emerging disease preparedness and response environment should center on collaboration between all impacted sectors, as well as fiscal and social commitment to strengthen the capacity of countries and communities to respond to threats as they emerge. When considering how best to participate in emerging disease response activities, it is important to identify these critical points and how interventions might work to strengthen the system in entirety. While these breakdown points are common across many settings, it is imperative that the preparedness and response activities be contextualized to specifics of the disease and setting.

Abbreviations

CDC Centers for Disease Control

EID Emerging Infectious Disease

SARS Severe Acute Respiratory Syndrome

US United States

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interests: The authors declare that they have no competing interests

Funding: None

Authors' contributions: HJM and NK conceptualized and designed the project. HJM performed the analysis wrote the original draft of the manuscript. CL and NK were major contributors in reviewing and revising the manuscript. SJ conducted the literature review. All authors read and approved the final manuscript.

Acknowledgements: Not applicable

References

1. Jones KE, Patel NG, Levy MA, et al. Global trends in emerging infectious diseases. *Nature*. 2008;451(7181):990–993. doi:10.1038/nature06536

2. Castillo-Chavez C, Curtiss R, Daszak P, et al. Beyond Ebola: Lessons to mitigate future pandemics. *Lancet Glob Heal*. 2015;3(7):e354-e355. doi:10.1016/S2214-109X(15)00068-6
3. USAID. West Africa—Ebola Outbreak: Fact Sheet #6, Fiscal Year (FY) 2016. 2015:1–5. https://www.usaid.gov/sites/default/files/documents/1866/west_africa_fs07_01-21-2016.pdf.
4. UN. Socio-Economic Impact of Ebola Virus Disease in West African Countries. A call for national and regional containment. United Nations Dev Gr - West Cent Africa. 2015:1–95.
5. Bogich TL, Chunara R, Scales D, et al. Preventing Pandemics Via International Development: A Systems Approach. *PLoS Med*. 2012;9(12):4–7. doi:10.1371/journal.pmed.1001354
6. Olson SH, Benedum CM, Mekaru SR, et al. Drivers of emerging infectious disease events as a framework for digital detection. *Emerg Infect Dis*. 2015;21(8):1285–1292. doi:10.3201/eid2108.141156
7. Semenza J, Lindgren E, Espinosa L, Svendotter M, Penttinen P, Rocklöv J. Determinants and Drivers of Infectious Disease Threats in Europe. *Eur J Public Health*. 2017;25(suppl_3):581–589. doi:10.1093/eurpub/ckv167.037
8. Fischer JE, Katz R. The International Health Regulations (2005): Surveillance and Response in an Era of Globalization The International Health Regulations (2005): Surveillance and Response in an Era of Globalization. *Heal* (San Fr. 2011;(June).
9. Rabinowitz PMG, Pappaioanou M, Bardosh KL, Conti L. A planetary vision for one health. *BMJ Glob Heal*. 2018;3(5):1–6. doi:10.1136/bmjgh-2018-001137
10. Chughtai AA, Barnes M, Macintyre CR. Persistence of Ebola virus in various body fluids during convalescence: Evidence and implications for disease transmission and control. *Epidemiol Infect*. 2016;144(8):1652–1660. doi:10.1017/S0950268816000054
- 11 Veldhuis A, Mars J, Stegeman A, van Schaik G. Challenging surveillance objectives during the different phases of an emerging vector-borne disease outbreak: The Schmallenberg virus example. *Preventive Veterinary Medicine*. 2019. doi:10.1016/j.prevetmed.2019.03.008
1. Sambala EZ, Manderson L. Anticipation and response: pandemic influenza in Malawi, 2009. *Glob Health Action*. 2017;10(1):1341225. doi:10.1080/16549716.2017.1341225
2. Thiam S, Delamou A, Camara S, et al. Challenges in controlling the Ebola outbreak in two prefectures in Guinea: why did communities continue to resist?. *Pan Afr Med J*. 2015. doi:10.11694/pamj.suppl.2015.22.1.6626
3. Tambo, E., Yah, C. S., Ugwu, C. E., Olalubi, O. A., Wurie, I., Jonhson, J. K., & Ngogang, J. Y. (2016). Fostering prevention and care delivery services capability on HIV pandemic and Ebola outbreak symbiosis in Africa. *The Journal of Infection in Developing Countries*. 2016;10(01), 1–12. doi:10.3855/jidc.6875
4. Ho LL, Tsai YH, Lee WP, Liao ST, Wu LG, Wu YC. Taiwan's Travel and Border Health Measures in Response to Zika. *Health Secur*. 2017;15(2):185–191. doi:10.1089/hs.2016.0106

5. Andrew T. Y. Wong, Hong Chen, Shao-haei Liu, Enoch K. Hsu, Kristine S. Luk, Christopher K. C. Lai, Regina F. Y. Chan, Owen T. Y. Tsang, K. W. Choi, Y. W. Kwan, Anna Y. H. Tong, Vincent C. C. Cheng, Dominic N. C. Tsang. From SARS to Avian Influenza Preparedness in Hong Kong, *Clinical Infectious Diseases*. 2017, S98–S104. doi:10.1093/cid/cix123
6. Dhama, K., Malik, Y. S., Malik, S. V. S., & Singh, R. K. (2015). Ebola from emergence to epidemic: the virus and the disease, global preparedness and perspectives. *The Journal of Infection in Developing Countries*. 2015;9(05), 441–455. doi:10.3855/jidc.6197
7. Kebede, Senait & Duales, Sambe & Yokouide, Allarangar & Alemu, Wondimagegnehu. (2010). Trends of major disease outbreaks in the African region, 2003–2007. *East African Journal of Public Health*. 2010;7. 20–9. doi:10.4314/eajph.v7i1.64672
8. Shirley S. Ho, Xianghong Peh, Veronica W. L. Soh. (2013) The Cognitive Mediation Model: Factors Influencing Public Knowledge of the H1N1 Pandemic and Intention to Take Precautionary Behaviors. *Journal of Health Communication*. 2013;18:7, 773–794.
9. Hamel MJ, Slutsker L. Ebola: the hidden troll. *The Lancet Infectious Disease Journal*. 2015. doi:10.1016/1473–3099(15)70167–2
10. Sigmundsdottir G, Gudnason T, Ólafsson Ö, Baldvinsdóttir G E, Atladottir A, Löve A, Danon L, Briem H. Surveillance of influenza in Iceland during the 2009 pandemic. *Euro Surveill*. 2010;15(49):pii = 19742. doi:10.2807/ese.15.49.19742-en
11. Kelly-Cirino CD, Nkengasong J, Kettler H, et al. Importance of diagnostics in epidemic and pandemic preparedness. *BMJ Glob Health*. 2019;4(Suppl 2):e001179. doi:10.1136/bmjgh–2018–001179
12. Purohit V, Kudale A, Sundaram N, Joseph S, Schaetti C, Weiss MG. Public Health Policy and Experience of the 2009 H1N1 Influenza Pandemic in Pune, India. *Int J Health Policy Manag*. 2017;7(2):154–166. doi:10.15171/ijhpm.2017.54
13. Kim DH. Structural Factors of the Middle East Respiratory Syndrome Coronavirus Outbreak as a Public Health Crisis in Korea and Future Response Strategies. *J Prev Med Public Health*. 2015;48(6):265–270. doi:10.3961/jpmph.15.066
14. Perlman S, Azhar EI, Memish ZA, Hui DS, Zumla A. Confronting the persisting threat of the Middle East respiratory syndrome to global health security. *The Lancet Infectious Disease Journal*. 2019. doi:10.1016/S1473–3099(19)30347–0.
15. Randremanana, Rindra et al. Epidemiological characteristics of an urban plague epidemic in Madagascar, August–November 2017: an outbreak report. *The Lancet Infectious Disease Journal*. 2019. doi:10.1016/S1473–3099(18)30730–8.
28. King, J., Tiwari, C., Mikler, A., & O'Neill, M. (2018). Challenges of Designing and Implementing High Consequence Infectious Disease Response. *Disaster Medicine and Public Health Preparedness*. 2017. 12(5), 563–566. doi:10.1017/dmp.2017.128

1. Khalil, IA et al. Morbidity and mortality due to shigella and enterotoxigenic *Escherichia coli* diarrhea: the Global Burden of Disease Study 1990–2016. *The Lancet Infectious Disease Journal*. 2019.

- doi:10.106/S1473–3099 (18) 30475–4
2. Tay J, Ng YF, Cutter JL, James L. Influenza A (H1N1–2009) Pandemic in Singapore—public health control measures implemented and lessons learnt. *Ann Acad Med Singapore*. 2010. 39(4): 313–12
 3. Gyawali N, Bradbury RS, Taylor-Robinson AW. The epidemiology of dengue infection: Harnessing past experiences and current knowledge to support implementation of future control strategies. *J Vector Borne Dis*. 2016. 53(4): 293–304
 4. The Singapore Zika Study Group. Outbreak of Zika virus infection in Singapore: an epidemiological, entomological, virological, and clinical analysis. *The Lancet Infectious Disease Journal*. 2017. doi: 10.1016/S1473–2099(17)30249–9
 5. SteelFisher GK, Blendon RJ, Ward JRM, Rapoport R, Kahn EB, Kohl K. Public response to the 2009 influenza A H1N1 pandemic: a polling study in five countries. *The Lancet Infectious Disease Journal*. 2012. doi: 10.1016/S1473–3099(12)70206–2
 6. Schuchat A, Bell BP, Redd SC. The Science behind Preparing and Responding to Pandemic Influenza: The Lessons and Limits of Science, *Clinical Infectious Diseases*. 2011. S8–S12. doi:10.1093/cid/ciq007
 7. Cordova-Villalobos JA, Macias AE, Hernandez-Avila M, Dominguez-Cherit G, Alpuche-Aranda C, Ponce de León-Rosales S. The 2009 pandemic in Mexico: Experience and lessons regarding national preparedness policies for seasonal and epidemic influenza. *Gac Med Mex*. 2017. 153(1): 102–110
 8. Hsu YC, Chen YL, Wei HN, Yang YW, Chen YH. Risk and Outbreak Communication: Lessons from Taiwan's Experiences in the Post-SARS Era. *Health Secur*. 2017;15(2):165–169. doi:10.1089/hs.2016.0111
 9. Bell BP, Damon IK, Jernigan DB, Kenyon TA, Nichol ST, O'Connor JP, Tappero JW. Overview, Control Strategies, and Lessons Learned in the CDC Response to the 2014–2016 Ebola Epidemic. *MMWR Suppl*. 2016. 65(3):4–11. doi: 10.15585/mmwr.su6503a2
 10. Rabkin M, El-Sadr W. Ebola: the real lessons from HIV scale-up. *The Lancet Infectious Disease Journal*. 2015. doi:10.1016/S1473–3099(15)70136–2
 39. Yen MY, Chiu AW, Schwartz J, King CC, Lin YE, Chang SC, Armstrong D, Hsueh PR. From SRAS in 2003 to H1N1 in 2009: lessons learned from Taiwan in preparation for the next pandemic. *J Hosp Infect*. 2014. 87(4): 185–93. doi: 10.1016/j.jhin.2014.05.005
 1. Matua GA, Van der Wal DM, Locsin RC. Ebola hemorrhagic fever outbreaks: strategies for effective epidemic management, containment and control. *The Brazilian Journal of Infectious Diseases*. 2015. doi:10.1016/j.bjid.2015.02.004
 2. Reeves A, Basu S, McKee M, Stuckler D, Sandgren A, Semenza J. Social Protection and tuberculosis in 21 European countries, 1995–2012: a cross-national statistical modelling analysis. *The Lancet Infectious Disease Journal*. 2014. doi:10.1016/S1473–3099(14)70927–2
 3. PRISMA. Retrieved from <http://www.prisma-statement.org/>

Figures

PRISMA 2009 Flow Diagram

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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Figure 1

PRISMA Flow Diagram

Table 1: Domains of EID Response Strategies Identified									
No.	Study (Author, Year)	EID surveillance and monitoring systems – tailored surveillance strategies to prevent and mitigate damage	Multi-stakeholder response focusing on healthcare system strengthening. Including sharing of resources between global, national, and local levels to improve care, EID assessment, and response time	Integration of EID diagnostics into EID prevention and control plans including strengthening vaccination/vector control treatment strategies	Pharmaceutical and non-pharmaceutical preventative measures	Improving communication strategies between government institutions and the public to improve feedback and regular monitoring especially risk-based communication strategies including risk communication interventions	Strengthening existing public health institution capabilities to better handle surges including influenza drills, exercises, and simulations for HCWs	Social, behavior, and culture change interventions including educational interventions including investment in social protection programs	Strengthening research and evaluation
16	Andrew et. al. (2017)	*	*						
37	Bell et. al. (2016)						*		
35	Cordova-Villalobos et. al. (2017)					*	*	*	*
17	Dhama et. al. (2015)	*							
31	Gyawali et. al. (2016)			*					
20	Hamel et. al. (2015)	*		*					
15	Ho et. al. (2017)	*	*						
36	Hsu et. al. (2017)					*			
18	Kebede et. al. (2010)	*	*						
2	Kelly-Cirino et. al. (2019)			*					
29	Khalil et. al. (2019)			*					
25	Kim et. al. (2015)		*				*		
28	King et. al. (2017)		*						
40	Matua et. al. (2015)							*	
26	Perlman et. al. (2019)		*						
23	Purohit et. al. (2017)		*	*					
38	Rabkin et. al. (2015)						*		
27	Randremanana et. al. (2017)		*					*	*
41	Reeves et. al. (2014)							*	
12	Sambala et. al. (2017)	*				*	*		
34	Schuchat et. al. (2011)			*				*	
19	Shirley et. al. (2013)	*	*				*		
21	Sigmundsdottir et. al. (2010)	*							
32	Singapore Zika Study Group (2017)			*				*	
33	SteelFisher et. al. (2012)			*	*				
14	Tambo et. al. (2016)	*	*	*	*	*		*	
30	Tay et. al. (2010)			*			*		
13	Thiam et. al. (2015)	*	*						
11	Veldhuis et. al. (2019)	*							
39	Yen et. al. (2014)						*	*	

Figure 2

EID Study Table

Figure 3

Sectors with a Role in Emerging/Reemerging Infectious Disease Preparedness and Response

Figure 4

Cascade of EID Response with Potential Points of Engagement

Supplementary Files

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