

Strengthening Health Systems While Responding to a Health Crisis: Lessons Learned by a Nongovernmental Organization During the Ebola Virus Disease Epidemic in Sierra Leone

Corrado Cancedda,^{1,2,4} Sheila M. Davis,¹ Kerry L. Dierberg,^{1,2} Jonathan Lascher,¹ J. Daniel Kelly,^{2,7,10} Mohammed Bailor Barrie,^{1,4,10} Alimamy Philip Koroma,¹³ Peter George,¹⁵ Adikali Alpha Kamara,¹⁴ Ronald Marsh,¹¹ Manso S. Sumbuya,¹² Cameron T. Nutt,^{1,4} Kirstin W. Scott,⁴ Edgar Thomas,¹ Katherine Bollbach,¹ Andrew Sesay,^{1,10} Ahmidu Barrie,^{1,10} Elizabeth Barrera,¹ Kathryn Barron,¹ John Welch,^{1,5} Nahid Bhadelia,^{1,6} Raphael G. Frankfurter,^{1,10} Ophelia M. Dahl,¹ Sarthak Das,¹ Rebecca E. Rollins,¹ Bryan Eustis,¹ Amanda Schwartz,¹ Piero Pertile,¹ Ilias Pavlopoulos,¹ Allan Mayfield,¹ Regan H. Marsh,^{1,3,4} Yusupha Dibba,^{1,10} Danielle Kloeppe,¹ Andrew Hall,¹ Karin Huster,^{1,16} Michael Grady,¹ Kimberly Spray,¹ David A. Walton,^{1,2} Fodei Daboh,^{1,10} Cora Nally,¹ Sahr James,^{1,10} Gabriel S. Warren,¹ Joyce Chang,¹ Michael Drasher,¹ Gina Lamin,^{1,10} Sherry Bangura,^{1,10} Ann C. Miller,⁴ Annie P. Michaelis,¹ Ryan McBain,¹ M. Jana Broadhurst,¹ Megan Murray,^{1,2,4} Eugene T. Richardson,^{1,2,8,9} Ted Philip,¹ Gary L. Gottlieb,¹ Joia S. Mukherjee,^{1,2,4} and Paul E. Farmer^{1,2,4}

¹Partners In Health, ²Division of Global Health Equity, and ³Department of Emergency Medicine, Brigham and Women's Hospital, ⁴Department of Global Health and Social Medicine, Harvard Medical School, ⁵Department of Anesthesiology, Perioperative, and Pain Medicine, Boston Children's Hospital, and ⁶Division of Infectious Diseases, Boston University School of Medicine, Massachusetts; ⁷Department of Medicine, University of California—San Francisco School of Medicine, ⁸Division of Infectious Diseases, Stanford University School of Medicine, and ⁹Department of Anthropology, Stanford University, Palo Alto, California; ¹⁰Wellbody Alliance, ¹¹Koidu Government Hospital, ¹²District Health Management Team, Koidu, ¹³Princess Christian Maternity Hospital, ¹⁴Ministry of Health and Sanitation, Freetown, and ¹⁵Port Loko Government Hospital, Port Loko, Sierra Leone; and ¹⁶Department of Global Health at the University of Washington, Seattle

An epidemic of Ebola virus disease (EVD) beginning in 2013 has claimed an estimated 11 310 lives in West Africa. As the EVD epidemic subsides, it is important for all who participated in the emergency Ebola response to reflect on strengths and weaknesses of the response. Such reflections should take into account perspectives not usually included in peer-reviewed publications and after-action reports, including those from the public sector, nongovernmental organizations (NGOs), survivors of Ebola, and Ebola-affected households and communities. In this article, we first describe how the international NGO Partners In Health (PIH) partnered with the Government of Sierra Leone and Wellbody Alliance (a local NGO) to respond to the EVD epidemic in 4 of the country's most Ebola-affected districts. We then describe how, in the aftermath of the epidemic, PIH is partnering with the public sector to strengthen the health system and resume delivery of regular health services. PIH's experience in Sierra Leone is one of multiple partnerships with different stakeholders. It is also one of rapid deployment of expatriate clinicians and logistics personnel in health facilities largely deprived of health professionals, medical supplies, and physical infrastructure required to deliver health services effectively and safely. Lessons learned by PIH and its partners in Sierra Leone can contribute to the ongoing discussion within the international community on how to ensure emergency preparedness and build resilient health systems in settings without either.

Keywords. Ebola; Sierra Leone; emergency response; health system strengthening.

The epidemic of Ebola virus disease (EVD) in West Africa, responsible for over 28 616 infections and 11 310 deaths through May 2016, has caused great suffering across a region already burdened by extreme poverty, recent histories of civil conflict, and weak health systems [1]. Sierra Leone, Liberia, and Guinea are among the countries with the world's lowest levels of public investment in health. Therefore, it was not surprising that their under-resourced and understaffed hospitals and health centers were the fault lines along which the EVD epidemic exploded. Nor is it

surprising that caregivers—both clinicians who lacked the personal protective equipment necessary to halt transmission and those who, by necessity, nursed sick family members at home—were infected at disproportionate rates. More than 500 health professionals have died from EVD since this epidemic began.

Multilateral organizations such as the United Nations and the World Health Organization, bilateral and philanthropic donors, and international nongovernmental organizations (NGOs) were initially slow to respond to the EVD epidemic. Eventually, exponentially increasing rates of new infections in West Africa and a handful of cases exported from West Africa to the United States and Europe in late 2014 spurred sizable, if belated, commitments of financial and human resources from the international community. While rates of new infections began to fall steeply as the EVD epidemic entered its second full year [2], case-fatality rates remained widely divergent across settings, and small clusters of cases continued to emerge across the region through the end of 2015 and into 2016. As the EVD

Correspondence: C. Cancedda, Harvard Medical School, Department of Global Health and Social Medicine, 641 Huntington Ave, Boston, MA 02115 (ccancedd@gmail.com).

The Journal of Infectious Diseases® 2016;214(S3):S153–63

© The Author 2016. Published by Oxford University Press for the Infectious Diseases Society of America. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs licence (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial reproduction and distribution of the work, in any medium, provided the original work is not altered or transformed in any way, and that the work is properly cited. For commercial re-use, contact journals.permissions@oup.com. DOI: 10.1093/infdis/jiw345

epidemic subsides, Sierra Leone, Guinea, and Liberia face the daunting challenge of building health systems resilient enough to protect their populations from other health crises (whether current, future, acute, or chronic). They face this challenge be-
nefit of health professionals.

While much has been written from policy and public health perspectives about the response to the EVD epidemic, less has been written from the perspective of those called to implement these policies and provide clinical care to patients. As implementing partners in the emergency Ebola response, international NGOs delivered a wide range of health services, which included identifying new infections in Ebola-affected communities, providing clinical care to the critically ill in Ebola treatment units (ETUs), advocating for and employing survivors of Ebola to help with the response, and reopening district hospitals and health centers shuttered at the height of the epidemic.

Partners In Health (PIH), an international NGO with more than 30 years of experience working with the public sector to deliver health services to poor and marginalized patients in 10 countries around the world [3], began working in Sierra Leone in October 2014 at the invitations of the national government and Wellbody Alliance, a local NGO that has delivered community-based health services in the eastern part of the country since 2006. In this article, we outline the strategic choices made, the guiding principles implemented, the activities pursued, and the lessons learned during PIH's participation in the emergency Ebola response. We also describe PIH's simultaneous efforts to strengthen the health system in 4 of Sierra Leone's most Ebola-affected districts (Port Loko, Kono, Kambia, and Western Area Urban; Figure 1). During the same time frame, PIH launched a response to help contain the EVD epidemic in Liberia, which will be described in a future article [4].

THE STATE OF SIERRA LEONE'S HEALTH SYSTEM AND OF THE EVD EPIDEMIC AT THE TIME OF PIH'S ENGAGEMENT

Sierra Leone's health system was unprepared to tackle the formidable challenge posed by the EVD epidemic. One careful study in 2010 compared the capacity of Sierra Leone's hospitals to perform essential surgery with that of US Civil War field hospitals, concluding that the latter were "equivalent and in many ways superior" [5, p 1743]. Another recent study assessed the capacity of district hospitals across the country to adopt universal precautions and to implement best practices for infection prevention and control, concluding that "items such as gloves, eye protection, and aprons were routinely in limited supply" and that "Government facilities were unacceptably deficient in protective supplies" [6, p 1196]. In the district of Port Loko, the main public hospital was found to be without electricity, running water, or a regular supply of oxygen [7]. Not surprisingly, by autumn 2014 the same hospital would be among the hardest-hit by nosocomial transmission of Ebola to health professionals in Sierra Leone.

In late October 2014, Sierra Leone was reporting over 500 new EVD cases per week (with more than 100 cases each week in the district of Port Loko alone—the highest Ebola incidence ever documented in a rural area) [8]. The British government warned that this figure would exceed 1000 by early December without a dramatically accelerated response from the international community [9]. Virtually no beds were available for patients with EVD at any of the health facilities in Port Loko [10], with the exception of an isolation ward in the district's main public hospital, which was filled to more than twice its capacity and dangerous for both patients and health professionals [11]. Although the Government of Sierra Leone was converting an abandoned vocational school into a 108-bed ETU, no international NGO was yet present in Port Loko to help provide clinical care to patients with EVD.

An assessment conducted that month (October 2014) by the Centers for Disease Control and Prevention revealed that most health professionals in Port Loko had received no formal training on infection prevention and control, that stocks of personal protective equipment were insufficient in quantity and did not meet internationally recognized quality standards, and that the number of health professionals was inadequate across all levels of the health system [12]. Furthermore, 23 health professionals had been infected with Ebola in the district between May and October 2014 [13]. As a result, basic health services, limited in scope and reach before the EVD epidemic, had collapsed: by mid-October, rates of deliveries in health facilities and malaria cases diagnosed and treated had fallen by 49.1% and 60.5%, respectively, in Port Loko when compared to rates in October 2013 (Figure 2) [14].

PIH'S GUIDING PRINCIPLES FOR THE EMERGENCY EBOLA RESPONSE

To guide its emergency Ebola response in Sierra Leone, PIH adopted the same principles that had been developed and refined over 3 decades of working to strengthen the health systems of low-income countries while responding to humanitarian and health crises (from earthquakes and floods to epidemics of cholera and multidrug-resistant tuberculosis).

PIH's main strategic goal is to be of service to national governments and support the public sector in areas (both geographic and programmatic) where the need is the greatest. In Sierra Leone, the National Ebola Response Center, the governance body responsible for leading the emergency Ebola response, attempted to coordinate the contributions of each donor and implementing partner from the international community. This was a daunting task, given the large number of partners involved, each with unique expertise and priorities, and the dynamic nature of the epidemic. PIH sought to support the National Ebola Response Center and the Ministry of Health and Sanitation (MoHS) by being a flexible partner and by tailoring its activities to address evolving local needs. This meant following the recommendations of the National Ebola Response Center and of the

PIH-SUPPORTED FACILITIES SIERRA LEONE

January 14, 2015



Figure 1. Health facilities supported by Partners In Health in Sierra Leone, 2014–2015. The capacity at each unit is as follows: Maforki Ebola treatment unit (ETU), 108 beds; District Hospital holding units, 60 beds; 12 community care centers (CCCs), 195 beds; and PCMH holding unit, 11 beds.

MoHS when selecting the districts and, within those districts, the health facilities to support. This also meant, at times, either conducting entirely new activities (such as initiating an Ebola survivor program) or opting out of activities (such as delivering community-based health services in 2 of 4 PIH-supported districts) in which PIH had significant expertise but were already underway or promised by other implementing partners.

To demonstrate commitment to building capacity within the public sector, PIH has traditionally pursued a 3-pronged

approach: (1) reinforcing ongoing government efforts with additional health professionals (both local and expatriate) and medical supplies, (2) improving and/or developing new policies and procedures for health service delivery, and (3) refurbishing the infrastructure of existing government-run health facilities [15]. In Sierra Leone, this meant that PIH would not build and operate a new purpose-built ETU independently (which would have taken up to 8 weeks) but would instead devote substantial human and financial resources to working in and

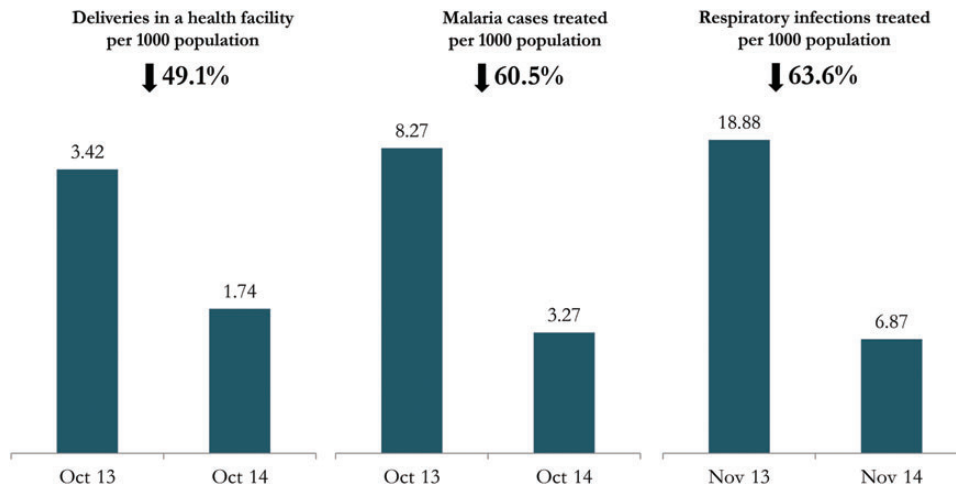


Figure 2. Disruption of essential maternal and child health services in Port Loko District.

improving health facilities already operated by the MoHS. As a result, PIH was able to scale up delivery of health services for patients with EVD and support to Sierra Leonean clinicians rapidly, in part by leveraging existing resources available to and partnerships established by the MoHS.

In the countries where it operates, PIH seeks to find the balance between the quality, scale, and safety of its activities. Therefore, in Sierra Leone, PIH decided to support 17 health facilities across 4 districts (Figure 1) and, within those facilities, sought to both improve the quality of clinical care provided to patients with EVD and ensure the safety of the clinicians providing such care. The response of the international community to previous EVD outbreaks in rural Africa had been characterized by placing more emphasis on halting transmission relative to improving outcomes for those already infected, a choice that was partly responsible for the abysmal case-fatality rates reported in the literature [16, 17]. However, policies that pit prevention against care deter sick individuals from going to health facilities, undermine trust, and hinder efforts to refer, isolate, rapidly diagnose, and effectively treat patients with viral hemorrhagic fevers [16, 18–20]. In Sierra Leone, PIH and other international NGOs sought to move away from a prevention-only focus (which prioritized isolation of patients with EVD over provision of clinical care) to an integrated approach, whereby the prevention of new infections and the improvement of patient outcomes would be equally prioritized and explicitly recognized as mutually interdependent objectives [21].

Last, effective delivery of health services requires a continuous and integrated chain of activities that links together hospitals, health centers, and communities. To achieve continuity and integration, PIH works to strengthen the public sector across all levels of the health system. In Sierra Leone, PIH believed that the emergency Ebola response should be no exception (Figure 3). For example, supporting an ETU would not suffice to contain the

EVD epidemic if communities in the surrounding areas were not effectively mobilized to recognize the symptoms of EVD and refer potentially infected individuals as early as possible to that facility [18]. Conversely, social mobilization and educational outreach efforts in those communities alone would not convince individuals with symptoms of EVD to seek admission in an ETU unable to provide high-quality and dignified clinical care, nor would transmission in the community be halted only by ubiquitous billboards discouraging either the consumption of bush meat (since all documented EVD cases in 2014 and 2015 spread from human to human) or prohibiting any contact with individuals with symptoms of EVD (since, in the absence of an ambulance service to transport them to a nearby ETU, this would mean leaving loved ones and neighbors to die) [22]. Such disruptions in the health service delivery chain had in fact facilitated the early spread of Ebola in West Africa and complicated efforts to build the trust required for effective disease surveillance and accurate reporting, to say nothing of early diagnosis and prompt initiation of effective clinical care [20, 23, 24].

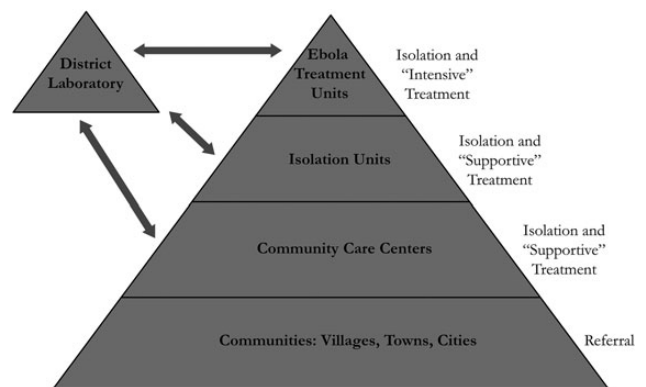


Figure 3. Levels of health service delivery in the emergency Ebola response.

IMPLEMENTING THE EMERGENCY EBOLA RESPONSE

By February 2015, PIH was working across 4 districts and supporting 17 health facilities that were providing clinical care to patients with EVD (totaling 374 beds; Figure 1). Those health facilities included a 108-bed ETU in Port Loko (the ultimate destination for all patients with EVD diagnosed in that district, where the most intensive clinical care was provided; Figure 4); 4 holding units (isolation wards at regular health facilities for patients with symptoms of EVD), including one within Princess Christian Maternity Hospital in Freetown (Sierra Leone's main maternity hospital); and 12 community care centers (smaller decentralized health facilities where individuals with symptoms of EVD were first isolated and stabilized prior to referral to an ETU). PIH also provided logistical support to 2 biocontainment laboratories with diagnostic capability operated by Erasmus University and funded by the Dutch government.

Between October 2014 and June 2015, approximately 1900 patients were admitted to the 17 PIH-supported health facilities, and 366 of those patients received a diagnosis of EVD. Based on a preliminary analysis, the overall case-fatality rate for patients with a diagnosis of EVD in the Port Loko ETU was 49%, which contrasts with anecdotal reports of rates exceeding 80% in the

same facility prior to PIH's engagement. Among the 274 pregnant women who were admitted to the holding unit at Princess Christian Maternity Hospital in Freetown, 28 received a diagnosis of EVD. Nine of them (and their fetuses) died, while 19 were stabilized and referred to one of the ETUs in Freetown. Mortality for patients with a diagnosis of EVD in the Port Loko ETU varied month to month and, as in other cohorts [8, 25–28], was higher in infants (71% among those aged <12 months) and patients aged >45 years (74%) than in adolescents and young adults.

There were obvious risks associated with providing clinical care to large numbers of patients with EVD in health facilities not designed specifically for this purpose. From the beginning, the MoHS and PIH worked together to both improve the quality of clinical care provided to patients with EVD and to reduce the risk of transmission among health professionals. Clinical protocols were refined through an iterative process, and PIH sought to standardize them across all the 17 health facilities supported. Clinicians in the Port Loko ETU and within Princess Christian Maternity Hospital's holding unit implemented aggressive intravenous fluid resuscitation, closer monitoring of inputs and outputs, management of electrolyte disturbances (measured by point-of-care i-Stat devices [Abbott Laboratories, Abbott Park, Illinois]), and enhanced nutritional support during and after patients' admission. To improve the safety profile of the health facilities, the MoHS and PIH worked together to strengthen water and sanitation systems, train local health professionals in infection prevention and control, and bolster supply chains for personal protective equipment. One expatriate clinician working for PIH became infected (and fully recovered following medical evacuation to the United States), while 3 health professionals employed by the MoHS who had worked alongside PIH clinicians became infected (1 died and 2 recovered after being treated at an ETU operated by the British military).

PIH also sought to strengthen the emergency Ebola response at the community level. By June 2015, approximately 800 community health workers employed by PIH and Wellbody Alliance had conducted over 1.1 million home visits in Ebola-affected communities to identify individuals with symptoms of EVD, referred 357 of those individuals to PIH-supported health facilities, monitored hundreds of family members of patients with EVD who were under quarantine at home, and delivered educational messages on Ebola to nearly 900 000 Sierra Leoneans. These community health workers were trained to couple education about Ebola with psychosocial support and empathetic counseling of Ebola-affected households and individuals. Especially in Kono, many of these community health workers had previous experience delivering health services to poor and underserved patients with human immunodeficiency virus (HIV) infection and other chronic diseases through Wellbody Alliance. As a result, they were able to leverage local



Figure 4. A, Clinicians from the Ministry of Health and Sanitation and from Partners In Health Providing Clinical Care to Patients at the Ebola Treatment Unit in Port Loko. B, Ebola survivors employed by Partners In Health ride through Freetown, Sierra Leone, to recruit other survivors to work for the emergency Ebola response. Photos are by Rebecca E. Rollins.

knowledge, trust, and bonds of solidarity to educate entire villages on the importance of identifying individuals with symptoms of EVD and seeking early diagnosis and referral to health facilities.

Survivors of Ebola remain vulnerable to both clinical and social sequelae, often experiencing lingering physical ailments, severe stigmatization, and economic marginalization [29]. As a result, PIH launched an Ebola survivor program that grew to include >900 survivors in the Port Loko, Kono, and Western Area Urban districts between October 2014 and May 2015. The program enrolls survivors in vocational and literacy training, pays school fees to help children who either survived Ebola or were orphaned by it, and directly employs survivors to lead social mobilization and community outreach efforts in Ebola-affected communities.

PIH partnered with the MoHS, GOAL Global, International Medical Corps, Christian Blind Mission, and the World Health Organization to operate a clinic for survivors of Ebola within the Baptist Eye Hospital in Port Loko. Between March and August 2015, >650 survivors were evaluated at this facility. Additionally, PIH partnered with the MoHS, GOAL, Médecins Sans Frontières, Médecins du Monde, Welthungerhilfe, Sightsavers, the University of Toronto, the Emory Eye Center, and the World Health Organization to launch a national initiative to screen and treat survivors for long-term ocular complications of EVD. As in previous outbreaks [30–32], many survivors present with arthralgias and myalgias, vision impairment, hearing loss, persistent fatigue, and other lingering physical ailments [33, 34]. More than 2700 survivors were screened for ocular complications of EVD through December 2015; approximately 1 in 5 received a diagnosis of uveitis (a condition that, when left untreated, can lead to blindness) and treated with topical or systemic corticosteroids. While providing clinical care to survivors, PIH and other partners were also generating knowledge on how

to diagnose and treat the clinical sequelae of EVD and training clinicians across the country in the management of those sequelae (Sierra Leone had only 2 ophthalmologists until 2015, one of whom practiced in the Port Loko clinic; Figure 5).

PIH considered the development and utilization of novel vaccines, diagnostic assays, and therapeutic tools to be an essential priority for the emergency Ebola response. PIH leveraged the resources and expertise available through its affiliation with Harvard Medical School and partnered with Public Health England and other stakeholders to conduct field validation studies of 2 novel rapid diagnostic tests for EVD: a point-of-care finger stick lateral flow immunoassay (ReEBOV Antigen Rapid Test Kit; Corgenix, Broomfield, CO) and an automated, 2-target, sample-to-answer reverse transcription–polymerase chain reaction (RT-PCR) assay (Xpert Ebola Assay; Cepheid, Sunnyvale, California). Both assays were shown to be highly sensitive and specific in comparison with the laboratory-based RT-PCR tests used for routine diagnosis of EVD [35, 36]. The Xpert assay is now being considered for scale-up across West Africa as part of ongoing surveillance efforts; both assays are being considered as key components of diagnostic algorithms to be implemented during the response to future EVD epidemics. The participation of Sierra Leonean laboratory technicians and health professionals in these studies ensured that local staff were trained in the diagnosis of EVD and provided an assessment of the feasibility of integrating point-of-care assays into future testing strategies in local health facilities.

HEALTH SYSTEM STRENGTHENING IN THE MIDST OF THE EPIDEMIC

Throughout much of 2014, government-run health facilities where regular health services had been routinely delivered were emptied of clinicians (who had died from EVD, were recruited to serve in an ETU, or refused to work in highly unsafe

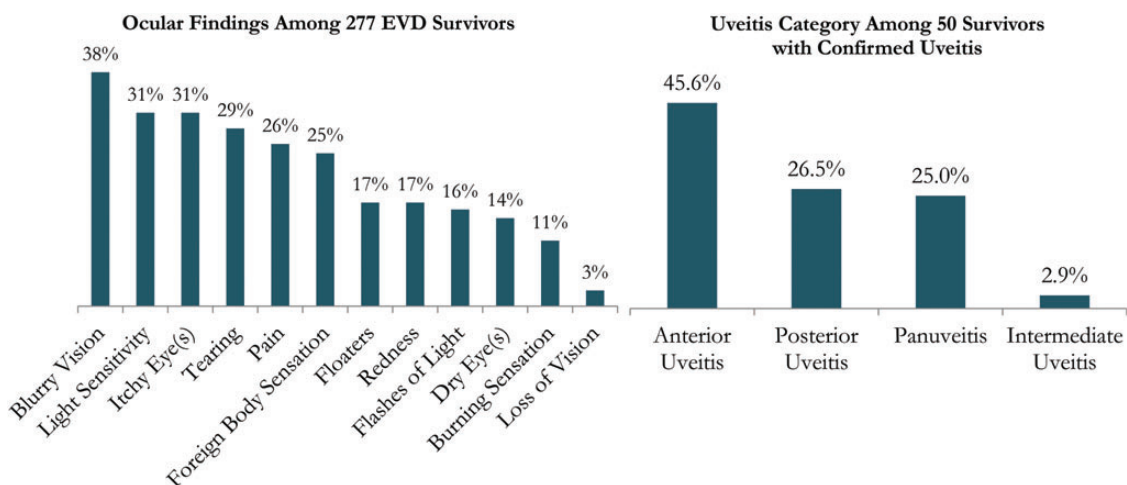


Figure 5. High prevalence of ocular symptoms and uveitis among survivors of Ebola at Partners In Health–supported clinic in Lunsar, Port Loko District. Abbreviation: EVD, Ebola virus disease.

environments) and patients (who had lost faith in the public sector) [37, 38]. Rates of premature mortality—already among the world’s highest, especially among women and children—increased dramatically as hospitals and health centers were closed, vaccination coverage plummeted, and supply chains for essential medications were interrupted [39]. Furthermore, attempting to contain the spread of Ebola only by building new ETUs and community care centers was not enough to halt transmission: the vast majority (90.3%) of health professionals infected with Ebola virus in Port Loko before PIH’s arrival, for example, were exposed at hospitals and health centers not specifically devoted to the treatment of EVD [40].

From the beginning of the emergency Ebola response, the MoHS emphasized that only long-term partnerships with donors and international NGOs would allow Sierra Leone to recover from the EVD epidemic. PIH therefore agreed to remain in country beyond the duration of the response, to help the MoHS and partners such as Wellbody Alliance resume the delivery of regular health services and strengthen the health system. In 2014 and 2015, PIH clinicians and logistics personnel worked alongside local health professionals to operate district hospitals and health centers, restart vaccination and antenatal care programs, respond to outbreaks of measles resulting from plummeting immunization coverage [41], and strengthen infection prevention and control policies and procedures. The health center operated by Wellbody Alliance and supported by PIH clinicians in Kono was one of the few health facilities in Sierra Leone that continued to treat patients with HIV infection and tuberculosis during the epidemic.

In April 2015, the MoHS outlined its long-term strategy to strengthen Sierra Leone’s health system. The following goals are at the core of the strategy, which have informed PIH’s strategic objectives for the next 5 years in Sierra Leone: (1) ensuring the safety of health professionals and patients, (2) resuming and improving the quality of basic health services, (3) capacity building and career development for health professionals, (4) robust and routine disease surveillance and community mobilization (Table 1). Over the coming years, PIH will leverage its long-standing partnerships with Harvard Medical School and Brigham and Women’s Hospital to support and strengthen the public sector and to ensure that, as in Rwanda, health service delivery across all levels of care (hospital, health center, and community) is linked to training and to the generation of new knowledge [42].

CHALLENGES AND LESSONS LEARNED

PIH faced significant challenges throughout the implementation of the emergency Ebola response and learned valuable lessons in the process of addressing them. While some resulted from factors inherent to PIH’s structure, others can only be understood within the broader context of the international

Table 1. Alignment Between Ministry of Health Goals and Partners in Health’s (PIH’s) Strategic Objectives and Activities for Long-Term Health System Strengthening

Health System Strengthening Goal	PIH’s Strategic Objectives and Activities for Next 5 Years
Ensuring the safety of patients and health workers	Developing infrastructure and protocols and providing training in non-Ebola public sector health facilities to improve infection control for EVD and other infectious diseases (ie, Lassa fever, measles, and cholera)
Resuming basic health services	Improving staffing, equipment, and infrastructure at district hospitals and health centers; resuming basic health services for maternal and child care, malnutrition, HIV infection, and tuberculosis; launching and sustaining programs to care for EVD survivors; and expanding or improving health services for other medical conditions (essential surgery, noncommunicable diseases, mental health, and cancer)
Career development and capacity building for health workers	Continuing professional development of local health workers through training, mentoring, and supervision; creating partnerships with local and international academic institutions to strengthen graduate and postgraduate health professional education
Ongoing disease surveillance and community mobilization	Creating a network of community health workers focused on integrated management of childhood and adult illnesses (and able to screen for EVD), maternal and child care, malnutrition, HIV infection, and tuberculosis; expanding the network of community health workers to include other illnesses (non-communicable diseases and mental health)

Abbreviations: EVD, Ebola virus disease; HIV, human immunodeficiency virus.

community’s current frameworks for emergency preparedness and for long-term development (Figure 6).

First, it is essential to build capacity for health governance and management within the public sector of low-income countries. In Sierra Leone, the MoHS was initially overwhelmed by

1. The capacity of local governments and ministries of health to articulate their strategies and coordinate the contributions of donors and implementing partners must be built before a health crisis occurs.
2. As the acuity and severity of health crises increases globally, implementing partners must be ready to intervene with greater flexibility, at a faster pace, and at a greater scale.
3. Improving the quality of clinical care is a strategic, epidemiologic, and moral imperative.
4. Knowledge generation must be integrated with health service delivery, and training and must go hand in hand with implementation, not lag behind.
5. Donors must facilitate rapid and effective implementation by minimizing restrictions on ways in which funds can be spent.
6. Donors and implementing partners should eliminate any dichotomy between the response to an acute health crisis and the effort to strengthen a chronically weak health system and should ensure continuity between both.

Figure 6. Lessons learned during the emergency Ebola response by partners in health.

the scale and complexity of the EVD epidemic. The establishment of the National Ebola Response Center was critical to the scale-up and eventual success of the emergency Ebola response because it improved coordination between donors and implementing partners and was able to mobilize what scant financial and human resources were available in the country. Representatives from Sierra Leone's MoHS served on the Center's leadership committee, an arrangement that has facilitated the transition from the emergency Ebola response to a long-term health system strengthening strategy. To support this transition, PIH has seconded staff within the MoHS to assist local policymakers with administrative duties and operational challenges. However, to prevent future health crises from having such a devastating impact in West Africa, it will be important to build capacity within the region's health sectors for emergency preparedness well before their onset. Some international NGOs (such as the Clinton Health Access Initiative and the Africa Governance Initiative) are now tackling the important priority of health governance and management both regionally and globally, but more remains to be done.

Second, increasing the speed by which the international community responds to another health crisis in the future is key. Like many other international NGOs, PIH began working in West Africa well into the course of the EVD epidemic and could have mobilized earlier than in autumn 2014. This delay was due in part to the limited number of experienced clinicians and logistics personnel available within the organization for immediate deployment. PIH is now considering the establishment of emergency teams that can be deployed in the event of similar health crises. The World Health Organization and other international NGOs are weighing similar solutions [43]. Additionally, for international NGOs like PIH to expand their reach, it will be necessary to recruit from a pool of less experienced expatriates willing to be trained and deployed for a limited period. Short-term clinicians and logistics personnel can add significant value but require considerable mentoring and supervision, as well as sufficient logistical and mental health support, to perform effectively in settings of privation and risk. The establishment of standardized procedures and processes to rapidly recruit, evaluate, train, deploy, and support short-term health professionals is critical and will require ongoing adjustments by PIH and other implementing partners [44].

Many clinicians at academic medical centers and other institutions with global health programs in the United States who wished to volunteer with PIH and other international NGOs in West Africa faced substantial administrative and legal barriers to doing so. Some who were deployed by PIH in Sierra Leone were obligated to return prematurely to the United States to attend on the inpatient service of their employing academic medical centers at a time when their expertise was sorely needed in Sierra Leone. Others had to quit their jobs to volunteer in Sierra Leone because their employers denied them unpaid leave.

Academic medical centers and other employing institutions should devise standardized policies regarding the deployment of their clinicians and the coverage of domestic professional duties during humanitarian and health crises.

Third, raising the quality of clinical care provided to patients remains imperative for both halting transmission and saving lives. Initially, the EVD epidemic was difficult to contain partly because patients avoided going to health facilities that were unable to provide high quality and dignified clinical care, while clinicians understandably feared for their own safety [45]. In Sierra Leone, the establishment of an ETU operated by the British military and capable of providing intensive supportive care more likely increased the retention of health professionals [46]. Access to high-quality clinical care for viral hemorrhagic fevers and other infectious diseases must be ensured not only for local clinicians, but also for the general population in the event of future epidemics.

The case-fatality rate for patients with EVD treated at the PIH-supported ETU in Port Loko remained too high, at 49%. While the case-fatality rate across the region was higher, at 64%, among admitted patients and exceeded 90% among those who remained at home [8], 2 ETUs near Freetown reported case-fatality rates of 31% and 37% in large cohorts following the implementation of more-intensive clinical protocols similar to those implemented by PIH [47, 48]. In PIH-supported health facilities, clinicians from Sierra Leone, the United States, and Cuba (in the Port Loko ETU) routinely provided intravenous fluid resuscitation, treatment of electrolyte disturbances, and even intra-osseous fluid resuscitation for infants and small children with hypovolemic shock caused by EVD [49, 50].

However, despite PIH's best efforts and the heroic dedication of all clinicians involved, the conditions within PIH-supported health facilities remained far below the standards of an average community hospital in the United States, much less those of an intensive care unit. Conversely, the case-fatality rate for those evacuated to medical centers in Europe or North America, where patients with EVD had access to high-quality supportive and critical care, remained <20% (0% among American clinicians, some of whom were shown to lose up to 10 L of fluid per day at rates that could never be replenished by oral rehydration alone) [51]. Debates regarding the reasons underlying such divergent outcomes will continue [16, 17, 52–54]. Yet it is clear that when patients have access to modern medicine, even without taking into account experimental drugs (such as specific antivirals, monoclonal antibodies, or small interfering RNA molecules), EVD is a treatable disease; the vast majority of patients infected with Ebola in West Africa did not—and still do not—have such access [55, 56].

PIH clinicians sought to challenge the notions that most pregnant women with EVD would die even with treatment—based on a case series of 15 women who received little supportive care during the 1995 EVD outbreak in Kikwit [57]—and

that caring for them posed too great a risk for health professionals. The final outcomes for all 28 pregnant women who received a diagnosis of EVD at Princess Christian Maternity Hospital are not known because those who were stabilized were referred to other ETUs. However, the opening of a holding unit at Sierra Leone's only tertiary-level health facility for women with complications of child birth meant that not only those 28 women, but hundreds of febrile women who had to be isolated and treated in the PIH-supported holding unit until they tested negative for EVD were able to deliver in a health facility when they might otherwise not have received any clinical care. Other international NGOs, including Médecins Sans Frontières, sought to demonstrate that EVD in pregnancy is treatable [58, 59]; more work remains to understand and address the factors responsible for high rates of fetal death.

Fourth, given the importance of timely data collection, surveillance, and quality improvement in the face of a dynamic epidemic, PIH sought to monitor and evaluate its activities from the outset of its engagement in Sierra Leone. As with many other responding organizations, the amount of financial and human resources devoted by PIH to monitoring, evaluation, and research was initially inadequate, leading to delays in PIH's ability to document what was being done and to lack of reliable data capturing the first 2 months of implementation. Despite these challenges, PIH was able to generate important knowledge regarding clinical care of patients with EVD and survivors [34] and to evaluate 2 point-of-care diagnostic assays that may significantly improve ongoing surveillance and preparedness for future EVD epidemics [35, 36]. Notably, these validation studies were possible to conduct under challenging field conditions because they were linked to ongoing efforts to support local clinicians, improve the quality of clinical care available to patients with EVD, and strengthen the health system. Even within the context of an epidemic, research should be integrated with health service delivery and training whenever possible [60].

Although promising results have recently been published, the international community could have done more to generate knowledge from the EVD epidemic as well [61]. For example, many studies to evaluate the effectiveness of experimental drugs or vaccinations began too late. A disconnect between implementing and research organizations, data-sharing challenges, and a lack of funding for phase 1 efficacy and safety studies prior to the epidemic are among the reasons for such delay [62]. The World Health Organization is now working on a much-needed framework to expedite research and development for diseases of poverty in anticipation of (and, if necessary, during) future health crises. Independent research organizations, companies, and funders should engage in similar efforts.

Fifth, more flexible funding mechanisms would likely have enhanced a more robust response to the EVD epidemic. The amount of funding eventually devoted to the emergency

Ebola response was substantial, and it was critical to halting transmission. However, by being too prescriptive regarding how funds should be spent, donors can unintentionally limit options for implementation and stifle innovation. For example, some donors' refusal to finance medical evacuations or the construction of permanent infrastructure, forced international NGOs like PIH to raise funds independently to fill gaps, especially for long-term projects. Furthermore, national and local health authorities across West Africa were often bypassed by donors in favor of international NGOs with limited experience in the region; by one conservative estimate, only 11.5% of resources appropriated for the emergency Ebola response were channeled through the governments of the 3 most affected countries [63]. This fraction was only 5% in Sierra Leone [64]. Limited management capacity and corruption are often presented, sometimes without much supporting evidence or without meaningful effort to address them, as justifications for neglecting the public sector across Africa. Yet it is perhaps too easy to conflate weak health systems with a propensity for graft; increased transparency on the part of donors and NGOs will also be essential to ensuring that shared goals translate into lasting results [65].

In future health crises, donors should consider prioritizing outcomes over inputs or processes, allowing national health authorities and implementing partners to spend funds as dictated by local needs and evolving circumstances rather than by contracts fixed at the outset of a dynamic health crisis. The establishment of standing emergency funds by the US Office of Foreign Disaster Assistance and the United Kingdom Department for International Development is an encouraging start, but more will be required to address the chronic emergencies that exist wherever outbreaks might evolve into epidemics after spreading through dilapidated health systems.

Sixth, the responsibility of the international community to West Africa will be fulfilled only when the health systems of Liberia, Sierra Leone, and Guinea are resilient enough to quickly identify and contain future epidemics of EVD and other infectious pathologies (from Lassa fever to cholera and measles) and, most importantly, to consistently deliver comprehensive and high-quality health services to their populations. Some international NGOs and donors have opted to remain in Sierra Leone beyond the duration of the emergency Ebola response and to work with the MoHS to strengthen the health system. However, despite this joint commitment, there have been large gaps in funding such a transition: implementing partners have often been unable to quickly redirect unspent or unused resources that were earmarked for Ebola toward resuming and expanding the delivery of regular health services (including meeting the needs of Ebola survivors and families heavily affected by the epidemic). For instance, PIH's ongoing effort to strengthen the health system is supported only through independently raised funds that are separate from those received for the emergency

Ebola response. Some private philanthropies (such as the Open Society Foundations and the Paul Allen Foundation) have begun to recognize and address this gap, yet greater donor flexibility is desperately needed to ensure the kind of continuity between intensive short- and long-term efforts that might render health crises less deadly or prevent them altogether. Finally, as in the global response to the AIDS pandemic, those most affected by a disease have much to teach, and their expertise is critical to efforts to build stronger health systems and a means of stopping this epidemic and preventing the next one. Ebola survivors have been at heart of PIH's response, and many today serve as community health workers at the forefront of efforts to heal the wounds caused by Ebola's march across West Africa and the long years of conflict and neglect that preceded it.

CONCLUSION

While the international response to the EVD epidemic saved many lives, major challenges have hindered the translation of these investments into long-term protection for the populations most affected; these issues must be addressed before the next unexpected health emergency arises here or elsewhere where poverty and a heavy burden of disease converge. The historic neglect of the region's health systems, delays in the engagement of donors and international NGOs, and the endorsement by responders of false dichotomies (between, for example, prevention and care, or between an emergency response and long-term health system strengthening) were among the main challenges encountered. We hope that the lessons learned by PIH and its partners in Sierra Leone to date will contribute to the ongoing dialogue on how best to improve the way the international community currently mobilizes against health crises and invests in health systems capable of detecting and preventing the spread of diseases like Ebola and offering quality care to those who do fall ill.

Notes

Acknowledgments. We thank the following individuals and others who made this response possible, for their invaluable contributions: Abu Bakarr Fofanah, Brima Kargbo, Palo Conteh, Finda Koroma, Bockarie Kamara, Thaim Kamara, Martin Salia, Sheik Humarr Khan, Jill Hackett, Giuseppe Raviola, Shinichi Daimyo, Lauren Galinski, Philip Parks, Jennifer Fitzpatrick, Jeff Marvin, Sara Stulac, Cynthia Maltbie, Gabriella Palmi, Cassia van der Hoof Holstein, Sheik Jalloh, Jamie O'Neill, Mary Hyland, Chris Welch, Hassan Bunduka, Dylan Becker, Robert Rains, Mark Young, Robin Martin, Nick Sarchet, Gianine Carbone, Quy Ton, Nick Stan, Nick Stahlschmidt, Musah Sillah, Adama Nyenkeh, Nira Pollock, Ermyas Birru, Katrina Hahn, Allison Stewart Elliott, Anany Prosper, Cate Oswald, Jehane Sedky, Abbey Gardner, Kelly O'Connor, Ian Crozier, Steven Yeh, Daniel Bausch, Elizabeth Tucker, Bebecca Morlu, Oliver Johnson, Marta Lado, Paul Allen, George Soros, Stephen Kahn, and Anthony Banbury.

Financial support. This work was supported by the United Kingdom Department for International Development, the US Office of Foreign Disaster Assistance, the Open Society Foundations, the Abundance Foundation, and the Paul Allen Family Foundation.

Potential conflicts of interest. C. C. reports receiving funding from the US Office of Foreign Disaster Assistance, the United Kingdom Department for International Development, the US Open Society Foundations, and the

Paul Allen Family Foundation. All other authors report no potential conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References

- World Health Organization. Ebola data and statistics. <http://apps.who.int/gho/data/node.ebola-sitrep.ebola-summary?lang=en>. Accessed 22 July 2016.
- WHO Ebola Response Team. West African Ebola epidemic after one year—slowing but not yet under control. *N Engl J Med* **2015**; 372:584–7.
- Partners In Health. Our Work. <http://www.pih.org/our-work>. Accessed 10 July 2016.
- McKay B. Ebola's Long Shadow: West Africa Struggles to Rebuild Its Ravaged Health-Care System. *Wall St J* **2015**; 265:A1–8.
- Crompton J, Kingham TP, Kamara TB, et al. Comparison of Surgical Care Deficiencies between US Civil War Hospitals and Present-Day Hospitals in Sierra Leone. *World J Surg* **2010**; 34:1743–7.
- Kingham TP, Kamara TB, Daoh KS, et al. Universal Precautions and Surgery in Sierra Leone: The Unprotected Workforce. *World J Surg* **2009**; 33:1194–6.
- Kingham TP, Kamara TB, Cherian MN, et al. Quantifying Surgical Capacity in Sierra Leone. *Arch Surg* **2009**; 144:122–7.
- WHO Ebola Response Team. Ebola Virus Disease in West Africa—The First 9 Months of the Epidemic and Forward Projections. *N Engl J Med* **2014**; 371:1481–95.
- Whitty CJM, Farrar J, Ferguson N. Tough Choices to Reduce Ebola Transmission. *Nature* **2014**; 515:192–4.
- World Health Organization. Ebola in Sierra Leone: A Slow Start to an Outbreak that Eventually Outpaced All Others. <http://www.who.int/csr/disease/ebola/one-year-report/sierra-leone/en/>. Accessed 16 December 2015.
- United Nations. UN Ebola Mission Chief Reports Mixed Picture in Sierra Leone, As Victims Outpace Beds in Port Loko. http://www.un.org/apps/news/story.asp?NewsId=49233#.VnsobMARL_M. Accessed 16 December 2015.
- Pathmanathan I, O'Connor KA, Adams ML, et al. Rapid Assessment of Ebola Infection Prevention and Control Needs—Six Districts, Sierra Leone, October 2014. *MMWR Morb Mortal Wkly Rep* **2014**; 63:1172–4.
- Kilmarx PH, Clarke KR, Dietz PM, et al. Ebola Virus Disease in Health Care Workers—Sierra Leone, 2014. *MMWR Morb Mortal Wkly Rep* **2014**; 63:1168–71.
- Assessment Capacities Project (ACAPS), Sierra Leone Ministry of Health and Sanitation. Ebola Outbreak Impact on Health Service Utilization in Sierra Leone. Free-town, Sierra Leone: ACAPS, 25 March 2015.
- Farmer P. *Diary*. London Rev Books **2014**; 20:38–9.
- Lamontagne F, Clément C, Fletcher T, et al. Doing Today's Work Superbly Well—Treating Ebola with Current Tools. *N Engl J Med* **2014**; 371:1565–6.
- Fowler RA, Fletcher T, Fischer WA, et al. Caring for Critically Ill Patients with Ebola Virus Disease: Perspectives from West Africa. *Am J Respir Crit Care Med* **2014**; 190:733–7.
- Jeffs B, Roddy P, Weatherhill D, et al. The Médecins Sans Frontières Intervention in the Marburg Hemorrhagic Fever Epidemic, Uige, Angola, 2005. I. Lessons Learned in the Hospital. *J Infect Dis* **2007**; 196:S154–61.
- Bausch DG, Feldmann H, Geisbert TW, et al. Outbreaks of Filovirus Hemorrhagic Fever: Time to Refocus on the Patient. *J Infect Dis* **2007**; 196:S136–41.
- Dillon RS, Kelly JD. Community Trust and the Ebola Endgame. *N Engl J Med* **2015**; 373:787–9.
- Farmer P. The Secret to Curing West Africa from Ebola Is No Secret At All. *Washington Post*, 16 January 2015.
- Richardson ET, Barrie MB, Kelly JD, et al. Biosocial approaches to the 2013–2016 Ebola pandemic. *Health Hum Rights* **2016**; 18:115–27.
- Richards P, Amara J, Ferme MC, et al. Social pathways for Ebola virus disease in rural Sierra Leone, and some implications for containment. *PLoS Negl Trop Dis* **2015**; 9:e0003567.
- National Academy of Medicine. “Annex 3–4: Acknowledging the Roots of Resistance and Distrust of Containment Measures,” In *The Neglected Dimension of Global Security: A Framework to Counter Infectious Disease Crises*. Washington, DC: National Academies Press, **2016**.
- Bah EI, Lamah M, Fletcher T, et al. Clinical Presentation of Patients with Ebola Virus Disease in Conakry, Guinea. *N Engl J Med* **2015**; 372:40–7.
- Schieffelin JS, Shaffer JG, Goba SA, et al. Clinical Illness and Outcomes in Patients with Ebola in Sierra Leone. *N Engl J Med* **2014**; 371:2092–100.
- Fitzpatrick G, Vogt F, Gbaba OBM, et al. The Contribution of Ebola Viral Load at Admission and Other Patient Characteristics to Mortality in a Médecins Sans Frontières Ebola Case Management Centre, Kailahun, Sierra Leone, June–October 2014. *J Infect Dis* **2015**; 212:1752–8.
- Qin E, Bi J, Zhao M, et al. Clinical Features of Patients with Ebola Virus Disease in Sierra Leone. *Clin Infect Dis* **2015**; 15:491–5.

29. Lee-Kwan SH, DeLuca N, Adams M, et al. Support Services for Survivors of Ebola Virus Disease—Sierra Leone, 2014. *Morb Mortal Wkly Rep* **2014**; 63:1205–6.
30. Rowe AK, Bertolli J, Khan AS, et al. Clinical, Virologic, and Immunologic Follow-Up of Convalescent Ebola Hemorrhagic Fever Patients and Their Household Contacts, Kikwit, Democratic Republic of the Congo. *J Infect Dis* **1999**; 179:S28–35.
31. Kibadi K, Mupapa K, Kuvula K, et al. Late Ophthalmologic Manifestations in Survivors of 1995 Ebola Virus Outbreak in Kikwit, Democratic Republic of the Congo. *J Infect Dis* **1999**; 179:S13–4.
32. Clark DV, Kibuuka H, Millard M, et al. Long-Term Sequelae After Ebola Virus Disease in Bundibugyo, Uganda: A Retrospective Cohort Study. *Lancet Infect Dis* **2015**; 15:902–12.
33. Chang JC. Ebola survivor care in Port Loko District, Sierra Leone. Presentation at: WHO Meeting on Clinical Care of Ebola Survivors, Freetown, Sierra Leone, 3 August 2015.
34. Mattia JG, Vandy MJ, Chang JC, et al. Early clinical sequelae of Ebola virus disease in Sierra Leone: a cross-sectional study. *Lancet Infect Dis* **2016**; 16:331–8.
35. Broadhurst JM, Kelly JD, Miller AC, et al. ReEBOV Antigen Rapid Test Kit for Point-of-Care and Laboratory-Based Testing for Ebola Virus Disease: A Field Validation Study. *Lancet* **2015**; 386:867–74.
36. Semper AE, Broadhurst JM, Richards J, et al. Performance of the GeneXpert Ebola Assay for Diagnosis of Ebola Virus Disease in Sierra Leone: A Field Evaluation Study. *PLoS Med* **2016**; 13:e1001980.
37. Dynes MM, Miller L, Sam T, et al. Perceptions of the Risk for Ebola and Health Facility Use Among Health Workers and Pregnant and Lactating Women—Kema District, Sierra Leone, September 2014. *MMWR Morb Mortal Wkly Rep* **2015**; 63:1226–7.
38. Elston JWT, Moosa AJ, Moses F, et al. Impact of the Ebola outbreak on health systems and population health in Sierra Leone. *J Public Health* **2015**; pii:fdv158.
39. Bolkan HA, Bash-Taqi DA, Samai M, Gerdin M, von Schreeb J. Ebola and indirect effects on health service function in Sierra Leone. *PLoS Curr* **2014**; doi:10.1371/currents.outbreaks.0307d588df619f9c9447f8ead5b72b2d.
40. Olu O, Kargbo B, Kamara S, et al. Epidemiology of Ebola virus disease transmission among health care workers in Sierra Leone, May to December 2014: a retrospective descriptive study. *BMC Infect Dis* **2015**; 15:416.
41. Takahashi S, Metcalf JE, Ferrari MJ, et al. Reduced Vaccination and the Risk of Measles and Other Childhood Infections Post-Ebola. *Science* **2015**; 347:1240–2.
42. Cancedda C, Farmer PE, Kyamanywa P, et al. Enhancing Formal Educational and In-Service Training Programs in Rural Rwanda: A Partnership Among the Public Sector, a Nongovernmental Organization, and Academia. *Acad Med* **2014**; 89:1117–24.
43. Heymann DL, Chen L, Takemi K, et al. Global Health Security: Lessons from the West African Ebola Virus Disease Epidemic. *Lancet* **2015**; 385:1884–901.
44. Rosenbaum L. License to Serve—U.S. Trainees and the Ebola Epidemic. *N Engl J Med* **2015**; 372:504–6.
45. Shuchman M. Sierra Leone Doctors Call for Better Ebola Care for Colleagues. *Lancet* **2014**; 384:e67.
46. Rees PSC, Lamb LEM, Nicholson-Roberts TC, et al. Safety and Feasibility of a Strategy of Early Central Venous Catheter Insertion in a Deployed UK Military Ebola Virus Disease Treatment Unit. *Intensive Care Med* **2015**; 41:735–43.
47. Ansumana R, Jacobsen KH, Sahr F, et al. Ebola in Freetown Area, Sierra Leone—A Case Study of 581 Patients. *N Engl J Med* **2015**; 372:587–8.
48. Hunt L, Gupta-Wright A, Simms V, et al. Clinical Presentation, Biochemical, and Haematological Parameters and Their Association with Outcome in Patients with Ebola Virus Disease: An Observational Cohort Study. *Lancet Infect Dis* **2015**; 15:1292–9.
49. Paterson ML, Callahan CW. The Use of Intraosseous Fluid Resuscitation in a Pediatric Patient with Ebola Virus Disease. *Int Emerg Med* **2015**; 49:962–4.
50. Trehan I, Kelly T, Marsh RH, George PM, Callahan CW. Moving towards a more aggressive and comprehensive model of care for children with Ebola. *J Pediatr* **2016**; 170:28–33.
51. Lyon GM, Mehta AK, Varkey JB, et al. Clinical Care of Two Patients with Ebola Virus Disease in the United States. *N Engl J Med* **2014**; 371:2402–9.
52. Roberts I, Perner A. Ebola Virus Disease: Clinical Care and Patient-Centered Research. *Lancet* **2014**; 384:2001–2.
53. Faye O, Andronico A, Faye O, et al. Use of Viremia to Evaluate the Baseline Case Fatality Ratio of Ebola Virus Disease and Inform Treatment Studies: A Retrospective Cohort Study. *PLoS Med* **2015**; 12:e1001908.
54. Crowe SJ, Maenner MJ, Kuah S, et al. Prognostic indicators for Ebola patient survival. *Emerg Infect Dis* **2016**; 22:217–23.
55. Fauci A. Ebola—Underscoring the Global Disparities in Health Care Resources. *N Engl J Med* **2014**; 371:1084–6.
56. Ker K, Tansley G, Beecher D, et al. Comparison of Routes for Achieving Parenteral Access with a Focus on the Management of Patients with Ebola Virus Disease. *Cochrane Database Syst Rev* **2015**; 26:1–84.
57. Mupapa K, Mukundu W, Bwaka MA, et al. Ebola Hemorrhagic Fever and Pregnancy. *J Infect Dis* **1999**; 179:S11–2.
58. Baggi FM, Taybi A, Kurth A, et al. Management of Pregnant Women Infected with Ebola Virus in a Treatment Center in Guinea, June 2014. *Eurosurveillance* **2014**; 19:2–5.
59. Hayden EC. Ebola's Lasting Legacy. *Nature* **2015**; 519:24–6.
60. Bausch DG. The Year That Ebola Virus Took Over West Africa: Missed Opportunities for Prevention. *Am J Trop Med Hyg* **2015**; 92:229–32.
61. Gates B. The Next Epidemic—Lessons from Ebola. *N Engl J Med* **2015**; 372:1381–4.
62. Cohen J, Enserink M. As Ebola Epidemic Draws to a Close, A Thin Scientific Harvest. *Science* **2016**; 351:12–3.
63. Grepin KA. International Donations to the Ebola Virus Outbreak—Too Little, Too Late? *BMJ* **2015**; 350:h376.
64. United Nations Office of the Secretary-General's Special Adviser on Community Based Medicine and Lessons from Haiti. Building Health Systems and Increasing Resilience to Crises: Lessons from Rwanda. New York: United Nations, 2015.
65. Grabowski A, Hohlfelder E. When Losing Track Means Losing Lives: Accountability Lessons from the Ebola Crisis. *Lancet Glob Health* [blog]. 1 July 2015. <http://globalhealth.thelancet.com/2015/07/01/when-losing-track-means-losing-lives-accountability-lessons-ebola-crisis>. Accessed 16 December 2015.