

Mitigating the Impact of Ebola in Potential Hot Zones

A Proof-of-Concept Approach to Help Decisionmakers Prepare for High-Risk Scenarios Outside Guinea, Liberia, and Sierra Leone

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The Ebola epidemic that surged in 2014 and continues into 2015 (hereafter, the *2014 Ebola outbreak*) is the largest in history, primarily affecting three countries in West Africa—Guinea, Liberia, and Sierra Leone. A small number of cases were reported in Mali, Nigeria, Senegal, and Democratic Republic of the Congo (DRC), but these countries intervened early and effectively to limit disease transmission. A handful of cases have also been reported in countries outside of Africa, including Spain, the United Kingdom, and the United States (World Health Organization [WHO], 2015a).

In August 2014, WHO declared the Ebola outbreak in West Africa a *public health emergency of international concern*, or PHEIC (WHO, 2015a). The organization's International Health Regulations (IHR) serve as the international framework for global disease detection, response, and obligations related to PHEICs. The IHR

define several core capacities that all states must develop and maintain to “prevent, protect against, control and provide a public health response to the international spread of disease, in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade” (WHO, 2005). Governments in West Africa, along with many international partners, including the United States, have been working to contain the disease and prevent its spread.

The way that the 2014 Ebola experience has played out, three countries in West Africa have become disease havens, while four others in the region have not. The successful experiences of the latter countries in eliminating the Ebola threat are important for two reasons. First, Nigeria and Senegal serve as crucial economic and transport hubs in the region, and an epidemic there would have been catastrophic, increasing the region's isolation and reducing

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its access to critical resources. Second, the experiences of all four countries that successfully contained Ebola relatively early can be informative for government officials, international organizations, and aid agencies seeking to capture the underlying factors that affect countries' resilience to such outbreaks. Such an understanding could help inform activities to mitigate the impact of Ebola or other similar health threats in other potential hot zones.

This perspective complements current efforts to accomplish this goal by (1) identifying countries potentially at high risk of a future Ebola outbreak and (2) exploring proactive approaches that policymakers can take to help prepare for such risks and mitigate their adverse effects if they materialize. We first seek to identify factors that shape national capabilities to prevent or contain disease outbreaks—as reflected by quantitative indicators that could be used to identify areas at high risk (in this instance, for Ebola). We next apply these indicators to examine the three most heavily affected West African countries and the four that successfully controlled the disease in 2014. We then use the framework to assess a larger number of countries in different regions, to identify those at highest risk for Ebola. Based on that assessment, we select

two countries that are at particularly high risk (Côte d'Ivoire and Ethiopia) and one that is at medium risk but is of high current political concern (Pakistan) to describe how and why Ebola might unfold there. Finally, we describe how tabletop exercises might be used to inform proactive mitigation efforts and provide a notional outline for such an exercise in one of these three countries.

While this perspective illustratively focuses on the 2014 Ebola outbreak, it provides a proof of concept for a two-phase approach to identify and mitigate risk for future disease or other disaster threats. The example explored here helps demonstrate its potential applications in different scenarios.

Factors Shaping National Capabilities to Prevent or Contain Disease Outbreaks: Developing a Framework to Assess Risk

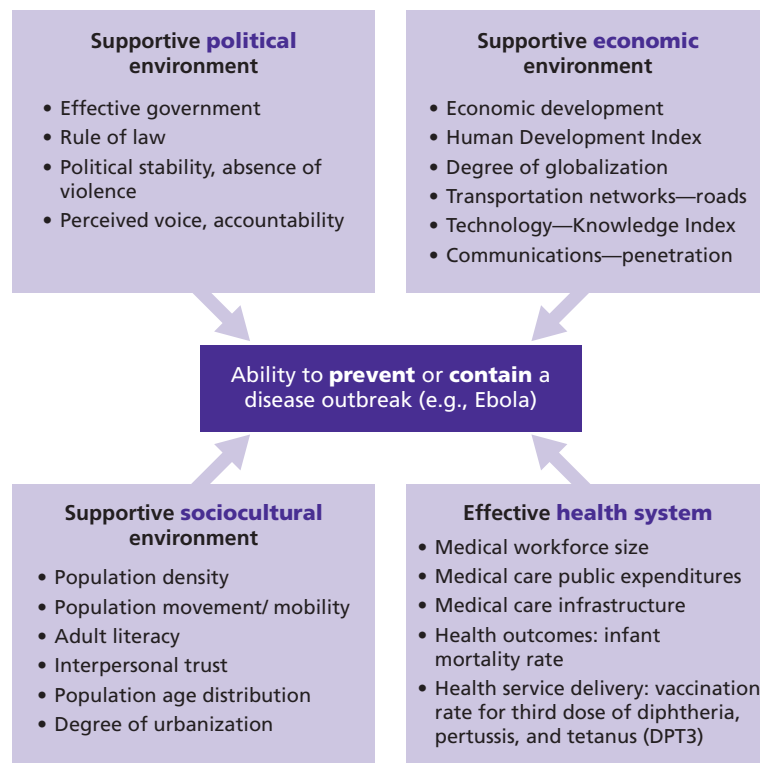
Taking a holistic approach to assessing the ability of countries to prevent or contain disease outbreaks, we hypothesized that there are underlying factors—for example, medical and public health capacities, which influence a country's level of risk, either positively or negatively. We began by asking ourselves what would make a country vulnerable to such outbreaks. We then parsed this question into four broad domains: What political factors would make a country vulnerable? What economic factors? What sociocultural factors? What factors related to the country's health system? After brainstorming answers to these questions, we sought quantitative indicators that reflect such factors. We hypothesized that these indicators, taken collectively, would provide a snapshot of a country's relative strength or vulnerability to a disease outbreak such as Ebola.

Within each domain, we identified several widely available indicators that we believed might reflect a country's ability to prepare for and respond to the kind of systemic health threat posed by Ebola. We found these indicators within trusted and reliable databases—from such sources as the Centers for Disease Control and Prevention (CDC), the World Bank, WHO, and other United Nations agencies. We also vetted them with approximately ten RAND researchers from across multiple disciplines (e.g., health, political science, economics, security, regional expertise) to assess the initial face validity of the indicators selected for our illustrative example. Figure 1 depicts the conceptual framework of these factors. For this initial proof of concept, we consider the framework to be instructive rather than strictly predictive: We did not attempt to judge the reliability or weight the relative importance of the various indicators; nor did we rigorously validate the framework's predictive value. Rather, we aim to provide a reasonable starting point for developing a more robust and definitive tool.

For this proof of concept, we also selected an illustrative number of mostly developing countries in the regions of sub-Saharan Africa, the Middle East, South Asia, and Southeast Asia. (We recognize that there are vulnerable countries in other regions, such as Haiti in the Americas, but our intention in this initial proof of concept is to be illustrative rather than exhaustive.) Our selection of developing countries was based on the underlying assumption that such countries are at higher potential risk than more-developed ones. Within each region, we chose countries from across a spectrum of potential vulnerability, ranging from those that are systematically weak (classified at the high end of the Fund for Peace Fragile States Index for 2014) on one end to more highly developed countries on the other end. We also chose to include countries that

we speculated may be vulnerable to infectious disease outbreaks due to geographical or demographic factors or that are strategically important regionally or internationally. In sub-Saharan Africa, for example, we included Central African Republic, Somalia, and South Sudan because they are all high alert-level fragile states and conflict zones; Ethiopia, Kenya, and South Africa, on the other hand, are key regional trading and transit hubs that abut failed states. In South Asia and Southeast Asia, we chose demographically

Figure 1. Factors Potentially Influencing Vulnerability to an Ebola Outbreak



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large, population-dense, low-income countries, such as Bangladesh and Cambodia, that epidemiologists feared might serve as potential disease epicenters. Again, conflict countries—including Afghanistan and Pakistan in South Asia and Iraq and Syria in the Middle East—were chosen because of systemic instability that could augur disease vulnerability. We also selected such countries as China, India, and Indonesia because of their considerable importance to the international economic and political systems.

After assembling a sample of countries to evaluate for purposes of our proof of concept, we collected indicator data for each country. To classify every country's risk level (high, medium, or low) for each indicator independently from others, we looked for natural breaks and clusters in the distribution of indicators' values. On that basis, we established functional threshold values, or *cut points*. Tables 1a–1d display the domains, indicators, and their respective sources, a description for each, the metric used, and threshold values. Because the countries that we selected for our illustration are almost exclusively at the lower end of the development spectrum, the threshold values are intended to distinguish among them and not to compare them with all countries worldwide; thus, the thresholds used here are functional for the

To simplify the results in a visual format, we used the indicators to classify the domain for each country as high, medium, or low risk, and then we further classified the country as overall high, medium, or lower risk.

purpose of this perspective but skewed with respect to the full spectrum of countries.

To simplify the results in a visual format, we used the indicators to classify the domain for each country as high, medium, or low risk, and then we further classified the country as overall high, medium, or lower risk. This process involved two key stages. First, we established criteria for classifying the level of risk for each domain. Because each domain consists of a different number of indicators, the threshold for the number of indicators classified as high risk varied by domain. For example, a country was judged to be at high *political* risk if at least two of the five political indicators were registered as high risk. Subsequently, we used the classification of each domain to further classify the country as being at high, medium, or lower overall risk. When at least three of the four domains were assessed as high risk, we classified those countries to be at high overall risk for a severe Ebola outbreak. We classified countries with one or two high-risk domains as medium overall risk (for some of these countries, data were insufficient to classify at least one domain; such countries may be at high risk and are indicated as “medium”). Finally, we classified all other countries as lower risk—not necessarily *low* risk, but not rising to the level of medium or high risk. Tables 2a–2e present the detailed indicator data for the three countries most heavily affected by Ebola and the four countries that successfully contained the disease in 2014. The aggregated (domain-level) highlights for the full list of countries are presented in Table 3. The detailed table for this longer set of countries (i.e., with all indicator-level data) is available separately on the website for this perspective (see back cover for web address).

Table 1a. Political Indicators

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Government effectiveness	Captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	Percentage scale 0–100	<ul style="list-style-type: none"> • Poor governance: < 20 • Adequate governance: 20–50 • Solid governance: > 50 	Reflects the degree to which governments can effectively manage threats or crises within their borders	World Bank, 2014k
Rule of law	Captures perceptions of the extent to which citizens have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence	Percentage scale 0–100	<ul style="list-style-type: none"> • Little to no rule of law: < 20 • Some rule of law: 20–50 • Solid rule of law: > 50 	Indicates the perceived ability of a state to enforce established rules or emergency procedures and protocols put into place by the government	World Bank, 2014k
Political stability and absence of violence	Measures perceptions of the likelihood of political instability and politically motivated violence, including terrorism	Percentage scale 0–100	<ul style="list-style-type: none"> • Little to no stability: < 20 • Moderate stability: 25–50 • Stable: > 50 	Political instability or violence can undermine or compromise efforts to respond to threats and crises within their borders	World Bank, 2014k
Fragile States Index (2014)	Measures 12 different indicators, revealing the degree to which governments are fragile or unstable, including demographic pressures, presence of refugees or internally displaced persons, vengeance-seeking groups, human rights violations, and deterioration of public services, among others	Indexed score from 10–120 based on 12 categories (each scored separately from 1–10)	<ul style="list-style-type: none"> • High warning or below: 10–79 • Alert or very high warning: 80–99 • Very high or high alert: 100–120 	Fragile and failed states pose unique challenges because of the lack of territorial control and the potential for catastrophic spiraling of events in crises	Fund for Peace, 2014
Voice and accountability	Captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, of association, and of media	Percentage scale 0–100	<ul style="list-style-type: none"> • Little to no voice or accountability: < 20 • Moderate amount of voice and accountability: 20–50 • Solid levels of voice and accountability: > 50 	Indicates the extent to which citizens perceive that their voices are being heard and heeded; important to know in a crisis response if popular opinion is reflected in government action and policy	World Bank, 2014k

Table 1b. Economic Indicators

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Wealth/ economic development	Total economic production per capita	Gross domestic product (GDP) per capita (\$)	<ul style="list-style-type: none"> • Low: < \$1,000 • Medium: \$1,000–\$6,000 • High: > \$6,000 	Demonstrates amount of resources that a country is able to devote to threats/crises, as well as its economic baseline	World Bank, 2014b
Human Development Index	Indexed score on a country basis that includes life expectancy, years of education, and gross income per capita	Score 0–1	<ul style="list-style-type: none"> • Low: < 0.5 • Medium: 0.5–0.7 • High: > 0.7 	Provides a well-rounded measure of social and economic development to show resources available to respond to a systemic crisis	United Nations Development Programme, 2014
Degree of globalization	Net inflows of foreign direct investment (new investment inflows minus disinvestment)	Foreign direct investment (\$ millions)	<ul style="list-style-type: none"> • Low: < \$500 million • Medium: \$500–5,000 million • High: > \$5,000 million 	May indicate the degree of economic interdependence and connectedness to the global economy of (and hence international interest in) a country were an incident to happen	World Bank, 2014a
Transportation networks: Road	Indicates the quality of roads for logistical and transportation purposes	Paved roads (% of total)	<ul style="list-style-type: none"> • Low: < 10% • Medium: 10–50% • High: > 50% 	Important to know for the transport of supplies and personnel	Nation Master, 2007
Technology: Knowledge Index	Indicates the ability of a country to generate and disseminate knowledge, measured through three key knowledge economy pillars: education and human resources, the innovation system, and information and communication technology	Composite, indexed score from 0–10 of average of scores for education and human resources, innovation, and information and communication technology	<ul style="list-style-type: none"> • Low: < 2.5 • Medium: 2.5–5.0 • High: > 5.0 	Level of technological sophistication can guide appropriateness of response solutions	World Bank, 2012

Table 1b—Continued

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Communications	Degree of penetration of mobile phones	Mobile cellular subscriptions per 100 people	<ul style="list-style-type: none"> • Low: < 50 • Medium: 50–100 • High: > 100 	Useful for knowing how to communicate mass messages in the event of a crisis	World Bank, 2014e
	Degree of penetration of Internet users	Internet users per 100 people	<ul style="list-style-type: none"> • Low: < 20 • Medium: 20–40 • High: > 40 	Useful to know about social messaging and mass education campaigns	World Bank, 2014d

Table 1c. Sociocultural Indicators

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Population density	Indicator of population crowding (higher population density may pose greater risk of disease spread)	Population per km ²	<ul style="list-style-type: none"> • Low: < 50 • Medium: 50–99 • High: > 100 	Should be considered to be a risk factor for spread of disease in densely populated areas	World Bank, 2014h
Population movement (mobility)	Average annual net number of migrants (immigrants minus emigrants) per 1,000 people	Net migration rate, expressed as average annual number of migrants per 1,000 people	<ul style="list-style-type: none"> • Low net migration: Between –5 and 5 • Medium: +/- 6 to 10 • High: +/- > 10 	Indicator of movement of people across borders and degree of interconnectedness of countries or regions	United Nations, 2012
Adult literacy	Ability of persons above 15 years of age to read at a basic level, often used as a proxy for general level of education	Persons aged 15 years or older who are literate (%)	<ul style="list-style-type: none"> • Low: < 50% • Medium: 50–75% • High: > 75% 	Provides a proxy for education and appropriateness or potential efficacy of different communication channels or modalities for threat responses (printed literature versus radio or word-of-mouth campaigns)	United Nations Educational, Scientific, and Cultural Organization, 2014
Interpersonal trust	Indicator reflecting interpersonal trust based on survey responses among the population	Indexed score 0–200; based on survey values: Trust Index = 100 + {(% most people can be trusted) minus (% can't be too careful)}	<ul style="list-style-type: none"> • Low: < 25 • Medium: 25–75 • High: > 75 	Reflects willingness of society to go along with government or public decisions; low trust may result in resistance to care or the implementation of new or unfamiliar medical practices or technology (such as quarantine or health workers in rural villages)	Medrano, undated

Table 1c—Continued

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Median age	Age at which 50% of the population are above and 50% below	Age, in years	<ul style="list-style-type: none"> • Low: < 20 • Medium: 21–30 • High: > 30 	Countries with younger or older median populations may pose differential risk for disease spread or mitigation	United Nations, 2012
Urbanization	Percentage of total population living in urban areas, as defined by national statistical offices	Population living in urban areas (%)	<ul style="list-style-type: none"> • Low-income countries: typically around 30% • High-income countries: typically around 80% 	Guide for which strategies to employ to respond to threats in various countries and environments (countries with more or less urbanization may pose differential risk for disease spread or mitigation)	World Bank, 2014i

Table 1d. Health Indicators

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Medical care workforce	Availability of health professionals in a country	Physicians per 1,000 people	<ul style="list-style-type: none"> • Low: < 0.5 • Medium: 0.5–1.0 • High: > 1.0 	More trained health professionals should augur a more comprehensive, professional response	World Bank, 2014j
		Nurses and midwives per 1,000 people	<ul style="list-style-type: none"> • Low: < 0.5 • Medium: 0.5–1.0 • High: > 1.0 		
Medical care expenditures	Availability of hospital beds	Hospital beds per 1,000 people	<ul style="list-style-type: none"> • Low: < 1 • Medium: 1–2 • High: > 2 	Availability of hospital beds in a country is another reflection of a country's ability to provide adequate medical care for its population	World Bank, 2014j
	Relative importance of the health sector in the government's national budget and expenditures	GDP spent on health (%)	<ul style="list-style-type: none"> • Low: < 4% • Medium: 4–8% • High: > 8% 	Reflects relative government priorities—however, low value may reflect either a lack of resources or more-conscious lower priority	
	Public-sector health expenditures per capita	Health expenditure per capita (\$)	<ul style="list-style-type: none"> • Low: < \$50 • Medium: \$50–100 • High: > \$100 	The amount of resources available for health may also be predictive of response capacity	

Table 1d—Continued

Indicator	Description	Metric	Threshold Values	Relevance	Data Source
Medical care infrastructure	Indicator of available ambulatory care facilities relative to population	Health centers per 100,000 people	<ul style="list-style-type: none"> • Low: < 5 • Medium: 5–10 • High: > 10 	Important for knowing the capacity of the health system for potential patients	WHO, 2013
Health outcomes: Infant mortality rate	Annual number of deaths among infants (i.e., ages 0–11 months), expressed per number of annual live births	Mortality rate for infants per 1,000 live births	<ul style="list-style-type: none"> • Low: < 20 • Medium: 20–70 • High: > 70 	Infant mortality rate is often a good proxy for the quality of health care services in a country	World Bank, 2014f
Health service delivery: DPT3 vaccination rate	Percentage of children 1 year of age (i.e., 12–23 months) who have received a third dose of the diphtheria, pertussis, and tetanus (DPT) vaccine; a good indicator of both health service delivery and the general level of child vaccination throughout the country	Children ages 12–23 months who have received DPT3 dose (%)	<ul style="list-style-type: none"> • Low: < 60% • Medium: 60–90% • High: > 90% 	Demonstrates the ability of a government to provide comprehensive preventive health services nationwide	World Bank, 2014c
Health emergency experience	Previous experience with Ebola	Number of previous Ebola outbreaks	<ul style="list-style-type: none"> • No prior experience with Ebola: 0 • Some experience with Ebola: 1–2 • Extensive experience with Ebola: > 2 	Countries with prior experience with Ebola (or similar diseases) may have existing plans, networks, and infrastructure to effectively care for patients and limit disease transmission	Centers for Disease Control and Prevention, 2015
Prevalence of natural disasters	Previous experience with natural disasters	Number of serious disasters (incidents with > 1,000 deaths over 20-year period)	<ul style="list-style-type: none"> • Low: < 3 • Medium: 3–5 • High: > 5 	Indicates the likelihood or frequency of major disasters, coupled with vulnerability to major disasters; may reflect negatively as persistent vulnerability, or positively as enhanced capabilities developed through repeated experiences	Centre for Research on the Epidemiology of Disasters, 2009

Initial Comparisons Using the Risk Indicator Framework

In order to determine which countries might be at greatest future risk for an Ebola outbreak, it is instructive to look at the commonalities among, and characteristics of, the three most highly affected countries—Guinea, Liberia, and Sierra Leone—and then compare them with countries that successfully controlled the 2014 Ebola outbreak. We compared the two groups of countries as an initial application of the potential risk indicator framework. Table 2a provides an aggregate look at the seven countries, summarized by domain, and Tables 2b–2e provide the detailed indicator data for each domain.

Examining overall risks for these two groups of countries reveals fairly similar profiles for types of risk. As shown in Table 2a, all three heavily affected countries are classified as high overall risk, but only one of the four successful countries (Mali) is at high overall risk; DRC might also be at high risk, were all data available; the

other two countries (Nigeria and Senegal) are classified as medium overall risk.

At first glance, there is not much to differentiate these countries, but the aggregated domain-level classifications obscure some important distinctions that become clearer with examination of the more detailed indicator data. From a sociocultural standpoint, these countries all have highly rural populations with low median age and low literacy rates that characterize many of the poorer states in sub-Saharan Africa. With the exception of Nigeria and Senegal, a confluence of high-risk factors threatened to overwhelm the capacity of the states to effectively respond to the Ebola outbreak. What the aggregated domain-level data do not reflect are certain key factors that may have been associated with a more- or less-effective response. Tables 2b–2e provide the specific indicator data across the four domains for the seven African countries that experienced Ebola in 2014.

Table 2a. Comparison of African Countries Experiencing Ebola in 2014

Group	Country	Overall Risk	Political Risk	Economic Risk	Sociocultural Risk	Health Risk
Heavily affected countries	Guinea	High	High	High	High	High
	Liberia	High	High	High	High	High
	Sierra Leone	High	Medium	High	High	High
Successful countries	Mali	High	Medium	High	High	High
	Nigeria	Medium	High	Medium	High	Medium
	Senegal	Medium	Medium	Medium	Medium	High
	DRC	Medium*	High	High	Medium	N/A

NOTE: N/A indicates that sufficient data were not available to classify the level of risk for the domain.
* indicates that unavailable or missing indicator data did not permit complete assessment and may underestimate overall risk.

Table 2b. Political Data for African Countries Experiencing Ebola in 2014

Group	Country	Overall Political Risk	Government Effectiveness (scaled score 0–100)	Rule of Law	Political Stability and Absence of Violence	Fragile States Index	Voice and Accountability
				(scaled score 0–100)	(scaled score 0–100)	(score 10–120)	(scaled score 0–100)
Heavily affected countries	Guinea	High	9.09	4.74	11.37	101.3	17.06
	Liberia	High	8.61	19.43	31.28	95.1	33.18
	Sierra Leone	Medium	12.44	21.33	40.76	91.2	36.02
Successful countries	Mali	Medium	22.01	27.01	6.64	89.3	37.91
	Nigeria	High	16.27	12.32	3.79	100.7	27.49
	Senegal	Medium	37.80	45.97	43.13	81.4	50.24
	DRC	High	1.44	2.84	2.37	111.9	7.58

NOTE: A country was judged to be at high political risk if at least two of the five indicators registered as high risk; at low risk if at least three of the five indicators were low risk, with no high-risk indicators; or otherwise at medium risk.

Delving slightly deeper into the data, and the reasons behind the effective responses of the four African countries that successfully contained Ebola in 2014, yields a few potential differences between these countries and their three heavily affected counterparts. In the case of Nigeria and Senegal, the difference that jumps out is in the economic domain. Both of these countries have much wealthier, more-developed economies, as evidenced by their substantially higher GDP per capita and quality of transportation and communication networks. The amount and quality of resources—health and otherwise—that they were able to devote to the Ebola crisis response was likely critical in their success (WHO, 2015b). In fact, WHO concluded that the presence of high-quality laboratory facilities alongside successful, rapid publicity and communication

campaigns were the common thread of an effective response in Mali, Nigeria, and Senegal (WHO, 2015b). A lack of trust in governmental authorities in the three heavily affected countries may have impaired effective messaging about Ebola, evidenced by health workers being attacked and even killed in Guinea. Unfortunately, interpersonal trust scores were not available for these countries to help verify this connection.

In addition, in the heavily affected countries, the lack of resources, the substandard health systems, and the inability to launch quick, effective communication campaigns thwarted an effective response. It has been difficult to successfully spread information about the disease, including transmission methods, symptoms, and the necessary precautionary measures. The gap in

Table 2c. Economic Data for African Countries Experiencing Ebola in 2014

Group	Country	Overall Economic Risk	Wealth/Economic Development		Degree of Globalization	Transportation	Communications		
			GDP per Capita (\$)	Human Development Index (0–1)	Total Foreign Direct Investment (\$ millions)	% of Roads That Are Paved	Knowledge Index (composite score 0–10)	Mobile Cellular Subscriptions (per 100 people)	Internet Users (per 100 people)
Heavily affected countries	Guinea	High	527	0.392	24	9.8	1.22	63	1.6
	Liberia	High	454	0.412	1,061	6.2	*	60	4.6
	Sierra Leone	High	809	0.374	579	8.0	0.97	44	1.7
Successful countries	Mali	High	715	0.407	410	18.0	1.86	129	2.3
	Nigeria	Medium	3,006	0.504	5,609	15.0	2.20	73	38.0
	Senegal	Medium	1,072	0.485	298	29.2	2.70	93	20.9
	DRC	High	454	0.338	2,098	1.8	*	44	2.2

NOTE: A country was judged to be at high economic risk if at least four of the seven indicators registered as high risk, at low risk if at least four of the seven indicators registered as low risk, with no high-risk indicators; or otherwise at medium risk.

* indicates that data for this indicator were not available.

resources was seemingly a critical factor, as was the fact that the second phase of affected Western African countries (Mali, Nigeria, and Senegal) all witnessed the toll and devastation that Ebola was taking on Guinea, Liberia, and Sierra Leone and acted with the appropriate urgency (WHO, 2015b).

Because Ebola had never been present in most of West Africa before, it was a relatively unknown disease, and the governments, health authorities, and populations of Guinea, Liberia, and Sierra Leone did not have procedures in place for an appropriate response. (It must be noted, however, that Sierra Leone did have extensive

prior experience with Lassa fever, another viral hemorrhagic disease. Nonetheless, Sierra Leone did not suspect or diagnose Ebola early, despite this previous experience.) DRC, though weak in terms of economic resources and health systems, had experienced six previous Ebola outbreaks and knew how to recognize the disease and the steps to take to respond, which may largely explain its successful response. Even before the first Ebola patients appeared in Mali, Nigeria, and Senegal, the governments (in cooperation with WHO) already had solid emergency plans and resources in place, which enabled them to respond rapidly and effectively.

Table 2d. Sociocultural Data for African Countries Experiencing Ebola in 2014

Group	Country	Overall Sociocultural Risk	Population Density (per km ²)	Population mobility (net migration per 1,000 people)	Adult Literacy (ages ≥ 15)	Trust (scaled score 0–150)	Median Age ^a	Urbanization (% of population) ^a
Heavily affected countries	Guinea	High	48	–1	25.3	*	18.3	36
	Liberia	High	45	10	42.9	*	18.3	49
	Sierra Leone	High	84	2	44.5	*	18.8	39
Successful countries	Mali	High	13	–2	33.5	44.8	16.5	38
	Nigeria	High	191	0	51.1	29.8	17.9	46
	Senegal	Medium	73	–3	52.1	54.2	17.9	43
	DRC	Medium	30	0	61.2	*	17.1	41

NOTE: A country was judged to be at high sociocultural risk if at least one of the four color-coded indicators registered as high risk; at low risk if at least two of the four indicators registered as low risk, with no high-risk indicators; or otherwise at medium risk.

^a For indicators that are not color-coded, high, medium, and low values do not necessarily equate with corresponding levels of risk (that is, we are not strictly asserting a direct or inverse relationship between indicator value and risk, in contrast to the indicators that are color-coded). These indicators did not factor into our judgments of the domain, but we believe they remain relevant enough to include.

* indicates that data for this indicator were not available.

Democratic Republic of the Congo, though weak in terms of economic resources and health systems, had experienced six previous Ebola outbreaks and knew how to recognize the disease and the steps to take to respond, which may largely explain its successful response. Even before the first Ebola patients appeared in Mali, Nigeria, and Senegal, the governments (in cooperation with the World Health Organization) already had solid emergency plans and resources in place, which enabled them to respond rapidly and effectively.

Table 2e. Health Data for African Countries Experiencing Ebola in 2014

Group	Country	Overall Health Risk	Medical Care Workforce	Medical Care Expenditures			Medical Care Infrastructure	Public Health Experience	Health Out-comes	Health Service Delivery		
			Physicians per 1,000 People	Nurses and Midwives per 1,000 People	Hospital Beds per 10,000 People	Health Expendi- ture (% of GDP)	Health Expendi- ture per Capita (\$)	Health Centers per 100,000 People	Prior Ebola Out- breaks Since 1976	Natural Disasters with > 1,000 Deaths in the Past 20 Years ^a	Infant Mortality Rate per 1,000 Live Births	DPT3 Vaccination Rate (% of children ages 12–23 months)
Heavily affected countries	Guinea	High	0.1	0.0	0.3	6.3	32	4.15	0	0	65	63
	Liberia	High	0.0	0.3	0.8	15.5	65	1.13	0	0	54	89
	Sierra Leone	High	0.0	0.2	*	15.1	96	1.26	0	0	107	92
Successful countries	Mali	High	0.1	0.4	0.1	5.8	42	5.68	0	1	78	74
	Nigeria	Medium	0.4	1.6	*	6.1	94	*	0	3	74	58
	Senegal	High	0.1	0.4	0.3	5.0	51	0.61	0	0	44	92
	DRC	Medium	*	*	*	5.6	15	*	6	0	86	72

NOTE: A country was judged to be at high health risk if at least five of the ten indicators registered as high risk; at low risk if at least five out of the ten indicators registered as low risk, with no more than one high-risk indicator; or otherwise at medium risk.

^a For indicators that are not color-coded, high, medium, and low values do not necessarily equate with corresponding levels of risk (that is, we are not strictly asserting a direct or inverse relationship between indicator value and risk, in contrast to the indicators that are color-coded). These indicators did not factor into our judgments of the domain, but we believe they remain relevant enough to include.

* indicates that data for this indicator were not available.

Applying the Framework to Identify Potential Hot Zones

As noted, for purposes of demonstrating the proof-of-concept application of this framework, we selected and collected indicator data for an illustrative set of countries in four different regions: sub-Saharan Africa, the Middle East, South Asia, and Southeast Asia. The summary (domain-level) results for all of these countries are presented in Table 3, with full (indicator-level) details available separately on the website for this perspective (see back cover for web address).

Beyond Mali, which successfully contained Ebola in 2014, and the three heavily affected countries in West Africa, six additional countries were identified as high risk. These included five countries in sub-Saharan Africa (Burkina Faso, Central African Republic, Chad, Côte d'Ivoire, and Ethiopia), and one in South Asia (Afghanistan). Four more countries are classified as medium risk but could be high risk (data are insufficient for at least one domain): Niger, Somalia, South Sudan, and Myanmar. Given the low level of economic development and poor governance and health systems in these countries, it is likely that they are at high risk. While DRC handled its Ebola outbreak well—with considerable help from the Médecins Sans Frontières nongovernmental organization (Sifferlin, 2014)—Somalia and South Sudan may present the most vulnerable cases of any of the countries examined here, given the endemic violence, instability, and poverty in these states. Not surprisingly, given sub-Saharan Africa's low level of economic development and poor quality of health systems, the vast majority of countries at high risk are located in this region.

Somalia and South Sudan may present the most vulnerable cases of any of the countries examined here, given the endemic violence, instability, and poverty in these states. Not surprisingly, given sub-Saharan Africa's low level of economic development and poor quality of health systems, the vast majority of countries at high risk are located in this region.

Eight countries are classified as medium risk: three in Africa (Angola, Guinea-Bissau, and Zimbabwe), two in the Middle East (Iraq and Syria), two in South Asia (Bangladesh and Pakistan), and one in Southeast Asia (Cambodia). We believe that these countries should be monitored but may not be the most vulnerable to future outbreaks. The nine remaining countries included in our illustrative assessment were classified as lower risk: two in Africa (Kenya and South Africa), two in South Asia (India and Sri Lanka), and five in Southeast Asia (China, Indonesia, Malaysia, Philippines, Thailand).

How Ebola Could Play Out in Potential Hot Zones: Three Illustrative Examples

We selected three potential hot zones to illustrate how an Ebola scenario could play out. We included two high-risk African countries with similarities to the three currently heavily affected

Table 3. Using the Risk Indicator Framework to Identify Countries Potentially Most Vulnerable to Ebola

Region/ Group	Country	Overall Risk	Political Risk	Economic Risk	Sociocultural Risk	Health Risk
Heavily affected countries	Guinea ^a	High	High	High	High	High
	Liberia	High	High	High	High	High
	Sierra Leone	High	Medium	High	High	High
Sub-Saharan Africa	Angola	Medium	High	Medium	Medium	Medium
	Burkina Faso	High	Medium	High	High	High
	Central African Republic ^a	High	High	High	High	High
	Chad ^a	High	High	High	High	High
	Côte d'Ivoire ^a	High	High	High	High	Medium
	DRC ^a	Medium ⁺	High	High	Medium	N/A
	Ethiopia	High	High	High	High	High
	Guinea-Bissau ^a	Medium	High	High	Medium	Medium
	Kenya	Lower	Medium	Medium	Medium	Medium
	Mali	High	Medium	High	High	High
	Niger	Medium ⁺	Medium	High	High	N/A
	Nigeria	Medium	High	Medium	High	Medium
	Senegal	Medium	Medium	Medium	Medium	High
	Somalia ^a	Medium ⁺	High	N/A	Medium	High
	South Africa	Lower	Low	Low	Medium	Medium
	South Sudan ^a	Medium ⁺	High	N/A	High	N/A
	Zimbabwe ^a	Medium	High	High	Medium	Medium
Middle East	Iraq ^a	Medium	High	Medium	Medium	Medium
	Syria ^a	Medium ⁺	High	N/A	Medium	Medium

Table 3—Continued

Region/ Group	Country	Overall Risk	Political Risk	Economic Risk	Sociocultural Risk	Health Risk
South Asia	Afghanistan ^a	High	High	High	High	High
	Bangladesh	Medium	Medium	High	Medium	High
	India	Lower	Medium	Medium	Medium	Medium
	Pakistan	Medium	High	Medium	Medium	High
	Sri Lanka	Lower	Medium	Medium	Medium	Medium
Southeast Asia	Cambodia	Medium	High	Medium	Medium	Medium
	China	Lower	Medium	Low	Medium	Low
	Indonesia	Lower	Medium	Medium	Medium	Medium
	Malaysia	Lower	Low	Medium	Medium	Medium
	Myanmar	Medium ⁺	High	N/A	Medium	N/A
	Philippines	Lower	Medium	Medium	Medium	Medium
	Thailand	Lower	Medium	Low	Medium	Medium

NOTE: N/A indicates that sufficient data were not available to classify the level of risk for the domain.

^a These countries had a level of “very high alert” or “high alert” in the 2014 Fragile States Index.

⁺ indicates that unavailable or missing indicator data did not permit complete assessment and may underestimate overall risk.

West African countries, as well as a third country that has other vulnerabilities of concern to the political and global health communities. We selected Côte d’Ivoire and Ethiopia from among the sub-Saharan African countries because they both emerged as considerably high risk on the matrix, in addition to representing other geographic and geopolitical concerns, which are often not easily captured in standard statistics. Côte d’Ivoire is at considerable geographical risk for Ebola because it shares a border with Guinea and Liberia and is very close to Sierra Leone. Ethiopia, on the other hand, is adjacent to the failed states of South Sudan and Somalia,

which are extraordinarily vulnerable given the lack of institutional capacity. For the latter reason, we also selected Pakistan, which is classified as medium risk but is of considerable concern because of its proximity to Afghanistan and because of the ongoing presence of conflict, which comes with an associated likely difficulty in managing a major disease outbreak.

Côte d’Ivoire

Côte d’Ivoire may be the next logical potential hot zone for Ebola, given its proximity and similarity to the three heavily affected

The fact that Côte d'Ivoire has thus far prevented Ebola from breaching its borders is an encouraging sign. It closed the border for a while and beefed up border security to enforce this edict. It may, however, be only a matter of time before the country has its first case, given its geographic proximity to the epicenter of the outbreak.

countries. It has a long, porous border with both Guinea and Liberia, and the country is still recovering from the effects of recent civil war, much like Liberia and Sierra Leone. With a population of more than 25 million people, Côte d'Ivoire is more populous than these three countries combined and represents a significant hazard from a domestic and regional standpoint were the virus to spread there.

Weaknesses

Côte d'Ivoire has suffered through two civil wars already this century, and its institutions continue to bear the marks of these conflicts. The political situation remains tenuous, and the economy has not fully recovered from the effects of the conflict and resultant instability. In line with these trends, Côte d'Ivoire registered as high risk in the political, economic, and sociocultural domains of the data matrix.

Not surprisingly, Côte d'Ivoire scored poorly on almost all measures of political risk. Of particular concern were indicators of government effectiveness, rule of law, and political stability

and absence of violence. The scars of the most recent civil war in 2010–2011 are slowly beginning to heal, but an Ebola outbreak would seriously test the capacity of the new regime, as well as the delicate postwar social fabric.

The economy of Côte d'Ivoire is also slowly rebounding as it resumes its position as a regional trading and transit hub. It still registers poorly on most development indicators, including the Human Development Index, the Knowledge Index, and measures of Internet penetration. It is highly dependent on agricultural prices, especially its leading export, cocoa; as a result, it is extremely vulnerable to external shocks and disruptions to the agricultural production cycle. Were an Ebola outbreak to hit the country during harvest and export season, it could cripple the country's economy and cause widespread economic suffering.

Mitigating Factors

Despite its political troubles, Côte d'Ivoire boasts the second largest economy in West Africa and has taken strides to shore up foreign investment. It scores well for per-capita income, and the country grew at an impressive 8.7 percent rate in 2014 (World Bank, 2015). Its health system scores reasonably well for a sub-Saharan African country, with an impressive number of health centers and a solid vaccination rate, notwithstanding a troublingly low number of physicians and a high infant mortality rate.

The fact that Côte d'Ivoire has thus far prevented Ebola from breaching its borders is an encouraging sign. It closed the border for a while and beefed up border security to enforce this edict. It may, however, be only a matter of time before the country has its first case, given its geographic proximity to the epicenter of the outbreak, and it is a country that should continue to be closely monitored.

Ethiopia

Ethiopia is a linchpin country in Africa because of its demographic and geopolitical importance. With a population of more than 90 million, it is the second largest nation in Africa behind only Nigeria. Its status as a regional transport and trading hub for East Africa, similar to that of Nigeria and Senegal in West Africa, means that an Ebola outbreak there could cripple economic networks and cut off inroads to other highly vulnerable, combustible countries in the region, such as Somalia and South Sudan.

Weaknesses

Ethiopia was one of only two non-failed or -fragile states to register as high risk in all four domains (Guinea was the other). With its vast and mountainous geography, substandard infrastructure, and poor transport and communication networks, Ethiopia would almost certainly face considerable difficulty in containing an Ebola outbreak. Furthermore, the degree to which it scored poorly in the economic and health domains is particularly troubling.

In the political realm, Ethiopia scored as high risk for political stability and absence of violence and for voice and accountability. An unstable environment with low government accountability and citizen voice augurs poorly for quickly containing an Ebola outbreak. Swift government action and effective communication were critical in successfully containing the disease in all the successful sub-Saharan African contexts; it may be unrealistic to expect the same kind of effective response from the Ethiopian government.

Socioculturally, Ethiopia looks very similar to most of the sub-Saharan African countries included in this report, with a low median age and low adult literacy that would make communicating effective ways to combat the spread of Ebola problematic. In the

event of an Ebola outbreak, solutions that were eventually effective in those countries, such as widespread public information campaigns and continual reinforcement of necessary containment measures (such as quarantine and adjustments to burial rites) should be immediately employed.

Ethiopia is a low-income country that scores poorly on development and connectivity indicators, as well as knowledge dissemination. It is a landlocked country with few resources spread out over a large, undereducated population. In short, it presents many of the same economic challenges as Guinea, Liberia, and Sierra Leone on a much larger scale. From a health perspective, Ethiopia has too few health professionals and health centers compared with international standards, along with very low levels of health expenditure per capita.

Mitigating Factors

Some mitigating factors could compensate for Ethiopia's systemic weaknesses. Despite its poor per-capita indicators, Ethiopia is still a large country with more economic and health resources at its disposal than other smaller states, such as Liberia and Sierra Leone. In fact, it scores highly for number of hospital beds, which may

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indicate solid capacity in large cities, albeit with a low overall number of health centers per capita nationwide.

Also in Ethiopia's favor is the fact that it is not likely to be abandoned or forgotten, given its aforementioned geopolitical importance. Ethiopia receives the third-highest amount of official development assistance of all developing countries, behind only Afghanistan and Vietnam (World Bank, 2014g). It is a magnet not only for aid but also foreign direct investment, and the long-standing presence of numerous international nongovernmental organizations would no doubt help to combat the domestic onset of Ebola.

The most serious consequence of an Ebola outbreak in Ethiopia may be beyond its borders in nearby conflict-affected states, such as Somalia and South Sudan, where it would be exponentially more difficult to address. Ethiopia presents enough of a potential risk to merit close monitoring and proactive efforts to mitigate the potential impact of a future Ebola outbreak.

Pakistan

If Ebola were to spread beyond Africa, Pakistan is one of the most dangerous potential destinations. A nation of 189 million

If Ebola were to spread beyond Africa, Pakistan is one of the most dangerous potential destinations. A nation of 189 million people at the junction of several regions, Pakistan combines the risk factors of a failed state with the transmission potential of a highly mobile and urbanized society.

people at the junction of South Asia, Central Asia, and the Middle East, Pakistan combines the risk factors of a failed state with the transmission potential of a highly mobile and urbanized society. The conflict-ridden Federally Administered Tribal Areas (FATA) are virtually shut off from external sources of medical or logistical assistance. The mega-city of Karachi, in which hundreds of thousands of FATA's 3 million residents live and work, is a nexus for global travel; it could provide a pathway for the initial entry of Ebola, and from there a route by which the disease might spread throughout Eurasia.

Weaknesses

Pakistan's national-level risk factors are comparable to those of Nigeria or Senegal, two of the African nations hit by Ebola that managed to effectively contain disease spread. At the subnational level, however, parts of Pakistan (most notably FATA, but also parts of Khyber Pakhtunkhwa and Balochistan) present a far more disturbing picture: FATA would probably rank on par with Afghanistan or the worst-hit nations of West Africa on most metrics considered. Scored separately, it emerges as high risk in each of the four domains.

In political metrics, FATA might score lower than all West African countries. The Pakistani government is essentially absent, apart from brutal counterinsurgency campaigns that have taken thousands of lives over the past decade; FATA would be rated near the bottom of the scale for government effectiveness, rule of law, political stability, accountability, and failed-state indexes. FATA exhibits deep popular alienation from the central government; lack of paved roads, communications, and logistical infrastructure; lack of even rudimentary medical facilities; and a fierce

distrust of medical personnel and international nongovernmental organizations.

In the sociocultural domain, FATA displays virtually no popular trust in any external authority—not the Pakistani government, not the United Nations, not medical authorities. Without such trust, few governments can contain an Ebola outbreak. Pakistan accounted for more than 85 percent of polio cases recorded in 2014, due largely to a popular fear of vaccination exacerbated by a 2010 Central Intelligence Agency operation involving medical personnel in FATA and neighboring areas (Polio Global Eradication Initiative, 2015).

The economic and health indicators in FATA mirror those of impoverished West African nations more closely than they do other parts of Pakistan. The national-level economic figures of Pakistan are elevated by centers of commerce, such as Karachi and Lahore. FATA has no such economic centers and very little formal economy. Likewise, the national-level health metrics of Pakistan reflect the resources available in the urbanized provinces of Punjab and Sindh rather than the remote, violent mountainous areas of FATA. No hard figures are immediately available on the number of doctors, nurses, and hospital beds in this region—but Pakistan's national-level figures are similar to those of Ebola-hit West African nations, and FATA's resources are very far below the national average.

Perhaps the greatest aggravating factor is the potential for FATA to serve as a distribution vector of disease to Pakistan's cities. A large percentage of working-age men in FATA seek employment in the Middle East, Africa, and further afield. This transient population, often flying to Persian Gulf destinations directly from Peshawar, could provide a two-way vector for the introduction of

Ebola to FATA, and for its onward global spread. (For more data on demographics of Karachi and other Pakistani cities, see Blank, Clary, and Nichiporuk, 2014.)

Mitigating Factors

Perhaps the most significant mitigating factor for Pakistan is its geographical isolation from the present-day Ebola hot zones. The Nigerian example suggests that even Pakistan's dysfunctional medical system might be able to contain an Ebola outbreak in an urban setting. This mitigating factor, however, should provide little reason for assurance. Even in cities such as Karachi and Lahore, Pakistan has seen institutional dysfunctions, ranging from uncontrolled political violence and major terrorist attacks to near-loss of nuclear assets. It is not hard to imagine a scenario in which a carrier of Ebola escapes detection (such as the traveler quarantined in New Delhi, India, in November 2014). Once in a large Pakistani city, Ebola could easily reach FATA—at which point it would be exceptionally difficult for the central government or any international institution to provide effective containment.

Tabletop Exercises to Inform Proactive Mitigation Efforts

The risk factors identified in this perspective represent long-term challenges for all of the countries involved. Given this reality, what actions can nations or regions undertake in the near term to mitigate the risks of an Ebola outbreak?

One approach to answering this question involves a type of policy-relevant tool known as a tabletop exercise (TTX). TTXs are tailored simulations intended to provide key organizations and planners the opportunity to run through a real-world scenario that

Because of the nature of responding to Ebola, many different actors should be involved in the tabletop exercise, typically including public health officials, medical experts, political leaders, transit authorities and border control, and the public safety and security sector.

will help to inform, prepare, and improve responses to an actual crisis. In essence, they are a low-burden way to collectively think through what to do to prepare for a future disaster. They serve as a tool for joint planning or decisionmaking. For example, a TTX on Ebola will allow key actors the ability to progress step by step through simulated yet realistic preparation for and response to an Ebola outbreak in a country that might be especially vulnerable but has not yet been affected, and to think through priority actions to take under such circumstances, including how to begin preparing now. Here we provide a brief outline for how a TTX might be structured, using Ethiopia as an illustrative example.

A TTX can be designed from the perspective of any set of decisionmakers. Examples could include a country's ministry of health or multiple ministries within a country. Alternatively, a TTX might be designed from the perspective of a specific donor country, such as the United States, or even the broader global community. The TTX outlined here was conceived with the U.S. government in mind (e.g., CDC, Department of Defense, Department of Health and Human Services, United States Agency for International Development, and others) to focus on proactive mitigation efforts

that could be undertaken now to address a myriad of Ebola-related concerns that could arise in a vulnerable country, with Ethiopia the example used to illustrate this. Because of the nature of responding to Ebola, many different actors should be involved in the exercise, typically including public health officials, medical experts, political leaders, transit authorities and border control, and the public safety and security sector, among others. International organizations, such as WHO and other United Nations agencies, can also be invited as exercise participants or observers.

The objectives of a TTX aimed at Ebola preparedness could be along the following lines:

- Identify concrete, realistic actions to proactively mitigate the potential impact of Ebola by identifying and prioritizing concrete actions to improve prevention, detection, and response.
- Decide upon the appropriate actors, their respective roles, and a mechanism for coordination among them in preparing for and responding to Ebola.

The structure of the TTX is designed to take the actors through a sequential process in which they examine the various dimensions of a potential Ebola outbreak while defining roles and developing strategies throughout the process. The exercise begins with a rollout of a country-specific scenario in a series of steps: It provides an explanation of the problem as it evolves over time and/or across various domains of activity. Overarching questions are provided to spur discussion about concrete actions that could and should be taken to address each area of interest. More detailed questions, or *probes*, are included for the facilitator to help guide the discussion toward concrete proposed actions. The scenario is designed to present a multitude of challenges to facilitate interaction among exercise participants so that the exercise itself is used

for coordinated planning and decisionmaking. During the exercise, a designated note-taker logs the central themes, discussion points, and decisions; the results and feedback are later consolidated and published as a structured After-Action Report.

The illustrative TTX outline below could be more fully developed and implemented. Most elements of this example could be used in TTXs for other countries, tailoring the scenarios to take into account traits of the specific country, such as political regime, terrain, and cultural practices.

Initial Scenario

Ethiopia has a large, dispersed population in a country characterized by austere geography and poor communication and transportation infrastructure. It is considered to be at high risk in terms of political, economic, sociocultural, and health considerations. Primary concerns are the lack of political stability; overall poverty, highlighted by low literacy; and inadequate availability of health professionals and health centers. The Ebola outbreak in West Africa (Guinea, Liberia, and Sierra Leone) has not yet been fully contained, but no cases have been identified in Ethiopia. Nonetheless, given the status of the country as a regional transport and trading hub, government officials are interested in preparing for Ebola so that they are confident they can respond quickly and effectively should a case appear within its borders.

Theme for discussion—Prevention/mitigation:

- What are realistic, actionable items that the host nation, the U.S. government, and other partners can take in Ethiopia before an Ebola outbreak to enhance preparedness?
 - Probes: What are the actions related to preparing medical facilities (patient isolation, personal protective equipment

and procedures for health care workers, supportive clinical care), public health systems (quality of disease surveillance; other potential detection modalities, such as social media; laboratory capacity and access to reference laboratory confirmation; establishment and training of rapid response teams), response systems (incident command structure, emergency operations center that could be activated when needed), communications among responders, and coordination mechanisms among key actors across government and with international partners?

Continuing Scenario

An Ethiopian national, infected with Ebola while working in Sierra Leone, has traveled home and passed through security at Addis Ababa Bole International Airport. He presented symptoms on the flight but was allowed by Ethiopian customs officials to leave after convincing them that the fever was due to malaria, a disease he had had multiple times before and knows well (as do the Ethiopian authorities). Blood tests, taken by airport monitoring officials, subsequently confirmed the presence of Ebola. His embarkation card

Ethiopia is considered to be at high risk in terms of political, economic, sociocultural, and health considerations. Primary concerns are the lack of political stability; overall poverty, highlighted by low literacy; and inadequate availability of health professionals and health centers.

indicates that he has returned to visit relatives, but the Ethiopian authorities only have a record of his entry into the country with no indication of his eventual destination.

Theme for discussion—Detection and early response to this initial (“index”) case:

- How will government authorities find this individual?
- How and when will the U.S. government learn about this case?
- Which government sectors and other actors should be involved, what are their respective roles, and how will they be coordinated?
- Probes: What information is needed? What actions are appropriate once the individual has been located? Is contact tracing needed and, if so, how will it be carried out? How will the patient be transported for care, and to what facility? Is a medical facility ready to receive and safely treat the patient? Are any border control measures needed at this point? If so, which ones and why?

Final Scenario

Authorities were not able to find the index case for several weeks, and the disease spread through the individual’s community and beyond, as people traveled to other villages and towns. The outbreak has now approached the border with South Sudan. Violent civil conflict has raged for months in South Sudan in a highly unstable political and social environment. The country is one of the poorest in sub-Saharan Africa and has little in the way of health infrastructure.

Theme for discussion—Outbreak response and prevention of cross-border spread:

- What actions are needed to contain the outbreak and prevent its spread beyond Ethiopia’s border into South Sudan?
- Who should be involved at this point?
 - Probes: What are the medical considerations (isolation and treatment facilities—Ebola treatment centers, trained and equipped health care workers, personal protective equipment, supportive clinical care)? What are possible public health measures (intensive case identification and contact tracing)? Who do you notify (WHO regional and headquarters offices, neighboring countries, the U.S. government, and other international partners)? What actions can be taken for border security (temperature screening at borders and relevant entry and exit points)?

Conclusions and Next Steps

This report describes a two-phase proof-of-concept approach to, first, identify countries potentially at risk and then, second, consider concrete mitigation actions. Our risk matrix facilitates examination of indicator data to help identify the countries potentially at high risk. The second phase of our proposed approach is to design and implement tailored tabletop exercises, along the lines outlined in abbreviated fashion in this report. Such exercises provide a means to jointly plan and prepare for a well-thought-out response to a future outbreak.

With this report, we hope to spur discussion and suggest further action to more fully develop and implement our proposed approach. For example, our risk matrix can be applied to other countries not included in our initial illustrative list. This will quite likely identify additional countries at high risk. We recognize that other geopolitical factors not reflected directly by global statistics

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also contribute to a country's vulnerability to Ebola, so such factors should be taken into account. We also recognize that the initial set of indicators included here would benefit from more rigorous development—for example, to add indicators, to weight or otherwise quantify the relative value or colinearity among indicators, and to validate their collective predictive value. Thus, we offer the proof-of-concept framework as an approach to be more fully developed and not as a definitive, validated tool. We also offer a notional outline of a potential tabletop exercise. Quite clearly, each exercise

must be fully developed—specifically tailored to a given country, to include both a relevant scenario and relevant areas for exploration.

In practice, some policymakers may wish to implement just one of the elements of our proposed two-phased approach while others may wish to implement both. Finally, the utility of this proof of concept is not inherently limited to Ebola. In principle, such a framework to identify countries or areas at risk and a proactive approach to mitigate that risk could also be applied to other types of public health or humanitarian disasters.

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About This Perspective

This perspective describes a two-part proof-of-concept approach that is intended to help decisionmakers first systematically assess the risk of the spread of the Ebola virus to potentially vulnerable countries and then consider actions that could be taken now to mitigate the impact of Ebola in such countries. Using a framework of widely available statistical indicators, this perspective examines factors associated with countries that have experienced severe outbreaks and with countries that quickly contained the disease; it then applies the framework to a larger number of countries to help identify those potentially most vulnerable to Ebola. Next, this perspective describes how Ebola could unfold in these vulnerable countries and outlines a tabletop exercise approach to facilitate planning for proactive mitigation efforts.

Table 3 of this perspective presents a compressed version of our proof-of-concept application of the proposed framework. For a PDF version of the indicator-level results for all countries, please visit www.rand.org/t/PE146. A Microsoft Excel version of that expanded table is available upon request.

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