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Chapter 2

Ebola and Health Partnerships, Action in a Time of Crisis

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Additional information is available at the end of the chapter

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Abstract

The chapter explores the role of health partnerships in delivering services throughout the West African Ebola Virus Disease epidemic, including the creation of the Ministry of Health and Sanitation, Sierra Leone, Ebola Holding Unit models, command and control structures, research into diagnostics and care pathways, and general medical care. It will highlight how this provided resilience during the Ebola response, and how this will aid health systems strengthening going forward.

Keywords: ebola, health partnership, impact, resilience, sustainable

1. Introduction to partnership working & existing health structure in Sierra Leone

In 2014, Connaught Hospital and the King's Sierra Leone Partnership (KSLP) were at the epicentre of the Ebola Virus Disease (EVD) outbreak in West Africa and, given the unprecedented nature of disease spread, had to develop new approaches to managing the clinical response. This chapter explores our model of Ebola Holding Units (EHUs) within government hospitals, including the role of international partnerships, how to maintain general health services during an outbreak and the importance of effective command and control. We

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discuss how to conduct research and build longer-term capacity during a crisis. We hope the chapter will be of interest to those organisations working in EVD-prone countries, as well as those interested in broader aspects of EVD resilience and outbreak response.

1.1. Connaught Hospital

Connaught Hospital is the main adult tertiary referral and teaching hospital in Sierra Leone. Established during the colonial period and located in the downtown area of the capital city, Freetown, it has 300 medical and surgical beds and a range of specialist clinics such as for human immunodeficiency virus (HIV), tuberculosis (TB) and ophthalmology. Prior to the outbreak, the hospital was operating with limited resources for many years. As a result, patients paid fees for individual services and the infrastructure, such as sinks and taps, was degraded, with limited equipment or supplies such as gloves or cannulas. The hospital had only 10 consultants, fully specialised doctors, a small number for a facility of this size, and few ward sisters. Therefore, more junior staff would have significant clinical responsibility and only limited access to supervision.

1.2. Sierra Leone context

Connaught is part of a wider government health system with about 30 hospitals and more than 1000 primary care units across a country of six million people. Despite significant progress over the last 10 years, the health system still faced major challenges before the Ebola outbreak. A colonial legacy of few health training institutions, with the county's only medical school established in 1988, was compounded by the effects of protracted civil war (1994–2002), which saw many health workers leave the country or left unable to complete their specialist training. This all contributed to a major human resource crisis, with about 150 doctors, equal to 2 doctors per 100,000 people (compared to 280 in the UK) [1], and well below World Health Organization (WHO) minimum standards [2].

The civil war also led to significant damage to health facilities across the country and undermined the capacity of key institutions that were responsible for the governance and management of health services, such as the Ministry of Health & Sanitation (MOHS). A small, albeit growing, economy resulted in low salaries for staff and limited resources to provide free drugs or services to patients. The country was heavily dependent on international donors to fund health services, both through the government and through non-governmental providers. Despite these challenges, the government had made a major commitment to health, symbolised by the launch of the Free Health Care initiative for under-5 year-old children and pregnant or lactating women in 2008.

Outside of the health systems, widespread extreme poverty resulted in poor housing, limited access to water and sanitation, low levels of formal employment and literacy, and a limited ability to pay for out-of-pocket fees for health services. There was also a strong culture of traditional beliefs and use of informal and unregulated health providers. These all had significant impacts on the burden of disease and the attitudes and behaviours of patients.

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Overall, the consequence was poor health outcomes: a life expectancy of 46 and one of highest infant mortality rates in the world (161/1000 live births) [1].

1.3. Partnership working

In this context, Connaught Hospital invited the support of King's Health Partners (KHP) in 2012 to help strengthen the capacity of the hospital over the long term. KHP is an Academic Health Sciences Centre consisting of King's College London (KCL), in the world's top 20 university rankings, and three of the largest acute and mental health hospitals in South London. King's had over 10 years of experience of health system strengthening work in Somaliland and a strong commitment to global health.

The King's Sierra Leone Partnership was established when a small team from King's arrived at Connaught Hospital in early 2013 with the mission to help to strengthen the government health system through supporting the improvement of clinical services, training, policy and research. KSLP also partnered with the College of Medicine & Allied Health Sciences (COMAHS) and MOHS.

The King's approach was to support the hospital to implement its own improvement programme, rather than coming with an agenda. Early priorities included restructuring the Accident & Emergency Department, supporting an application for accreditation to provide postgraduate training in surgery, establishing a dental therapy training programme, reviewing management structures within the hospital and developing a regular teaching programme for junior doctors.

KSLP recruited a small international team on the ground including doctors, nurses, pharmacists, hospital managers and others, embedded within the hospital doing a mixture of clinical and technical advisory work and teaching. This team was supported by senior specialists from the UK, who supported from a distance or visited on short trips.

The partnership was founded on the principles of mutual respect and shared learning and based on supporting the hospital's own leadership and strategy. It recognised that King's had as much or more to learn and benefit from the partnership as Sierra Leonean institutions did. Its strategy was to plan over the long term, over decades rather than months or years, and focused on the structural causes of health system challenges, such as addressing the lack of postgraduate training opportunities, rather than short term fixes, for example deploying large numbers of foreign volunteers to prop-up clinical activities. In addition, the approach was holistic, recognising that a hospital is a complex system and that to improve a particular aspect of patient care you need to address a number of interlinked components at once, which might range from developing clinical protocols to training staff, refurbishing the physical environment, improving access to medical equipment and supplies, and overhauling the medical records and finance systems.

It was in this context, Connaught Hospital and KSLP found themselves on the frontline of the outbreak when the first EVD cases were identified in Freetown in July 2014, and had to radically restructure their work in order to mount an effective response to the epidemic whilst maintaining essential health services.

2. West African EVD outbreak

The 2014–2015 West African outbreak of Ebola Virus Disease was unprecedented in terms of longevity and magnitude. More than 11,300 people have died, with some 28,600 infected across seven countries [3]. Although the reservoir of EVD is unknown, it is thought to be a fruit bat [4,5]. One introduction from the animal reservoir to the West African population is likely responsible for all of the cases seen in the region [6]. It was apparent early in the outbreak that inadequate human resourcing and physical infrastructure delayed intervention in the face of exponential spread, with "each new suspected case bring[ing] an exponential increase in resources required for testing, isolation and contact tracing" [7].

2.1. Existing models of EVD control

There have been many models of EVD care facility established to redress this challenge, some traditionally used in combatting EVD outbreaks and others developed in response to the scale of the outbreak and adapted to local design. In Sierra Leone, there were three models of care that were utilised. Ebola Treatment Centres (ETCs) most closely represent the standard model of care. These were standalone units, often purpose-built by international agencies outwith government procurement processes and placed away from population hubs. They are often subdivided into suspect and confirmed wards for all patients presenting with illness suggestive of EVD. The UK government response in Sierra Leone included the construction of many of these ETCs, operated by a variety of Non-Governmental Organisations (NGOs) [8]. Community Care Centres (CCCs) were developed in response to uncontrolled spread of EVD, often in areas with limited access to other care facilities, and provided basic health care while suspect patients awaited their EVD test results, or for provision of early treatment of confirmed cases awaiting beds to become available at ETCs. Often built in repurposed structures or as collections of small tents, they were "small, low technology, mainly staffed by nurses and community health workers and can accommodate 8 to 10 (maximum 15) patients" [9]. Ebola Holding Units were constructed in existing healthcare facilities, either repurposing existing buildings or constructing standalone units within hospital grounds. They utilise local health care workers (HCWs), allowing for ongoing healthcare services to be safely delivered alongside safe isolation, testing, initial treatment and onward referral of EVD-positive patients to ETCs or ward-based or outpatient care of EVD-negative patients. They were adopted by MOHS in partnership with organisations such as KSLP, who helped establish EHUs attached to MOHS hospitals, initially at Connaught Hospital then four others. KSLP also helped other facilities prepare for EVD cases, trained local and international staff for a variety of organisations, and supported command and control structures across the Western Area of the country (the peninsula area surrounding Freetown) to harmonise referrals and transfers between units [10].

2.2. Partnership working in EVD care

In March 2014, KSLP was invited by MOHS to contribute to the national Ebola Case Management Taskforce. Utilising infectious disease experience within the in-country team, we helped

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develop national guidelines for suspect case definition and developed safe isolation protocols for isolating and testing suspect cases across MOHS settings. KSLP staff later contributed to the WHO EVD management guidelines. The MOHS, with the support of KSLP and other international partners, started establishing EHUs at MOHS hospitals in Freetown in May 2014, before the first case of EVD in country. Initially a two-bed EHU at Connaught Hospital was opened, and as the outbreak escalated in Freetown in August 2014, KSLP and MOHS increased Connaught Hospital capacity and established four further units. We also assisted in setting up of two additional units.

The EHU model aimed to "(1) reduce cases in the local community through rapid isolation of symptomatic and suspect EVD cases to prevent onward transmission, (2) prevent nosocomial transmission through patient separation and regular decontamination of surfaces and floors, (3) improve survival of isolated patients through provision of safe EVD and non-EVD medical care, (4) maintain general healthcare through prompt diagnosis of EVD and onward transfer of patients to dedicated ETCs, alongside exclusion of EVD and triage of negative patients into outpatient or inpatient facilities for general care, allowing hospitals to remain safe and functional, even during peak EVD transmission, and (5) reducing healthcare worker infections through staff training inside the EHU and infection prevention and control strengthening on general wards, avoiding closure of facilities" [11].

Between 29th May 2014 and 19th January 2015, the five KSLP-supported MOHS EHUs (with 79 beds) had isolated a substantial proportion of the confirmed cases seen within the Western Area Urban and Rural districts (1159 of the 3097 cases). These facilities were 'front-loaded' in terms of construction of facilities, largely clustered early in the response efforts. They were cheap and quick to develop, with construction costs arriving at under $50,000 in total with one-week start-up times. We believe this model of care, detailed in Section 3 for Connaught Hospital, has significance for future outbreak control due to the rapidity of development and resilience for hospital functioning [11].

2.3. Outputs of partnership working

Within the EHU, Connaught Hospital and KSLP staff were able to validate a newly developed Rapid Diagnostic Test to prove its utility; assess the efficacy of the WHO suspect case definition, and determine whether a screening algorithm could be used prospectively to identify which suspect cases had a high likelihood of being EVD-positive; identify risk factors for mortality; assess how many patients discharged with a negative EVD-diagnosis were readmitted to any other facility in the Western Area, identifying the risk of potential infection within the EHU; and examine whether our environmental decontamination practices were effective (all Section 4). An ongoing programme of education focuses on delivering resilience within the hospitals for Intensive Care, Accident & Emergency and General Medicine and Surgery (Section 5), and Infection Prevention and Control (IPC) and Water and Sanitation (WASH) projects (Section 6) that will increase infrastructural resilience (Section 6). The command and control structures were developed alongside these operational research questions, which allowed for early harmonisation across the Freetown response and served as a model for national scale up to the district responses outside the Western Area (Section 7). We have also

remodelled temporary EHUs into permanent infection diseases units, retaining capacity to isolate, test, and treat EVD along with other infectious outbreaks, now and in the future, and laboratory strengthening with assistance from Public Health England (PHE) will aim to provide the necessary capacity to diagnose and detect future outbreaks of cholera and other diseases that could mimic EVD. A dedicated Infectious Disease Centre for Excellence will bring together leaders for the purposes of training, education, research and capacity building. A cohort of local healthcare staff of all cadres has developed significant skills and experience that can be harnessed. These areas are expanded in the following sections.

3. Operations of an Ebola Holding Unit, Connaught Hospital

To better understand how partnership working enabled rapid instigation and scale-up of the Connaught Hospital response, the following section highlights the various aspects regarding developing the EHU facility.

3.1.1. Staffing

The first isolated patients were cared for by one of Connaught's three consultant medical physicians, junior medical staff and the senior nurse in charge of accident & Emergency. Following the consultant's sad death from EVD in June 2014, a small team of two or three international staff who had been working with KSLP before the EVD outbreak, took over care within the isolation facility. Over time the confidence of national hospital staff and volunteers grew and the team expanded to keep pace with the increase in bed numbers (see **Table 1**). As the number of Ebola cases in Freetown escalated the EHU expanded from an initial two bedded unit in late May 2014 bed capacity to nine, then a 16-bed unit with two additional child cots in August 2014. Consequently the operational aspects of running the unit also had to be scaled up.

Staff	Roles	Number
Caregiving staff	Admit patients and give personal/nursing care Administer medications Ensure blood sample collection by laboratory staff and check results Arrange patient transfer to ETU or discharge from EHU to hospital or home Wash bodies, collect oral swabs for testing and prepare for collection by burial team	13 (national) and 8 (international)
Cleaners	Clean EHU and patients items to prevent cross infection between patients Ensure safe disposal of waste Prepare chlorine water Wash bodies and prepare for collection by burial team	12 (national)
Security staff	Ensure public safety during patient admission or removal of corpses Liaise with visitors and relatives Ensure security of patients, staff and supplies	4 (national)

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Staff	Roles	Number
Laboratory technicians	Collect and package blood samples Arrange transport of samples to laboratory	7 (national)
District surveillance officers	Interview patient for contact tracing Undertake contact tracing Liaise with the Command Centre to arrange transfers to ETU Liaise with relatives to discharge patients Liaise with burial team and families about dead patients	2 (national)
Screeners	Screen and identify suspected cases at the main entrance of the hospital Liaise with caregiving staff about patients requiring admission	6 (national)

Table 1. Numbers of clinical staff required for the twenty bed Ebola Holding Unit at Connaught Hospital at the height of the EVD outbreak, November 2014.

The caregiving staff, cleaners, screeners and security staff provided 24-h cover for the unit across three shifts. In order to repair and maintain the unit, some hospital maintenance staff (e.g. carpenters, electricians and plumbers) were trained in using Personal Protective Equipment (PPE) and would occasionally work in the unit under the guidance of an experienced member of staff. In addition, there was an operational team to provide support for the EHU (see **Table 2**) who were able to draw on technical advisors and an operations manager based in London for advice and assistance as required.

Staff	Roles	Number
Programme director	Overall management of EHU Liaison with partners and external agencies	1 (international)
Clinical lead—infectious diseases specialist doctor	Technical advice and clinical supervision Staff training and management Liaison with central coordinating agencies	1 (international)
Operations lead	Co-ordinate supplies, logistics and finances Staff training and management	1 (international)
Operations assistant	Assist with logistics	1 (national)
Supplies coordinator	Order and manage all supplies Staff training and management	1 (international)
Supplies assistant	Assist with supplies	2 (national)
Human resource coordinator	Recruitment of international staff In-country support for international staff	1 (international)
Senior nurse	Recruitment of national staff Management of national staff in EHU	1 (national)

Table 2. Numbers of operational staff required to support the Ebola Holding Unit at Connaught Hospital, November 2014.

3.1.2. Equipment and supplies

With the agreement of Connaught Hospital management, a space was identified within the hospital for use as an EHU. This was prepared jointly by international volunteers and a range of hospital staff including nurses, doctors and maintenance staff. All initial equipment was purchased locally. As the outbreak continued some specific pieces of equipment which would improve safety within the EHU but were not available locally were shipped in e.g. non touch clinical waste bins. Several features made the identified space useful to create the EHU—it was adjacent to the triage area at the front of the hospital, so any patients identified at being at risk of EVD were easily transported into the unit. There were no steps, separate entrance and exits (though the latter had to be constructed) with the capacity for unidirectional flow, and was a physical building that withstood the rigors of repeated cleaning, allowed for security, and ventilation for patients. It also was self-contained from the rest of the hospital, had its own water supply, and space for dressing areas and decontamination. Construction was relatively simple and involved building temporary doors, plastic sheets between bedspaces, wooden furniture and supplies such as buckets, cabinets to store medication, and clocks.

Availability of PPE, cleaning supplies and drugs was limited at the beginning of the outbreak and a rapid donation of essential items was sent by air freight from KHP in August 2014. As more supplies became available in Central Medical Stores (CMS), the government agency responsible for distributing healthcare supplies to hospital facilities, the majority of supplies for the EHU were requested through the government supply chain. Hospital management authorised the orders which were prepared by the supplies coordinator. This approach was adopted to reduce dependence on a parallel supply chain which could distort overall data about supply requirements. Specific items continued to be shipped in either because they were considered essential but in short supply (e.g. shoe covers and long gloves) or because they were required on safety grounds (i.e. disposable masks with visor attached). Non-medical supplies for patients (e.g. soap, bedsheets, clothes and drinking water) were sourced locally and provided through another NGO who received donor funding specifically to fulfil for this function for a number of EHUs. Storage space for all the supplies was provided by the hospital management.

3.1.3. Safety

To ensure safe operation of the EHU, many aspects of care were carefully negotiated with the MOHS and hospital management. Concerns regarding overflow were managed by strictly limiting bed numbers to a capacity that was deemed safe. We never accepted more patients into the EHU than we had beds available for, however we constructed a tented area outside the hospital entrance to deal with overflow where families could bring relatives awaiting admission and were provided with IPC to care for them. Early in the Western Area outbreak, when there were no EHU beds available the Accident & Emergency department was temporarily closed until spare beds became available to protect the general hospital wards. The whole hospital staff played a tremendous role in safely managing the wards during the outbreak, and morale was boosted for all healthcare staff who were given limited additional hazard payment for their work. Plastic sheeting was challenging—it was initially employed in the unit

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to provide separation between patients, however this was taken down as IPC management was easier without having to decontaminate the plastic surfaces. Security was occasionally a concern in healthcare facilities and the Royal Sierra Leone Armed Forces were stationed at the main entrance to aid with calming measures, given the high numbers of patients presenting given Connaught was one the few functioning facilities in the Western Area. Towards the end of the outbreak, from March 2015 we started testing all inpatients for HIV. All patients who tested negative for EVD and diagnosed with HIV were linked into onward services for HIV care, and all EVD-negative patients were showered and given a clean pair of clothes before leaving the unit for onward management on the medical wards. This care was enabled by a credit provided by KSLP to pay for basic medications and tests.

3.2. Model of supervision

Building on the existing model of partnership working, the ultimate aim was to build the capacity of EHU staff to run the unit independently in the future.

At the beginning of the outbreak fear of infection, lack of training and lack of resources were the main reasons for hospital staff being unwilling to work in EHUs. In order to address these issues international staff provided practical training and ongoing supervision. The role and importance of standard operating procedures was emphasised regularly to minimise HCW infection. Role modelling was an important factor in building the confidence of new staff. This helped consolidate the adoption of the correct procedures by new staff and built confidence in the safety of those procedures. For that reason international staff were recruited on the understanding that they would be expected to perform the same duties as all other staff. Development of a responsive supply chain for the unit also helped to maintain staff commitment. As the numbers and competency of the national staff increased, the numbers of international staff decreased significantly so that by the end of the outbreak only one international clinician was on-call to assist with clinical issues. The management of supplies from CMS was handed over to the hospital pharmacy and storekeeper.

Good working relationships with the Matron and the Senior Nurse in the Emergency Department were critical for the recruitment, management and disciplining of EHU staff. An identified team leader for each shift strengthened communication between staff.

One challenge was the stigma experienced by those working inside the EHU from relatives and colleagues. There were reports of workers being shunned by other health workers or expelled from their houses by their families. It was important to acknowledge these difficulties with staff in the early stages of training and discuss contingency plans for dealing with these challenges.

All staff working inside the EHU were entitled to a risk allowance which was distributed by the National Ebola Response Centre (NERC). There were often problems in the access to this financial incentive, and KSLP provided a smaller performance related bonus (based on a written report of attendance, performance and safety while working) in addition to this allowance which was an effective tool for providing feedback and incentive for good per-

formance. However at other EHUs, this was not attempted, and good mentorship and encouragement were sufficient to motivate local staff.

3.3. Using the Connaught Hospital EHU as a training hub

Training was one of the KSLP pillars of work during the outbreak. After setting up the Connaught EHU, the first in the Western Area for suspected EVD cases, KSLP developed a training method used to train more than 400 health care workers, international and national, to work in EHUs and ETCs.

3.3.1. Model of training

The training groups were structured in small groups of trainees (between 6 and 10 people per group subdivided into small teams of between 3 and 5 members). It was important to ensure that the training was practical, interactive and with opportunities for the students to engage with the live environment and implement what they had learnt in lectures with direct supervision from the trainer.

All staff working in patient areas received the three-phase training described below (see **Figure 1**). Before starting clinical work, all staff had to complete Phase 1 and Phase 2 training. See **Table 3** for an example of training timetable for Phases 1 and 2.

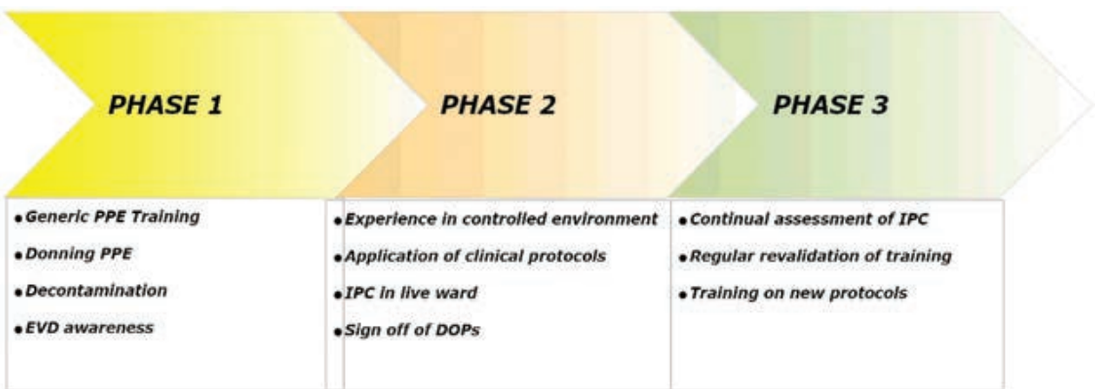


Figure 1. Three phase training model at Connaught Hospital Ebola Holding Unit.

Day 1—Phase 1		
AM	General induction and orientation	Conference room
PM	Training session 1	Conference room followed by isolation unit
	• Ebola	
	• Connaught isolation unit	
	• Infection prevention	

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Day 1—Phase 1		
	⚜ Hand hygiene	
	⚜ PPE dressing and undressing	
	⚜ Cleaning and waste management	
	• Tour of the isolation unit	
Day 2—Phase 1 followed by start of Phase 2		
AM	Training session 2: isolation unit standard operating procedures	Conference room
PM	Training session 3: practical training	Isolation unit
	• Standard operating procedures	
	• Chlorine preparation	
	Case discussions	
Day 3—Phase 2		
AM/PM	Practical training	Isolation unit

Table 3. Example Timetable for Phases 1 and 2.

Phase 1 consisted of generic EVD training, including basic PPE training, decontamination procedures, IPC protocols and basic knowledge and awareness of EVD. The method was based on theoretical lectures and included the principles of the construction and setting up of an isolation unit according to the WHO and Médecins Sans Frontières guidelines.

Phase 2 focused on the application of protocols to the real life environment. Training took place within the Connaught EHU, and was provided by experienced staff who ensured adequate supervision. Throughout Phase 2, there was a gradual increase in both time spent inside the unit and procedures performed by trainees. Direct observation of procedural skills (DOPs) was used to assess competence. These practical lessons were developed inside the EHU with real patients and different scenarios to help the trainees to understand and put in practice the best clinical management with EVD patients.

Phase 3 training was provided within their own EHU. Staff were formally revalidated in their decontamination procedures and IPC protocols on a regular basis. See **Figure 2** for an example of an assessment tool used for revalidation. All staff were retrained as new procedures or protocols were adopted. In many training sessions, direct explanations and advice in storage, supplies of consumables and PPE were also provided, based on the experiences gained at Connaught Hospital, with the aim of assisting in the setting up of new units at government facilities in the Western Area and all over the country through other partners [12].

Phase 4, the newest training phase, was established after Sierra Leone was declared EVD-free. It allows EVD-healthcare workers to receive updates and refreshment of previously deployed EVD training to ensure readiness when new cases arise. Currently, KSLP is developing updated training for HCWs that is focused on lessons learnt from the outbreak, mainly based

Removing PPE

Step	Achieved	Comments
1. Stand in chlorine footbath at the entrance of the room for one minute.		
2. Wash gloved hands with water and soap (**First bucket**).		
3. Wash gloved hands in 0.5% chlorine solution for one minute (**Second bucket**).		
4. Remove apron by grasping at sides and holding away from you deposit in bin.		
5. Wash gloved hands in 0.5% chlorine solution for one minute (**Second bucket**).		
6. Remove outer gloves and deposit in bin		
7. Wash gloved hands in 0.5% chlorine solution for thirty seconds (**Third bucket**).		
8. Looking in mirror take zip of PPE suit between thumb and forefinger of one hand and undo. Grasp hood of suit and pull off head. Roll suit down, touching as little as possible.		
9. Wash gloved hands in 0.5% chlorine solution for thirty seconds (**Third bucket**).		
10. Looking in mirror remove face shield.		
11. Wash gloved hands in 0.5% chlorine solution for thirty seconds (**Third bucket**).		
12. Remove inner gloves.		
13. Wash hands in 0.05% chlorine solution for one minute (**Fourth bucket**).		
14. Proceed to chlorine footbath for one minute.		
15. Put on gloves.		
16. Remove boots and place in boot rack, put on shoes.		
17. Remove gloves.		
18. Wash hands with water and soap (**Fifth bucket**).		
19. Leave isolation unit through back door.		
20. Wash hands with soap and water outside the clinical office.		

Figure 2. Staff PPE competency assessment tool used during phase 3 training.

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in case management and care of the patients with actors and different scenarios inside the EHU, e.g. management of sepsis, and of confused and agitated patients. It also includes an update in IPC and special situations such as pregnant EVD patients. This training is also oriented to prepare trainers to deliver this material to more HCWs to ensure onward resilience. **Table 4** details an example timetable for this phase.

Day 1		
AM	Refresher training in	Conference room
	• Ebola	
	• EVD clinical management	
	• IPC updates	
	• Training skills (for those who will be trainers)	
PM	• Clinical cases	Conference room
	• Simulation scenarios in the isolation unit	Isolation unit
	• Pregnancy in EVD patients	Conference room

Table 4. Example timetable for Phase 4.

4. Prioritising research in the EVD outbreak setting: the role of health partnerships

The scale and duration of the West African EVD outbreak provided a unique opportunity to study the clinical features and management of EVD to generate evidence for best practice. Prior to this outbreak, case management was based on expert opinion and evidence from limited case studies and small patient cohorts in Central and East Africa [13–16]. Several KSLP clinical volunteers and senior Connaught medical staff had research expertise. However, significant barriers to undertaking research existed. There was a shortage of staff to deliver basic clinical care for much of the outbreak. Upholding high standards of ethical conduct and governance was essential, but many of the clinicians (doctors and nurses) working in the EHU had not received prior training in research methodology and the necessary training and associated research governance processes required considerable time and effort to set up.

4.1.1. The importance of research in an outbreak setting

In this context, we focused our efforts on standardising best clinical practice and carefully recording important clinical information so that retrospective analysis could be performed. We prioritised questions that would influence patient management and interrogated our clinical dataset for the answers. In doing this, we felt we could generate evidence to improve wider practice, whilst continuing our focus on care at an individual level.

4.1.2. What were the important research questions?

Identification of suspected clinical cases for isolation and EVD testing was a critical step in EVD outbreak control. We noticed that despite applying the consensus case definition to all admissions at Connaught Hospital, several inpatients who became unwell and were later found to have EVD, did not meet the suspected case definition at presentation, and therefore potentially exposed nursing staff and other patients on general wards. Other individuals may have remained in the community, putting friends and family at risk of EVD. Effective screening of suspected cases was identified as a critical part of the patient pathway that was liable to impede EVD outbreak control.

Additionally, we struggled with lack of capacity in our facility. Despite increasing the number of Connaught EHU beds, we frequently had patients waiting outside the hospital for space to become available due to high transmission in the community. Our capacity was limited by duration of stay, proportional to the time required to obtain an EVD test result. Once a patient was admitted, a blood sample was collected for EVD testing and transported to centralised specialist laboratory for EVD polymerase chain reaction (PCR) testing. The PCR assay required technical skill and advanced laboratory equipment and turnaround time ranged from 1 to 7 days. We could not discharge or transfer patients until their results were available. It became apparent that a point-of-care test with a high sensitivity and a reasonable specificity would transform our case management, allowing us to discharge negative patients with confidence, freeing up beds for new suspected cases, and increasing our admission rate.

4.1.3. Operational research around data management and EHU safety

Clinical information was collected daily from patients admitted to the EHU using a standardised proforma, by clinicians and district surveillance officers. This included demographic data of patients including contact details and travel history, symptoms on admission, date of admission and symptom onset, source of admission, specimen collection date and time, laboratory result and patient outcome i.e. whether the patient was discharged home, transferred to the wards, referred to an ETC or died. This information was then entered into a database in Microsoft Excel, which was used to analyse the data.

In several instances, the information gathered was used to improve the quality of care and to identify bottlenecks in the management of patients in the isolation unit. For instance, a retrospective cohort study of presenting features of EVD confirmed our suspicion that case definitions were not sensitive enough, that baseline symptoms were poor at discriminating EVD-positive cases from other illnesses, and supported the implementation of rapid diagnostic testing [17]. These findings were published open-access in July 2015. The number of hours/days taken to send the blood sample to the laboratory and the time taken to get the results back was analysed to identify delays for targeted interventions, including reorganisation of the laboratory transport system. Delays in turnaround led to increased length of stay and delays in public health action such as contact tracing, highlighting that up-to-date real-time operational data is critical to optimise resource allocation and response [18]. When concerns about nosocomial transmission within the isolation unit were raised, we were able to demonstrate that this was infrequent, by examining the frequency of readmissions (amongst patients

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who tested negative and were discharged), which was low. We identified a maximum positive readmission rate of 3.3% [19], lower than has been previously reported [20].

These findings support the EHU model as a safe method for isolation of suspect EVD patients and their role in limiting the spread of EVD, and will be very important in the coordination and implementation of a response to any future outbreak of EVD. Further operational research was conducted within the EHU to inform decontamination practices, as evidence was lacking. We conducted an audit of decontamination procedures inside Connaught Hospital EHU, showing that prior to decontamination, Ebola virus RNA was detected by PCR within a limited area at all bedside sites tested, but not at sites distant to the bedside. Following decontamination, few areas contained detectable Ebola virus RNA, however in areas beneath bedspaces there was evidence of transfer of Ebola virus material during cleaning. By retraining of cleaning staff (outlined in Section 3) we saw reduced evidence of environmental contamination after decontamination, highlighting that regular refresher training is essential during the course of EVD outbreaks [21].

4.2. Case study—evaluating a point-of-care rapid diagnostic test for EVD

We conducted a study assessing the diagnostic accuracy of a new point-of-care test (RDT) against the gold-standard EVD PCR assay. The RDT test had been developed by the UK Defence Science Technology Laboratories and was delivered to us by PHE who had constructed laboratories in the Western Area. We received 300 prototypes for evaluation. The new test required only one drop of capillary blood generated from a single finger-prick (compared to several millilitres of peripheral venous blood for the standard test). The result was generated by a lateral flow device at the site of testing within 20 min. We designed a diagnostic accuracy study to evaluate the test in an operational setting. Clinical staff who provided care for patients in KSLP-supported units were trained in the study procedure and use of the new test, and tested all admissions to their isolation units with suspected EVD, following informed consent. Phlebotomists who would routinely collect venous blood from all admissions for standard EVD testing by PCR continued to do so. Therefore, all patients enrolled in the study received two tests (the new unproven RDT test) and the routine (gold standard) test. At the end of the study, we were able to compare the performance of the new test with the routine test and estimate the sensitivity, specificity, positive and negative predictive values. The study was implemented in early 2015, in four KSLP-supported clinical sites. The incidence of EVD in Freetown was rapidly decreasing during this time but despite this, the study recruited 138 participants. The test proved highly sensitive and specific and was published in an open access peer-reviewed journal, within two months of study completion [22].

4.2.1. Research governance

There were ethical and governance issues to consider with the sensitive nature of the information that was being collected. Patients were assured of confidentiality and anonymity and permission for the research database was sought from of the Medical Superintendent of Connaught Hospital. The purpose, objectives and method of data collection were explained to all four Medical superintendents, who allowed the study to take place. The study had

institutional approval at all sites and received prospective approval of the Sierra Leone Ethics and Scientific Review Committee.

4.2.2. Challenges in study implementation

A major challenge to study implementation was human resources. Few staff were willing to have direct patient contact, and these staff were overwhelmed by the demands of delivering essential clinical care under challenging circumstances. Working conditions inside the EHU were difficult, with full PPE required at all times and exemplary infection control as per the Phased Training (Section 3).

Patient notes were kept outside the unit, as records inside could not be removed. For data entry, these were inputted in batches after the patient had been discharged, which was time-consuming given the high turnover of patients. A major challenge was forms with incomplete data, and source documents (admission logs and laboratory records) were required to fill in gaps. The RDT result was documented inside the unit and then called out to staff outside. Patient study information leaflets were kept inside the EHU, but destroyed on discharge. A fresh copy was given to patients who were discharged to take away with them. Verbal, rather than written informed consent was taken from patients. Staff documented the process by signing a log outside the EHU.

All staff working on the RDT study offered their time voluntarily, and the study received no specific funding. There were no financial incentives for staff or patients to engage with research and whilst there was enthusiasm amongst staff to be trained in research methods and to assist with the development of an RDT, this diminished once the practicalities became apparent. Taking consent and performing the test required extra time inside the EHU and some staff felt they should be financially compensated for this. Government payments for clinical work had been delayed and some staff were suffering considerable financial hardship and low morale, as described in Section 3.

The RDT study protocol required amendment to routine sample transport and processing policies and some clinical and technical staff expressed (not unfounded) concern that this would negatively impact on patient care. These concerns were addressed by the local ethical and institutional boards and the study was conducted in adherence to international standards of research practice. However, despite this there was some reluctance to support the study and instances in which this resulted in protocol interference.

4.3. Lessons learned

Recognising staff participation in clinical research was important. Certificates of achievement were produced and were popular. An experienced full time study coordinator at each study site would have been effective at encouraging staff and patient participation, and financial incentives for staff would probably have been more effective. However as with routine clinical work, leadership by example of an experienced individual was the most effective way to improve staff morale and motivation.

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Communication was extremely important at all levels. Firstly, more widespread consultation with hospital, clinic and laboratory staff about research protocols prior to decisions to implement them would have been beneficial. Decisions tended to be taken at senior level without dissemination to those in key management positions on the ground and this caused misunderstandings. Training of staff in good clinical practice and research governance was vital, and as few had prior experience close supervision and re-training was necessary. Communication with patients about research was essential. We took time to do this and felt that it was effective.

With respect to the clinical database, more detailed training of the screeners on how to fill forms completely would have been beneficial and may have improved efficiency at data entry level. Automating entries into the Excel spreadsheet would have further minimised typographical errors. Innovative technologies to improve data capture inside the unit would have helped, had they been available. Various methods were considered and some were tried e.g. the use of intercoms, photography and wireless transfer of electronic records, although none were sufficiently accessible at peak of the outbreak to make a significant impact.

One strategy to address the shortage of research staff was recruitment of medical students as volunteers, who were available as the medical school was closed. This was extremely beneficial and provided the students with experience in research methods.

Despite the demonstrated accuracy of the RDT and rapid publication, the RDT is still not widely or commercially available. Lack of financial and institutional endorsement may have delayed this, and we have learned that is not sufficient to generate evidence, we must also campaign for this work to be recognised and petition for translation into improved patient care.

As a health partnership involving KHP and Connaught staff delivering and supporting clinical care for patients with suspected EVD, we were ideally placed to address important clinical research questions. Undertaking research training addressed the partnership aim of health system strengthening. However, considerable challenges existed in terms of lack of time and human resources. We addressed this by strengthening clinical data collection, which was an essential part of routine clinical care and undertaking operational research studies that we felt would have early translational impact, as detailed above.

5. General hospital functioning

Throughout the epidemic, and in particular following the death of one of the three consultant medical physicians at Connaught Hospital, a senior British medical physician volunteering with KSLP assisted the two remaining consultant physicians through providing consultant-led ward rounds and medical student teaching. He became an integral part of the delivering clinical supervision, assisting in patient management and safety, and providing valuable ongoing training opportunities for junior medical staff [22]. This was particularly important as all school and university level education was suspended in Sierra Leone for a full year.

Internal audits of tuberculosis and HIV services showed a limited reduction in number of attendances of existing and new suspect cases, and medical inpatient numbers decreased by up to half during the early outbreak [23]. Surgical cases, sadly influenced by the death of two hospital surgical staff including the country's only trauma surgeon, dramatically dropped in August 2014, and fell to 3% of expected activity [24]. This was on a background of existing shortages in "all aspects of infrastructure, personnel, and supplies required for delivering surgical care in Sierra Leone" [25]. Despite this drop in outpatient and inpatient attendance, the hospital remained open for the duration of the outbreak, in contrast to the major referral hospitals in Guinea and Liberia, and medical wards were very busy alongside the work in the EHU. The partnership approach between COHMAS, KSLP and Connaught allowed for ongoing clinical care and training of HCWs, and all aspects of Connaught Hospital are now fully operational.

As part of reconfiguration of Accident & Emergency services KSLP assisted Connaught Hospital in establishing an effective triage system, provision of free emergency treatment and improving medical record keeping within the Emergency Department. Though Emergency department attendance was negatively correlated with the local prevalence of Ebola virus disease from June 2014-June 2015, possibly due to changes in health-seeking behaviour due to fear of EVD, it remained one of the only facilities in the country where people could access non-EVD medical care [26].

Senior infectious disease staff from KSLP were engaged in the revision of the national TB and HIV guidelines, and the TB clinic was temporarily relocated to new premises, allowing for the construction of a dedicated infectious diseases unit that can be utilised for safe isolation of patients in future highly infectious outbreaks such as cholera.

6. Water, sanitation and hygiene (WASH), infection prevention & control (IPC), and general hospital functioning

6.1.1. Background to IPC in Sierra Leone

IPC was not a known term in Sierra Leone until the recovery phase of the epidemic and there were no dedicated IPC specialists at hospital or national level. IPC was not an element of medical or nursing undergraduate training nor was there any IPC training provided by hospital facilities. Poor IPC practices within healthcare facilities have been attributed as one reason why Ebola outbreaks propagate including that seen in West Africa [27–30] and are a contributing factor in the high rate of HCW infections seen in Sierra Leone [31]. It was clear that the establishment of IPC in Sierra Leone had to be a key part of the postepidemic recovery plan that would help protect against another outbreak. Major factors affecting the proper implementation of IPC included: lack of IPC infrastructure, appropriate PPE and other essential supplies at healthcare facilities, and hand hygiene stations, and poor WASH infrastructure, inadequate systems for medical waste disposal, limited concepts of screening or triage, a lack of IPC knowledge among HCWs, and no IPC policies.

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6.1.2. IPC post-EVD epidemic

In the wake of the epidemic, with funding and technical assistance from the US Centres for Disease Control and Prevention and as part of the Presidential Recovery Plan for Ebola, a large national IPC Project was started in Sierra Leone, covering all MOHS public health units and hospital facilities, titled 'IPC in Hospitals Program'. The 12-month project began in March 2015 and the first stages involved constructing an IPC infrastructure within the country, from national to facility level.

A National IPC Coordinator was appointed and the National IPC Unit was established, based at MOHS. Two national IPC policies were drawn up: one for use during an outbreak of Ebola and one for use once in non-epidemic times. Each hospital appointed a MOHS staff member as an IPC Focal Person who would be responsible for IPC within their facility. Each of these Focal Persons was supported by an NGO worker, known as an IPC Mentor. KSLP allocated IPC mentors to four different facilities in Freetown, including one to Connaught Hospital—these Mentors were international clinicians with a specific background in IPC. All of the IPC Focal Persons and IPC Mentors were sent on a specialist 2-week IPC training course to give them the specialist knowledge required to induct them into their new roles.

KSLP became a member of the Ebola Response Consortium (ERC), who gathered together the majority of partners involved in the project, enabling them to guide and monitor progress as well as instigate consistency among partners in the implementation of different stages of the project.

6.2. Establishing IPC at Connaught Hospital

The IPC team at Connaught was made up of an IPC Focal Person, IPC deputy and IPC NGO Mentor. KSLP also recruited an IPC Project coordinator who oversaw the project across the four hospital sites.

The newly formed Connaught IPC Team included an IPC Focal Person and appointed IPC Deputy who had extensive clinical and leadership experience within the hospital system and good working relationships with staff and management, liaison with MOHS, and specific IPC issues within their hospital. The KSLP IPC Mentor had a specific background and extensive training in infection control and technical knowledge and practical experience to help implement the project. Together this combination of skills and experience within the team was key to improving IPC within the hospital. We garnered support from the Medical Superintendent, Matron, and departmental managers. The IPC Focal Person always chaired and arranged these meetings, as it was essential she was recognised as the central manager for IPC at Connaught.

With over 800 workers at the hospital and a physically large facility, the IPC team established a system of IPC link persons in each clinical department, as recommended by the KSLP IPC Mentor. These were mostly nurses selected by their managers to be advocates for IPC on the wards and other clinical areas, attend regular IPC meetings and to monitor and report relevant problems to the IPC team. A Patient Safety Committee was established, comprising of heads of departments that were relevant to IPC practice and implementation, such as the environmental services department, supplies manager, Matron, Medical Superintendent, senior ward

managers, and representatives from high risk areas such as the laboratory, theatres and the Infectious Diseases Unit. The IPC Focal person always chaired the meetings and guided the agenda as it was essential to establish her as the key person for IPC across the hospital.

There were several key areas that the team worked on to improve IPC within the hospital, detailed below with examples of how we used partnership working to improve the IPC system at the facility.

6.2.1. Supplies

The IPC project highlighted a long-standing national problem of lack of essential supplies and an inadequate national supplies system. Vital items such as examination gloves, bin bags, sharps containers, liquid hand soap and hand sanitiser had always been in short supply or not supplied before or during the outbreak.

The first stage of the IPC in Hospitals Program trained all staff in key IPC elements including hand washing, how and when to use and dispose of PPE, waste segregation and sharps disposal. The Connaught IPC team were aware that the theoretical training would be less effective if staff were not able to fully employ what they had learnt due to lack of supplies in clinical areas. The IPC Team therefore decided to withhold training until they first established the appropriate facilities and supplies to aid implementation of IPC practices.

The hospital staff had long been used to poor access to essential supplies and the KSLP IPC Mentor and IPC Focal Person determined the best way to improve the internal supply chain. The IPC Team used KSLP connections to liaise with and highlight supply problems to the CMS, and linked with other NGOs to see how they tackled supply issues. The IPC Focal Person and deputy used their own status and networks within MOHS to try to address existing problems.

It was vital to establish long-term sustainability within systems and also to ensure that safe practices were maintained, particularly during the tail of the EVD epidemic: this often presented a challenge with supplies. When essential supplies were not received through national procurement, KSLP resolved to provide supplies in the interim, but worked with hospital management to establish a plan of providing supplies in the long term. This strategy was effective and within two months the hospital was procuring essential IPC supplies independently. The improvements seen were due to the efforts of the management and IPC Focal Person, with encouragement and support from KSLP, to redress the problems surrounding long-term provision of supplies.

6.2.2. Training

Under guidance from the IPC in Hospitals Program, the Connaught IPC team set about training every HCW in relevant IPC aspects. Although HCWs in Sierra Leone had training during the outbreak, this was always focused on EVD and PPE, and not on more general aspects. Therefore, this was the first universal training of its kind in Sierra Leone and plans to involve all HCWs across the country were produced.

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At Connaught, as with most institutions in the country, there is difficulty accessing lists of all relevant department employees, however after advertising the training the IPC Focal Person was able to organise attendees into the appropriate sessions. The team established two separate curricula for clinical and non-clinical staff. The IPC Focal Person and deputy highlighted specific IPC problems that clinical staff encountered and targeted the training around this, with the IPC Mentor giving guidance on specific technical areas. The non-clinical staff training presented a challenge as most participants were illiterate so the IPC team adapted training materials and used non-written assessment during the course. All team members were keen on pre- and postcourse testing for participants: the IPC Focal Person was clear that without assessment many would not study and attend all aspects of the course. The KSLP IPC mentor was aware of the valuable data that could be gathered from this training, and helped design appropriate tests, with the IPC Focal Person advising on what language was appropriate to use, the academic level of the participants and the types of questions that trainees would understand. The test was used to determine if participants should pass the training course and we shared resulting data with the hospital Monitoring and Evaluation department, the ERC, and relevant donors to help them understand IPC knowledge within the facility and the effectiveness of the training program.

6.3. WASH

As with many hospitals in Sierra Leone, there were occasional shortages of running water, and a lack of working sinks and taps, flushing toilets and functioning showers within Connaught, and it was clear that improved WASH infrastructure would have a direct impact on IPC practices within the hospital. It made IPC more implementable, and the sense of improvement and investment in hospital infrastructure raised HCW morale that subsequently increased enthusiasm for the project and improved IPC practice. With the involvement of the hospital management and the IPC team, we engaged an external contractor to work on WASH infrastructure and this was monitored and evaluated by KSLP, the ERC, MOHS and the President's office with regular updates given to Connaught senior management. In order to ensure longevity, new fixtures and fittings were procured internationally. The IPC team was keen to ensure that the fixtures would be properly maintained as they could not be easily replaced. KSLP management and the IPC team liaised with Connaught management and together we gave responsibility to the heads of each clinical department for the new fixtures and fittings in their area and ensured that they worked with the IPC team and regularly monitored WASH facilities. This provided a sense of responsibility and ownership from the clinical areas to ensure fittings were properly cared for. Successes outside of WASH included the construction of a building housing a new oxygen plant within Connaught Hospital.

6.4. Ward assessments

It was clear to the IPC Mentor and IPC Coordinator that there would need to be documented evidence of positive behaviour change and improved practice to submit to donors, the MOHS and the President's Office. The local IPC staff were not familiar with the concept of observational audits, assessing routine practice and data reporting but were quick to grasp the concept

when it became clear how useful it would be to project implementation. The IPC Mentor designed an initial ward assessment and audit tool and the local IPC staff were able to give input into what were the specific ward problems and how they should be monitored. The ERC were keen to develop national ward monitoring, and Connaught's assessment tool was used as the basis of the national tool given its success. Local members of the IPC team harnessed a competitive nature among staff through weekly and monthly IPC competitions based on the results of the ward assessments, with initial prizes and scores displayed in public areas around Connaught. This remains one of the most effective ways of improving IPC practice in the hospital, though early prizes were discontinued as it was felt this was not sustainable or desirable.

6.5. Ongoing IPC at Connaught

The focus on sustainability, partnership and knowledge-sharing meant that before the end of the project, the team established an ongoing IPC system within the hospital involving regular training, link nurse meetings, sustainable supply chains and regular ward monitoring with a focus on constant improvement and evidence based practice. With this in place, Connaught, as the main tertiary hospital in the country, can further develop to become a model for the IPC in Hospitals program and for other institutions hoping to improve their own IPC practice and systems.

7. Command centre

In September 2014, KSLP assisted the District Health Management Team (DHMT) for the Western Area in building a Command Centre, as a result of an emerging need to integrate a growing number of KSLP (and other) EHUs within the wider Ebola response, and to create robust systems to direct the flow of cases from the community to EHUs, and from EHUs to ETCs. Before this time, there was a major perceived risk of EHUs overflowing (with concomitant risks to the safety of health care workers and patients), little was known of the number of suspect and probable cases within the Western Area, and there was no co-ordinated system for the transfer of suspect and positive EVD cases. With the support of KSLP, the Command Centre:

- Created a system of real-time case-identification and reporting of suspect cases by ensuring that alerts from the national alerts hotline were conveyed to a Disease Surveillance Officer (DSO) as soon as received (within daylight hours), and that DSOs alerted the Command Centre as soon as a suspect met the case definition
- Tracked in real time the number of beds available in EHUs to ensure that cases were distributed according to space and facilities did not incur the risk of overflow, and to ensure that every available bed was filled
- Created a system of ambulance co-ordination to enable the transfer of suspect EVD cases from the community into EHUs, from EHUs already at capacity into other EHUs, and EVD-positive patients to ETCs

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- Created a central database of all suspect EVD cases, updated with final outcomes, and maintained a live master list of all suspect EVD cases awaiting transfer to an EHU
- Collated laboratory results and communicated these results with facilities that could not access or did not have the capacity to ascertain their own results.

7.1.1. Systems

All systems were either paper based, using simple spreadsheets or using whiteboards, and most operations were carried out by phone and SMS—systems that could be easily be understood and learnt.

In the absence of technological resources, large whiteboards were set out around the Command Centre to enable to whole team to track operations. These detailed the following:

1. Case board: Names, addresses and contact details of all identified EVD suspect cases, their unique case ID, their location, known exposure to EVD, clinical symptoms, and risk factors and the priority category they belonged to for transfer. Also logged on this board was which facility they were assigned to, the status of their collection by ambulance (updated live), and the ambulance team assigned to their collection
2. Capacity board: Bed capacity of all EHUs and ETCs, and beds available to the Command Centre for the transfer of cases by ambulance (all facilities ensure adequate space for walk-in cases). This whiteboard was updated live to reflect the changes in bed capacity throughout the day as cases were transferred.
3. Ambulance board: The number of functional vehicles, names and contact details of all ambulance staff, assigned into numbered teams, their starting location, destination and time of dispatch.
4. Map of Western Area: The location of all suspect EVD cases pinned on a map in order to determine the closest available facility and to identify potential hotspots.

7.1.2. Early operations

The early stages of set-up of the Command Centre at the DHMT, and particularly the presence of an international NGO embedded within in a government organisation, required a great deal of sensitivity to the enormous pressure the DHMT was under to respond to the rapidly growing numbers of cases in the Western Area. One of the key aims of the Command Centre was to create an objective referral system that regulated strictly prevented the overflow of the already severely limited capacity of existing EHUs and ETCs. Severe shortages of beds, ambulances, training and other resources meant that a majority of EVD-suspect cases could not be moved from their homes within 24 h. The first weeks of Command Centre operations drew attention to acute gaps in the response and the need for a rapid scale up of resources, capacity and services, such as co-ordinated ambulance, laboratory and burial services; the need for specific EVD-related services for special populations (pregnant women, neo-nates and children, those with mental health needs); better co-ordination between pillars and partners

on district and national levels; better allocation and prioritisation of resources and the formation of consistent strategic policy.

Whilst data generated by the Command Centre called immediate attention to both the severity of the outbreak in the Western Area and the acute lack of resources available to mount a robust response, it was also perceived to reflect adversely on the DHMT's management of the response. KSLP remained aware of the DHMT's concerns, and tried to ensure that its relationship with the DHMT was both supporting and supportive, both operationally and in public. However, such issues highlighted how essential it was to ensure that the Command Centre was represented by a trusted figurehead with thorough knowledge of national context and good relationships with local and national government bodies, who could actively promote Command Centre operations but also resolve sensitive issues diplomatically. In the absence of such a figure during the early response period, KSLP, as the external partner helping build the Command Centre systems was continually at risk of being perceived as an undermining force.

7.1.3. Evolution

As a result of reporting from the Command Centre, in November 2014, with support from the Government of Sierra Leone and international donors, a NERC was built to ensure co-ordination and implementation of strategy and resources at national scale, to oversee Ebola Response Centres in each District (DERC). A DERC comprised of surveillance, case management, burial, quarantine, laboratory sample co-ordination and protection cells. The DERC model, which began in the Western Area and which evolved directly from operations at the DHMT Command Centre, was implemented across the country, with adaptations in line with the needs and requirements of each district.

Having assisted with the migration of the DHMT Command Centre and its functions into this new structure, KSLPs work within the DERC in the Western Area continued to focus primarily on the 'Live Case Management' cell, with a rapidly expanded team of national volunteers, who were by this time well-trained in the core processes outlined above.

7.2. Staffing

Staffing of the Live Case Management Cell were divided into five 'teams' in a flat structure under a co-ordinator who was ultimately responsible for overseeing day-to-day operations of the cell:.

Chief functions of each team were as follows:

- Case management: focal point for all EHUs and ETCs; determine bed occupancy and availability for transfers and track on whiteboards; communication of lab results, determine the movement of suspect and positive EVD cases, track and record details of patients across all units and their outcomes
- Fleet management: Manage the maintenance, fuelling and supply of ambulances, ambulance staff rotas

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- Ambulance co-ordination: Dispatch and live tracking of ambulance teams, communication of ETAs to facilities
- Communications: focal point for Disease Surveillance Officers; record information of suspect cases into logs and on whiteboards; prioritise case collection according to scoring system (see Section 7.1); highlight unique risk factors or circumstances to Case Management and Ambulance Co-ordinations teams
- Data: Maintain central database of cases, aggregation and analysis of data according to reporting requirements, release daily and weekly reports as required, track KPIs

7.3. Case prioritisation

Still with an acute shortage of beds, KSLP introduced an accessible, public health-based scoring system to prioritise collection of suspect EVD cases based on their clinical state, whether they were from a home that was already quarantined, the number of people residing in the household, and their vulnerability, e.g. children under 15 who were alone, cases in public places, cases with known or perceived mental health issues.

7.4. Co-ordination

A rapid scale up of EHUs and ETCs across the Western Area began in November 2014. The Live Case Management cell, with KSLP support, became the focal point for co-ordinating and monitoring the safe opening of these facilities, ensuring each facility fully integrated with DERC systems and processes. This rapid expansion also signalled a greater need for co-ordination between EHUs and ETCs, which led to the introduction of weekly meetings, led by KSLP. These meetings became a valuable forum for updating partners on the wider picture of the response, assessing outbreak trends, for discussing daily clinical challenges, and for providing a vital feedback loop for the Live Case Management Cells on their operations. With King's support, a 'scorecard' system based on the throughput of patients through facilities, was produced and presented to all facility representatives at these meetings, which incentivised lower performing facilities to quickly resolve bottlenecks that hindered optimal throughput.

7.5. Reporting

KSLP's more targeted support to the Live Case Management Cell included developing existing capacity within the data team to generate sophisticated reports from their main database (a simple but extensive spreadsheet). As a result of KSLP's assistance in this area, by January 2015 the data team within the Cell were able to:

- Generate daily reports with Key Performance Indicators (KPIs) such as percentage occupancy of holding and treatment beds, the percentage of suspect EVD cases attended to within a 24-h period, and the inflow and outflow of cases through EHUs and into ETCs.

Such KPIs facilitated tailored decision making at strategic levels of the response, for example EHU and ETC expansion was planned according to need, and additional resources were allocated as needed to ensure that suspect EVD cases were responded to within a 24-h period.

- Develop metrics to assess case flow from the time of identification of a suspect case by a DSO, through to discharge (if EVD-negative) or to ETC (if EVD-positive). These metrics were crucial in assessing the throughput of cases through facilities, identifying bottlenecks in the system, and enabling facilities to assess and optimise their own performance (see **Figure 3**). The optimal throughput target was for a suspect EVD case to be tested and either discharged or transferred to an ETC within 24 h of admission.
- Collect and aggregate simple clinical data such as fatality rates and rates of discharge across EHU and ETCs for use by EHUs, ETCs and epidemiological partners.
- Assess and aggregate the number of EVD suspect cases admitted to EHUs via notification to the national hotline, and the number of EVD suspect cases arriving at EHUs of their own volition, thereby helping policy makers assess and monitor the use and effectiveness of the national hotline.
- Maintain a database of all suspect EVD cases in the Western Area and their paths to testing and treatment, eventually enabling status updates to be given to families as required.

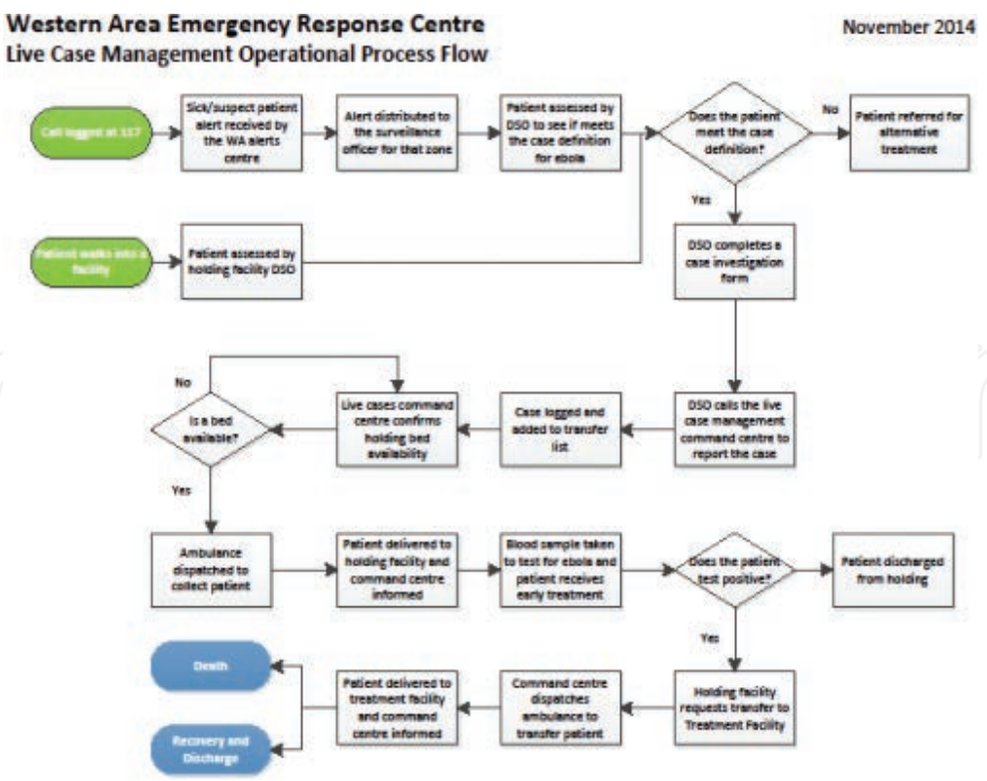


Figure 3. Live case management operational flow.

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7.5.1. SMS Platform

KSLP supported an SMS platform to relay laboratory results to EHUs as close as possible to the publication of results. This was crucial in a low-resource setting with limited internet and data sharing capabilities, and the system was later adopted by laboratories in the Western Area. Relaying results via SMS from source sought to minimise errors in communication and create accountability for the reporting of results by creating a record of time between the receipt of results by the Live Case Management Command Cell and the time results were relayed by SMS.

7.6. Lasting capacity

By the time KSLP phased out its support of the Western Area DERC in March 2015, a team of twenty national volunteers were able to confidently manage the Live Case Management Cell, and continued to utilise the systems KSLP helped to put in place to manage case flow. A number of national staff were seconded during later periods of the outbreak to support and mentor teams in other districts of Sierra Leone.

8. Legacy of EVD partnership working

Moving forward, KSLP has ongoing partnership and collaboration with the national secretary of HIV and TB, providing technical support for training, elaboration and implementation of treatment and management guidelines. Together we have established the first infectious diseases unit in the country at the main referral hospital, and will work with the medical school to undertake teaching of medical students in infectious diseases.

KSLP will assist Connaught in creating a Centre of Excellence in Infectious diseases to be a hub for care, education and research of infectious diseases. The main aims are to build individual, institution and national clinical research capacity in infectious disease response, with a focus on three work streams:

- Human resources—training hospital staff and students to plan, lead, and undertake clinical research;
- Research infrastructure—establishing the necessary infrastructure to support clinical research activity;
- Enabling environment—creating an enabling environment for clinical research across both main adult hospitals in Freetown, as part of a national clinical research agenda.

There is also very limited information available on antimicrobial resistance across the region, and KSLP aims to work with Connaught and partners in developing protocols for clinical management of patients based on a variety of syndromic management. The new ID unit will have an electronic patient record established in order to track demographics and clinical syndromes of patients. Other areas of clinical activity will include the ongoing care of those suffering sequelae of EVD infection, as ongoing IPC and WASH developments continue. KSLP

and Connaught are also working with MOHS to initiate free tertiary care for adult Ebola survivors at the hospital.

These outcomes described were delivered through a partnership model. In this chapter we have revisited the various stages of the EVD outbreak, from early triage and case definitions, through ramping up isolation and treatment capacity, to how best to retain and develop resilience in health systems, alongside research efforts and outbreak control principles. We hope we have highlighted how an embedded organisation working in close collaboration with senior leaders in an MOHS hospital and other partners can assist in developing institutional and national response.

Glossary

Central Medical Stores	CMS
College of Medicine & Allied Health Sciences	COMAHS
Community Care Centre	CCC
District Ebola Response Centre	DERC
District Health Management Team	DHMT
Disease Surveillance Officer	DSO
Ebola Holding Unit	EHU
Ebola Response Consortium	ERC
Ebola Treatment Centre	ETC
Ebola Virus Disease	EVD
Health Care Worker	HCW
Human Immunodeficiency Virus	HIV
Infection Prevention and Control	IPC
Key Performance Indicators	KPI
King's Health Partners	KHP
King's Sierra Leone Partnership	KSLP
National Ebola Response Centre	NERC
Non-Governmental Organisations	NGOs
Personal Protective Equipment	PPE
Polymerase chain reaction	PCR
Public Health England	PHE
Rapid Diagnostic Test	RDT
Tuberculosis	TB
Ministry of Health & Sanitation	MOHS
Water, sanitation & hygiene	WASH

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