Contextual data for IPC Ring approach

KQ3 - Should the IPC ring approach be used versus not used to prevent and control transmission of Ebola Virus Disease (EVD) in health care facility and community settings?

Objectives: To reduce Ebola/Marburg transmission in a predetermined risk area whenever a case is identified.

- The IPC Ring approach is based upon the premise that early cluster detection can trigger a rapid, localized response in the high-risk radius around one or several health facilities to reduce transmission sufficiently to extinguish an outbreak or reduce its spread. This premise is the operating principle in case-area targeted interventions against cholera epidemics.[1]
- Although IPC Ring shows promise for outbreak control in Liberia, Guinea, Sierra Leone and the Democratic Republic of Congo, it is critically dependent on IPC training, contact tracing and triage capacities (table). [2] [3] [4] [5] [6]
- IPC Ring is an IPC approach that requires effectiveness evaluation. It was developed rapidly and collaboratively in response to an urgent public health need; as such, data were not collected and aggregated systematically across all facilities, potentially limiting the generalizability of these results (table).[3]

Stakeholders: Patients, health workers, health facilities, communities, health systems, governments of affected countries and countries providing humanitarian support, international health and humanitarian organizations.[6, 7]

Settings: Health facilities and communities in areas with low Ebola/Marburg community transmission, especially in settings of very limited resources and capabilities to deal with the disease burden.[3]

- In these settings, the effectiveness of new Ebola treatment centers can be maximized with concurrent acceleration of case ascertainment.[8]

Epidemic phase: Early or late phase of an endemic.[3]

Populations: patients and health workers

Health-system strategies related to IPC Ring intervention:

Establish governance structure for the IPC Ring intervention, such as IPC Task Force.[3]

Conduct surveillance of potential cases in the community and conduct contact tracing.[9]

Public communication to improve knowledge of signs and symptoms of Ebola/Marburg diseases in the community and notice of triage procedures at health facilities targeted by the IPC Ring intervention.[9, 10]

Conduct rapid IPC needs assessments at target health facilities (HFs) using validated assessment tools, focusing on *triage procedures, isolation structures, PPE use, gaps in PPE supply chain, general IPC training and specialized triage training*.[3]

- Coordination and collaboration among the national Incident Management System, county health teams, CDC, WHO, African Union and nongovernmental organization partners was key to identifying gaps in IPC needs and preventing duplication of efforts.[3]

Ring Intervention

The IPC Task Force formalizes components of the Ring IPC approach, including identification of target HFs, ***a focus on triage, organizing external staff members to support triage*****,** and coordination and definition of roles among partners.[3]

- The initial ring was coordinated by the IPC Task Force under Ministry of Health and Social Work (MOHSW) leadership. In subsequent rings, the national Incident Management System and county health departments joined efforts with CDC, WHO, African Union, and multiple nongovernmental organization partners participating in initial discussions, planning, and rapid IPC assessments.[3]

The Task Force identifies target HFs for the Ring IPC intervention, e.g. based upon known health worker exposure to an Ebola patient, neighboring HFs that ring around the HF that treated a case, or HFs in close proximity to the residence of a patient with confirmed Ebola.[3]

- Operating procedures for the implementation of the IPC Ring intervention are not available, e.g., the potentially relevant studies did not discuss implementation details (table).

Initiate Ring IPC intervention

Rings around target HFs should be initiated within 4 days after recognition that a facility had provided care to a case.[3] The isolation of 75% of individuals infected with Ebola virus in critical condition within 4 days from symptom onset has a high chance of eliminating the disease.[11]

Ensure PPE supplies for HWs and patients seeking help at target HFs.[9]

Conduct IPC training, triage training and training on PPE use for HWs at target HFs.[3]

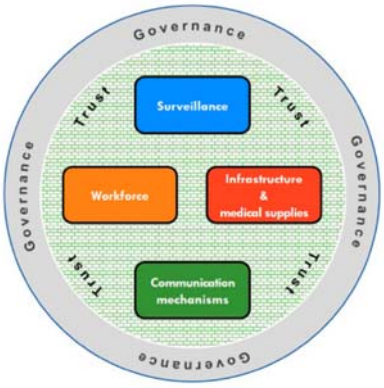
Providing ***rapid, intensive and short-term*** (21-days) support to healthcare facilities and communities in areas of active Ebola transmission - had a good impact in Guinea and Liberia. Throughout the EVD outbreak in Guinea, individual healthcare workers (usually 1 or 2 per healthcare facility) were selected to take part in an intensive five-day IPC training with a focus on EVD, organized by the Ministry of Health and partners (WHO, CDC and others). The participants were strongly encouraged to organize cascade training, i.e. training to other medical staff within their respective healthcare structures, following guidelines developed by the Ministry of Health. [12]

The first ring was initiated 4 days after recognition that a facility had provided care to an Ebola patient; subsequent rings were initiated within 2 days after recognition of other Ebola patients. In total, 59 target HFs were identified, 52 in Montserrado County (out of a total of 294 HFs) and seven (out of a total of 32) in Margibi County. There was an average of 15 HFs per ring (range = 3–31).[3]

Overall, Ring IPC efforts appeared to be associated with an increase in the identification and isolation of suspected or probable Ebola patients. Nevertheless, triage was not always completely successful (table).[3]

Issues to consider when implementing the IPC Ring intervention

The figure below displays a conceptual framework potentially relevant to the implementation of IPC Ring intervention. It includes six core constructs: (1) Surveillance, (2) Infrastructure and medical supplies, (3) Workforce, (4) Communication mechanisms, (5) Governance, and (6) Trust (table).[9]



Surveillance

Gaps in event-based Ebola surveillance systems in Ghana led to inadequate early case detection and response preparedness to prevent Ebola virus outbreaks and spread. An absence of Ebola surveillance systems was noted during a 2014 assessment of emergency preparedness in South Eastern Liberia. This led to a series of surveillance training workshops and creation of an Ebola incident management system, which enhanced preparedness and reduced Ebola case burden in the region, compared to other areas of the country (table).

The collaboration between the contact tracing team, active case finding teams and case investigation teams resulted in the detection of previously unidentified Ebola virus disease contacts and the locations of missing contacts in a 2015 cluster outbreak in Monrovia, Liberia (table).

Community health monitors in active (and early) case finding, contact tracing and the quarantine of high-risk individuals led to the eventual 2014–15 control of Ebola transmission in Liberia (table).

Community-appointed Village Health Teams in supporting outbreak response activities resulted in the quick containment of Ebola and Marburg virus epidemics in Uganda. This strategy of strong community mobilization also increased acceptability of the community to bring patients to isolation facilities (table).

Workforce

Three articles reinforced the need for a strong health workforce appropriately distributed at the sub-national level, rather than just a target aggregate number of health workers nationally. Continuity of health worker training, particularly around infection, prevention and control, was stressed as a critical aspect of emerging infectious disease prevention (table).

Infrastructure and medical supplies

Existing studies stress the presence of operationally ready isolation centers that are able to treat patients in as safe an environment as necessary. Studies also reinforced the need to ensure accessibility of health care facilities, both geographically and financially (table).

A study described the important role of a Government-NGO partnership in strengthening existing health facility infrastructure for the scale up of services for Ebola patients at the height of the 2014 outbreak in Sierra Leone, which included bolstering PPE supply chains. A lack of basic supplies of gloves, gowns and intravenous fluid were noted in another study as limiting the abilities of front-line health workers. The authors commented that the systems required for high-quality care during a crisis are the same as those required for effective routine health care and chronic disease management. The impact of weak existing

medicines supply chain systems was revealed in a qualitative study of community health workers in Liberia, where the Ebola outbreak response interrupted the district supply of essential medicines for community case management of diarrhea and pneumonia (table).

Communication mechanisms

A scoping review found 23 articles illustrating communication mechanisms underpinning effective emerging infectious disease prevention and response. Ten of these reinforced the necessity of a risk-communication strategy to guide a timely, coordinated and standardized approach to information sharing during outbreak management. The importance of partnership between national health organizations and media agencies to ensure dissemination of clinically accurate messages supportive of prevention and control efforts during public health emergencies was confirmed in a further eight articles (table).

The valuable role of community members as key players in risk communication activities was widely acknowledged (table).

Established and documented protocols, guidelines and procedures were widely affirmed by the literature as an integral element of the communications mechanisms associated with emerging infectious disease preparedness. For secondary and tertiary health facilities, these included a health worker protocol for infectious disease management, security protocols for both facility infrastructure and personnel, and procedures for patient isolation (table).

Governance

Governance here refers to a relational view emphasizing the making, changing, monitoring and enforcing of the rules that govern the demand and supply of health services. Leadership and coordination across global, regional, national and sub-national levels were presented as critical enablers of an effective, cohesive response to emerging infectious disease threats (table).

The capacity of governments to engage and collaborate with non-state actors and civil society was another facet of good governance identified as supporting health system preparedness for emerging infectious disease. Central to such effective engagement and partnerships is the ability to mobilize additional resources in the event of an outbreak – including emergency teams of clinicians and logistics personnel, community resources, and national and international non-government organizations (table).

Trust

The concept of trust – from the community level through to global governance – emerged as a fundamental element of health system preparedness for an EID outbreak, extending across each of the five identified core constructs. The notion of trust has been defined as encompassing both interpersonal trust between, for example, patient and provider as well as institutional trust between individuals/ communities and the health system or government (table).

Table: Contextual data for the implementation considerations of the IPC Ring intervention

Author	Year	Study methods	Findings relevant to the extraction of contextual data	Data type	Contextual data
Palagyi [9]	2019	Narrative synthesis, 49 included studies	The article reinforces the interconnectedness of the traditional health system building blocks to emerging infectious disease (EID) detection, prevention and response, and highlights the critical role of system 'software' (i.e. governance and trust) in enabling LMIC health systems to achieve and maintain EID preparedness.	Conceptual framework	The resulting conceptual framework recognised six core constructs: four focused on material resources and structures (i.e. system 'hardware'), including (i) Surveillance, (ii) Infrastructure and medical supplies, (iii) Workforce, and (iv) Communication mechanisms; and two focused on human and institutional relationships, values and norms (i.e. system 'software'), including (i) Governance, and (ii) Trust.
			Surveillance is the building block in EID detection, prevention and response: the early detection and monitoring of infectious diseases is an overarching enabler of EID preparedness.	Conceptual framework	Use indicator-based and event-based systems for surveillance. Indicator-based surveillance refers to the routine reporting of cases of disease, usually from health care providers to public health officials; event-based surveillance is the organised and rapid capture of information about events that are a potential risk to public health, through both formal and informal channels. Gaps in event-based Ebola surveillance systems in Ghana led to inadequate early case detection and response preparedness to prevent Ebola virus outbreaks and spread. An absence of Ebola surveillance systems was noted during a 2014 assessment of emergency preparedness in south-eastern Liberia. This led to a series of surveillance training workshops and creation of an Ebola incident management system which enhanced preparedness and reduced Ebola case burden in the region, compared to other areas of the country.
			Surveillance: The ability to rapidly implement effective patient screening processes for EIDs, and maintain such processes alongside systems for identification of known existing infectious diseases, was emphasized as a vital lesson learned from the West African Ebola outbreak.	Conceptual framework	For example, an integrated community-based management system of illness cases in children was no longer functioned effectively during the 2014 Ebola crisis in Liberia, and a reduction in immunization coverage and an increase in cases of severe malaria among children were observed during the 2014 Ebola outbreak in Guinea.
			Surveillance: Established contact tracing and monitoring procedures were another essential element of effective EID surveillance. These included contact identification and listing, classification of risk status, daily monitoring for symptoms and the effective management of symptomatic contacts.	Conceptual framework	For example, the collaboration between the contact tracing team, active case finding teams and case investigation teams resulted in the detection of previously unidentified Ebola virus disease (EVD) contacts and the locations of missing contacts in a 2015 cluster outbreak in Monrovia, Liberia.
			Surveillance: A functional data management system (and procedures for data sharing) is important.	Conceptual framework	Community health monitors in active (and early) case finding, contact tracing and the quarantine of high-risk individuals led to the eventual 2014–15 control of Ebola transmission in Liberia.
				Conceptual framework	Community-appointed Village Health Teams in supporting outbreak response activities resulted in the quick containment of Ebola and Marburg virus epidemics in Uganda. This strategy of strong community mobilization also increased acceptability of the community to bring patients to isolation facilities.
			Surveillance: Contact tracers need to practice 'subtlety and diplomacy' during often extended periods of personal interactions in situations of high stress and fear.	Conceptual framework	
			Surveillance: The inclusion of both zoonotic and animal surveillance was important to optimize local, national, and global EID surveillance and monitoring systems, as illustrated by the examples of Ebola, West Nile virus, Nipah virus, severe acute respiratory syndrome and Zika virus. These EID are notable emerging zoonotic infectious diseases of humans that have been caused by pathogens arising from animal reservoirs.	Conceptual framework	The authors state the importance of a 'One Health' approach to controlling zoonotic pathogens, involving sustainable and equitable collaborations between the animal, human, ecosystem, and environmental health sectors at the local, national, and international levels. Jacobsen et al. (2016) commented on the necessity for proactive zoonotic and animal surveillance activities in their review of lessons learned from the Ebola outbreak. They signaled the need for effective human − animal health collaboration and coordination, including simultaneous monitoring and linkage of human and animal disease surveillance systems, to promote early detection of potential pandemic

Author	Year	Study methods	Findings relevant to the extraction of contextual data	Data type	Contextual data
					pathogens, and rapid response to protect health in both populations.
			Workforce: The availability of frontline healthcare workers (including doctors, nurses and midwives) in sufficient numbers and with appropriate training was identified in 13 articles as a key characteristic of an EID-prepared health system.	Conceptual framework	Three of these articles (Gostin & Friedman, 2015; Kruk et al., 2015 and Regmi, Gilbert, & Thunhurst, 2015) reinforced the need for a strong health workforce appropriately distributed at the sub-national level, rather than just a target aggregate number of health workers nationally. Continuity of health worker training, particularly around infection, prevention and control, was stressed as a critical aspect of EID prevention by both Thiam et al. (2015) and Nyarko, Goldfrank, Ogedegbe, Soghoian, and de-Graft Aikins (2015). Regmi et al. (2015) advocated for appropriate disease-specific health worker training programmes, tailored to the local circumstance, with inclusion of veterinary public health awareness, and training for health managers in outbreak and emergency response systems.
			Workforce: Other studies noted the requirement for sufficiently skilled epidemiologists able to define and validate signal events, integrate data from a variety of information sources and translate these into a public health response (Balajee et al., 2016; Siedner, Gostin, Cranmer, & Kraemer, 2015).	Conceptual framework	Balajee et al. (2016) support the concept of 'field epidemiology training' where, under the mentorship of more experienced epidemiologists, public health workers use real-life local events to develop the necessary skills to gather and assess critical disease data and use this to inform action. Trained laboratory officers with capacity to collect, prepare, analyse and store specimens were also identified as a critical addition to the frontline health workforce (Adokiya & Awoonor-Williams, 2016; Balajee et al., 2016; Bhatnagar, Grover, Kotwal, & Chauhan, 2016).
			Workforce: Eight articles addressed the need for trained community health workers (CHWs) to enhance the routine provision of essential primary health care services in addition to outbreak response activities.	Conceptual framework	Siekmans et al. (2017) described the successful involvement of CHWs in communicating awareness and prevention messages through village-based activities during the Ebola crisis in Liberia. Thiam et al. (2015) presented views of local stakeholders in Guinea, who underlined the essential role of both CHWs and members of community-based organizations in bridging the gap between communities and international agencies in Ebola response activities. The importance of this bridging role was reinforced by Scott, Crawford-Browne, and Sanders (2016) who, using evidence from the West Africa Ebola outbreak, highlighted the difficulties in engaging communities in prevention and response activities without a network of health workers who were both accountable to, and embedded within, those communities. Two articles (Alexander et al., 2015; McPake et al., 2015) advocated for the training of traditional healers in infection control and the delivery of public health messages as an important mechanism for sharing accurate and constructive information with communities regarding outbreak prevention and control. This needs to be balanced against the risks of providing traditional healers legitimacy within the health care system, if there is no system to ensure acceptable practice and minimal standards of care (Krah, de Kruijf, & Ragno, 2018).

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			Workforce: Aspects of financing and incentivizing the health workforce for effective EID preparedness were discussed by McPake et al. (2015). The authors list financial (along with logistical and managerial) investment in the health workforce as integral to building trust between communities and health providers.	Conceptual framework	Attracting and retaining a well-educated workforce to rural and remote locations poses a major challenge (Grobler, Marais, & Mabunda, 2015; Wilson et al., 2009). Nyarko et al. (2015) cite a lack of indemnities such as health insurance, workers' compensation and other services for health care workers in Ghana as a barrier to their commitment and continued quality care in the event of an Ebola virus outbreak. Non- and delayed payment of financial incentives implemented to attract, retain and motivate health workers in rural postings instead served as a source of demotivation and attrition during the 2014–15 Ebola outbreak in Sierra Leone.
			Infrastructure and medical supplies: Adequate numbers of health facilities and inpatient beds for population size, and their distribution relative to the geographic location of communities, were highlighted as factors integral to a health system's outbreak response capacity (Boozary et al., 2014; Cancedda et al., 2016; Espinal, Aldighieri, St John, Becerra-Posada, & Etienne, 2016; McPake et al., 2015; Regmi et al., 2015).	Conceptual framework	Likewise, the presence of operationally ready isolation centres, able to treat patients in a safe environment as necessary. Studies also reinforced the need to ensure accessibility of health care facilities, both geographically (Buseh, Stevens, Bromberg, & Kelber, 2015; Siekmans et al., 2017) and financially (Kaufman, 2008).
			Infrastructure and medical supplies: The importance of available and well-maintained medical equipment was commonly emphasised (19/49 articles), with particular attention to the lack of personal protective equipment (PPE) in West Africa health facilities during the Ebola crisis.	Conceptual framework	Cancedda et al. (2016) described the important role of a Government-NGO partnership in strengthening existing health facility infrastructure for the scale up of services for Ebola patients at the height of the 2014 outbreak in Sierra Leone, which included bolstering PPE supply chains. A lack of basic supplies of gloves, gowns and intravenous fluid were noted by Boozary et al. (2014) as limiting the abilities of front-line health workers; a product of inadequate supply and distribution systems. The authors commented that the systems required for high-quality care during a crisis are the same as those required for effective routine health care and chronic disease management. The impact of weak existing medicines supply chain systems was revealed in a qualitative study of community health workers in Liberia, where the Ebola outbreak response interrupted the district supply of essential medicines for community case management of diarrhoea and pneumonia (Siekmans et al., 2017).
			Infrastructure and medical supplies: The essential elements of a public health laboratory system underpinning early EID outbreak detection and response were described in 13 articles. These included: readiness of trained personnel and accessories for appropriate specimen collection (Bhatnagar et al., 2016; Cash & Narasimhan, 2000); availability of sample collection and transport kits at select sites in the laboratory network (Balajee et al., 2016); safe and rapid transport mechanisms to both national (Lapao et al., 2015) and international (Espinal et al., 2016; Forrester et al., 2014; Thiam et al., 2015) reference laboratories; and timely characterization of pathogens with mechanisms for the efficient feedback of results to national focal points to enable rapid and appropriate responses (Balajee et al., 2016).	Conceptual framework	Jacobsen et al. (2016) listed the need for point-of-care diagnostic assays among lessons learned from the West Africa Ebola outbreak of 2014–15.
			Communication mechanisms: The authors found 23 articles illustrating communication mechanisms underpinning effective EID prevention and response. Ten of these reinforced the necessity of a risk-communication strategy to guide a timely, coordinated and standardized approach to information sharing during outbreak management. The importance of partnership between national health organizations and media agencies to ensure dissemination of clinically accurate messages supportive of prevention and control efforts during public health emergencies was confirmed in a further eight articles.	Conceptual framework	Ozawa, Paina, and Qiu (2016) discussed how negative messages about vaccines from the media in Ebola-affected countries could undermine efforts to rebuild community trust in the health system following system-wide shocks.

Author	Year	Study methods	Findings relevant to the extraction of contextual data	Data type	Contextual data
			Communication mechanisms: The valuable role of community members as key players in risk communication activities was widely acknowledged.	Conceptual framework	Nyarko et al. (2015) described the significance of bi-directional communication in devising educational messages for Ebola preparedness, i.e. engaging communities to understand fears, challenges and opinions on how issues should be addressed, through a co-production process involving community leaders and members, frontline healthcare workers and community- based organisations. Buseh et al. (2015) labelled this approach an 'empowerment model', in which community leaders are enabled to contribute positively to programs that embrace and represent the values of their community members, with the aims of reducing fear and stigma, and to encourage care-seeking.
			Communication mechanisms: Established and documented protocols, guidelines and procedures were widely affirmed by the literature as an integral element of the communications mechanisms associated with EID preparedness. For secondary and tertiary health facilities, these included a health worker protocol for infectious disease management (Bhatnagar et al., 2016; Boozary et al., 2014; Cancedda et al., 2016; Mulinge & Soyemi, 2016; Regmi et al., 2015; Siekmans et al., 2017), security protocols for both facility infrastructure and personnel (Cancedda et al., 2016; Lapao et al., 2015), and procedures for patient isolation (Bhatnagar et al., 2016; McPake et al., 2015; Regmi et al., 2015).	Conceptual framework	Four articles also addressed the need for standardized procedures to guide social mobilization for EID prevention and response, and community-centered infection prevention and control protocols championed by local leaders and community HWs (Cancedda et al., 2016; Espinal et al., 2016; McPake et al., 2015; Stoto et al., 2013). Bhatnagar et al. (2016) drew learnings from the 2014 West Africa Ebola outbreak to reinforce the need for a laboratory biosafety protocol, together with adherence to this by laboratory personnel. A simple, accessible directory containing the contact details of reference laboratories and contact information of key national (and subnational) laboratory personnel was also recommended as necessary for improving capacity for outbreak response (Balajee et al., 2016).
			Governance: Governance here refers to a relational view emphasizing the making, changing, monitoring and enforcing of the rules that govern the demand and supply of health services (Abimbola, Negin, Martiniuk, & Jan, 2017a). In the reviewed publications, leadership and coordination across global, regional, national and sub-national levels were presented as critical enablers of an effective, cohesive response to EID threats.	Conceptual framework	Gostin and Friedman (2015) discussed the vital role of an empowered global health leader (i.e. the WHO) in steering the overall direction, and coordinating the many participants, of an epidemic response. Scott et al. (2016) and Cancedda et al. (2016) highlighted the need for shared regional and national governance in mitigating the transboundary threat posed by many EIDs: Scott citing weak national governance in Sierra Leone and Guinea as lessening the ability of already compromised national health systems to manage the spread of Ebola virus associated with the movement of communities across country borders. The requirement for sub-national (local) governance structures that promote district-level coordination and management of EID detection and response featured in five articles (Kruk et al., 2015; Lapao et al., 2015; McPake et al., 2015; Stoto et al., 2013; Thiam et al., 2015). Thiam et al. (2015) provided the example of Regional and Prefecture Response Committees in the coordinated response to the 2014 Ebola outbreak in Guinea. They found that the effectiveness of these structures were weakened by a lack of community consultation in the appointment of Committee coordinators. Other studies also highlight the centrality of community advisory bodies, formed by national and local governments, in responding to an EID outbreak (e.g. Siedner et al., 2015; Siekmans et al., 2017). Ideally, such groups would represent a broad spectrum of community interests and comprise religious leaders, community leaders, representatives from NGOs, and other stakeholders.

Author	Year	Study methods	Findings relevant to the extraction of contextual data	Data type	Contextual data
			Governance: The capacity of governments to engage and partner with non-state actors and civil society was another facet of good governance identified as supporting health system preparedness for EID. Central to such effective engagement and partnerships is the ability to rapidly mobilize additional resources in the event of an EID outbreak – including emergency teams of clinicians and logistics personnel (Kaufman, 2008; Siedner et al., 2015), community resources (Cancedda et al., 2016; Mbonye et al., 2014), and national and international non-government organizations (Gostin & Friedman, 2015).	Conceptual framework	Buseh et al. (2015) emphasized the need for public-private partnerships, both regionally and internationally, to strengthen the capacity of affected countries to handle infectious disease outbreaks while maintaining the provision of basic health care. McPake et al. (2015) described how stable governance arrangements facilitated effective coordination of international agencies in the containment and control of the 2000–2001 Ebola outbreak in Uganda, drawing contrast with the aid co-ordination problems undermining Ebola control efforts in Sierra Leone in 2014–15. The rapid control of the 2014–15 Ebola outbreak in Liberia was also attributed to effective engagement and collaboration between government and international partners by Nyenswah et al. (2016).
			Trust: The concept of trust – from the community level through to global governance – emerged as a fundamental element of health system preparedness for an EID outbreak, extending across each of the five identified core constructs. The notion of trust has been defined as encompassing both interpersonal trust between, for example, patient and provider as well as institutional trust between individuals/ communities and the health system or government (Topp & Chipukuma, 2016).	Conceptual framework	Kruk et al. (2015) incorporated trust as one of several preconditions for health system resilience – 'Health systems that earn the trust and support of the population and local political leaders by reliably providing high-quality services before crisis have a powerful resilience advantage' – reinforcing the need for inclusive and robust community engagement with the health system. Both Thiam et al. (2015) and Alexander et al. (2015) highlighted the role of community distrust of frontline health services in generating resistance to seeking health care and implementing infection control measures during the Ebola crisis. Through interviews with community leaders and community-based organisations, Thiam et al. (2015) found that the use of personal protective equipment by authorities during village-level infection control activities engendered fear in the community, and heightened mistrust of Western medicine and practices. Such negative reaction was primarily a result of the absence of both initial community consultation and appropriate community-led education on infection prevention and control. Alexander et al. (2015) discussed how a fear of Western medical practices led to individuals depending on traditional healers or family members for care during the Ugandan outbreak (Chan, 2014), with many patients fleeing hospitals after linking the hospital environment to likelihood of death. Dhillon and Kelly (2015) presented a case study demonstrating how mistrust of formal power structures led to community members hiding the sick from Ebola response teams. They recommended that trust be built through close, long-term engagement with community members and local leaders, and the incorporation of community preferences into infection prevention and control measures. Jacobsen et al. (2016) further identifies the centrality of community in the success of global zoonotic surveillance activities, suggesting that active community involvement builds trust, increases participation in zoonotic monitoring and improves existing surveillance systems.
			Trust: Health workers' trust in their local health leadership and government was identified by Nyarko et al. (2015) as essential to the effective control of infectious disease transmission. Based on a roundtable discussion involving frontline clinicians, they identified 'inadequate staff, space, stuff and systems' as the foundation of increased health worker fear and insecurity in the management of patients with suspected EVD, eroding both confidence and commitment to providing care.	Conceptual framework	There were reports of nursing staff claiming they would leave their jobs out of fear 'if Ebola comes'. The legitimacy of these claims was evidenced during the year 2000 Ebola epidemic in Uganda, where an account of nurses abandoning their posts at Kampala hospital following the suspicious death of a male patient was widely reported in the media (Kinsman, 2012). The distrust of healthcare workers in their leadership's ability and commitment to mobilize resources in the event of an EID outbreak was also noted by Nyarko in the Ghanaian context, arising from feelings of ineptness in dealing with EVD-like symptoms and inadequate availability of personal protective equipment.

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			Trust: Martineau (2016) applied evidence from the 2014–2016 West African Ebola outbreak to reinforce the importance of understanding, and engaging with, social and cultural dynamics in preparing health systems for future crises. Such relationships span those with and between national governments, non-formal health crisis response actors, non-health actors, non-government organizations, and influential local leaders (in addition to communities, health care providers and local leadership described previously).	Conceptual framework	Martinez et al. suggested that initiatives to strengthen a health system 'must embed explicit localized efforts to build mutual trust, respect and dignity between health actors and the communities they serve…' (Martineau, 2016, p. 308).
Nyenswah [4]	2015	This report describes possible health care worker exposures to the cluster's eight patients who sought care from an HCF and implementation of the Ring IPC approach.	Members of the IPC Task Force met to formalize components of the Ring IPC approach, including **identification of target HCFs, a focus on triage, involvement of external staff members to support triage, and coordination and definition of roles among partners**.	Implementation	The purpose of Ring IPC was to provide intensive IPC support (3,4) to HCFs in areas of active Ebola transmission, thus forming a strategically placed protective ring of intensified IPC attention around persons with known Ebola to help break the chain of transmission. This strategy entailed selecting target HCFs for Ring IPC intervention based on known health care worker exposure to an Ebola patient, neighboring HCFs around the HCF that treated a patient, or HCFs in close proximity to the residence of a patient with confirmed Ebola.
			Rapid IPC needs assessment found **inadequate or absent triage and isolation structures, gaps in the personal protective equipment supply chain, and a need for general IPC training in addition to specialized triage training.**	Implementation	Rapid IPC needs assessments were conducted at these HCFs using approved assessment tools (5). **These assessments focused on triage procedures and personal protective equipment use.**
			Training and Equipment: Identified challenges were addressed by the national IPC Task Force developing training that targeted key personnel. **Triage training**, based on existing MOHSW-approved IPC training materials, was developed and provided to 47 African Union clinicians. **Nongovernmental organization partners assessed and constructed triage structures when needed.**	Implementation	These clinicians were deployed to 36 target HCFs in Monteserrado County to provide onsite daily triage mentoring and support for the duration of the high-risk exposure monitoring period, or for at least 2 weeks. Three nurses, previously employed by an Ebola treatment unit, provided similar triage support for one hospital. In addition, three 1-day triage training sessions were provided for more than 125 staff members working in three target HCFs. In Margibi County, a 1-day triage training session was conducted for 11 staff members working in five target HCFs. African Union staff and nurses or other county health staff members provided ongoing triage mentoring and IPC support to seven target HCFs. This intensive IPC approach served to alert health care workers to recent Ebola virus transmission in their communities, identify additional contacts at HCFs where Ebola virus exposure had occurred, and provide a secondary source (in addition to contact tracing) of information on the health status of exposed health care workers.
			PPE supply in response to PPE shortages at HCFs	Implementation	In response to heightened awareness of clinic needs, partners provided personal protective equipment and other essential IPC supplies to target facilities. Ring IPC partners in Montserrado County and the national IPC Task Force initiated an emergency release of a 1-month supply of personal protective equipment to priority clinics.
			Initiation of Rings: During January 23–February 9, in response to the ongoing St. Paul Bridge cluster, four IPC rings were initiated in Liberia, three in Montserrado County and one in Margibi County (Figure). The first ring was initiated 4 days after recognition that a facility had provided care to an Ebola patient; subsequent rings were initiated within 2 days after recognition of other Ebola patients. In total, 59 target HCFs were identified, 52 in Montserrado County (out of a total of 294 HCFs) and seven (out of a total of 32) in Margibi County. There was an average of 15 HCFs per ring (range = 3–31).	Implementation	Overall, Ring IPC efforts appeared to be associated with an increase in the identification and isolation of suspected or probable Ebola patients. For example, three probable Ebola patients were identified through triage during training conducted at one target HCF in Montserrado County. Only one of the 166 exposed health care workers in the St. Paul Bridge cluster became infected with Ebola. This low prevalence of secondary infection among health care workers suggests that basic infection prevention principles were being observed by health care workers during this period. Nevertheless, **triage was not always completely successful;** the one health care worker who became infected with Ebola after Ring IPC activities were initiated

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					actually sought care at his place of employment, an identified target HCF, and was permitted to enter without first being properly triaged as a probable or suspect Ebola patient.
			Although a comprehensive strategy remains critical to raising the level of IPC capacity nationwide, an appropriately **targeted Ring IPC approach** might be an effective supplemental strategy to focus IPC support in response to clusters of disease.		Included among the Ebola response efforts in Liberia was the creation in early September 2014 of a national IPC Task Force to support the MOHSW. The **IPC Task Force** served as a coordinating body to facilitate IPC planning and implementation of activities in both health care and non–health care facilities, as well as providing IPC guidance and technical assistance through policy development and standardization of IPC training and implementation tools consistent with MOHSW priorities. The national IPC strategy had focused on providing a comprehensive package of IPC training and support, through trained IPC specialists, at major health facilities throughout the country because of widespread Ebola transmission occurring at the time. This strategy includes promoting essential IPC practices among health care workers, such as hand washing and proper use of personal protective equipment.
			The **initial ring was coordinated by the IPC Task Force** under MOHSW leadership. In subsequent rings, **the national Incident Management System and county health departments joined efforts with CDC, WHO, African Union, and multiple nongovernmental organization partners participating in initial discussions, planning, and rapid IPC assessments.**	Implementation	The public health intervention described in this report was rapidly implemented and integrated into Liberia's national Ebola response as a result of coordinated, collaborative efforts by multiple partners. Coordination and collaboration among the national Incident Management System, county health teams, CDC, WHO, African Union and nongovernmental organization partners was key to identifying gaps in IPC needs and preventing duplication of efforts. In general, HCFs welcomed additional training, personal protective equipment provision, and triage mentoring and support. The placement of IPC staff members trained in triage at target HCFs following training was readily adopted by clinic staff.
			The implementation of Ring IPC in Liberia might offer a useful model for rapid response to Ebola virus transmission and health care worker exposure in other settings.		This approach, however, might be most appropriate **at the beginning or near the end of an outbreak, when specific chains of transmission can be identified and when HCFs can be identified and targeted based on their risk for encountering an Ebola patient when there is known active transmission in their geographical area.**
				Implementation	Urban settings present challenges to this approach, because persons might seek care at HCFs outside of their immediate community.
				Resources/Costs	Although limitations in both supplies (personal protective equipment and infrared thermometers) and human resources (appropriately trained personnel) might inhibit a timely response to initiating IPC activities, **the Ring IPC approach might be used to prioritize these limited resources.**
			The Ring IPC approach was developed rapidly and collaboratively in response to an urgent public health need; as such, data were not collected and aggregated systematically across all facilities, potentially limiting the generalizability of these results. Nonetheless, as a result of Ring IPC efforts, health care workers at HCFs in areas with recent active transmission are now better equipped and trained to rapidly triage, isolate, and refer suspected	Implementation	As Liberia looks ahead, a new culture of IPC can be incorporated into the health system; a Ring IPC approach might be useful in minimizing the transmission in non-Ebola HCFs should new cases of Ebola occur.

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			and probable Ebola patients to appropriate Ebola treatment unit facilities.		
Dahl [2]	2016	Summary report of CDC's Response to the 2014–2016 Ebola Epidemic — Guinea, Liberia, and Sierra Leone	The MoHS in Sierra Leone used CDC's concept of Ring Infection Prevention and Control (Ring IPC) (24), and CDC was integral to implementing the strategy;	Implementation	This strategy supported improved screening, isolation, referral for treatment, use of hand hygiene and personal protective equipment, waste management, and cleaning and decontamination practices for health care facilities and health care workers at highest risk for Ebola exposure and infection. CDC staff commonly coordinated Ring IPC activities in collaboration with WHO, the United Kingdom's Department for International Development, and nongovernment organizational partners.
Nyenswah [13]	2016	Summary report of Ebola and Its Control in Liberia, 2014–2015	By the end of 2014, >4,000 healthcare workers from 350 facilities had received training in basic IPC. A cadre of physicians were trained to serve as technical advisors in the counties. IPC focal points for major hospitals were selected and trained; surveillance and investigative capacity for Ebola in healthcare workers was developed; and personal protective equipment was delivered to major facilities nationwide (gloves and bleach were made as widely available as possible).	Implementation	Weak IPC rendered all 657 healthcare facilities in Liberia vulnerable. The value of surveillance among healthcare staff was highlighted by a single transmission chain in early 2015, in which 166 non-ETU healthcare workers at 10 facilities were exposed to the virus; remarkably, only 1 healthcare worker became infected (24). An innovative intervention in response to this cluster was the ring IPC strategy, which provided intensified IPC training and support to healthcare facilities around areas of active transmission (25).
Hageman [14]	2016	CDC summary report of Infection Prevention and Control for Ebola in Health Care Settings — West Africa and United States	A critical first step was to establish national IPC task forces to coordinate infection control efforts within Guinea, Sierra Leone, and Liberia.		To supplement efforts to strengthen IPC practices systemwide, a new strategy known as Ring IPC was introduced in which rapid, intensive, and short-term IPC support is delivered to health care facilities in areas of active Ebola transmission to help break the chain of transmission (7). Once high-risk facilities were identified, IPC assessments were conducted to guide technical assistance, medical supply distribution, and daily supportive supervision to ensure HCWs were trained to triage, isolate, and refer suspected and probable Ebola patients rapidly to ETUs.
			Early in the Ebola epidemic, Ebola transmission to HCWs occurred in health care facilities that were not Ebola treatment units (ETUs) (1–3). Health care facility assessments conducted by CDC and partners in 2014 documented substantial gaps in IPC. These gaps (i.e., a lack of IPC oversight, poor waste management procedures, a lack of triage and isolation protocols, frequent lack or misuse of personal protective equipment [PPE], and inadequate standard infection control precautions) increased the risk for Ebola transmission in non-ETU health care settings (4,5).	Acceptability	Ring IPC impacted several places. For example, in Liberia, three febrile HCWs were identified when screened for work; all were properly isolated and transferred to an ETU for testing (7). Sierra Leone integrated Ring IPC around clusters of Ebola patients in three districts. Guinea focused on minimizing transmission by rapidly investigating infected HCWs and remediating IPC lapses.
Cooper [5]	2016	Report of Infection prevention and control of the Ebola outbreak in Liberia, 2014–2015: key challenges and successes	In September 2014, at the height of the outbreak, the national IPC Task Force was established with a Ministry of Health (MoH) mandate to coordinate IPC response activities. A steering group of the Task Force, including representatives of the World Health Organization (WHO) and the United States Centers for Disease Control and Prevention (CDC), supported MoH leadership in implementing standardized messaging and IPC training for the health workforce. This structure, and the activities implemented under this structure, played a crucial role in the implementation of IPC practices and successful containment of the outbreak.	Implementation	Montserrado County was divided into four geographic sectors, each with its own team. Each team focused primarily on healthcare facility readiness, with an emphasis on triage. Although the national IPC Task Force continued to set priorities and establish minimum standards, the implementation and monitoring of these standards in Montserrado was delegated to sector teams. These intensified efforts, implemented in a "ring approach", helped Liberia approach its goal of "getting to zero" after identification of the cluster of 22 EVD infections near St Paul Bridge in Monrovia in February 2015 [13].

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Keïta [12]	2018	This research aimed to evaluate the impact of IPC training and the quality of IPC performance in health care facilities of one municipality of Conakry, Guinea.	Twenty-five percent of health centres had one IPC-trained worker, 53% had at least two IPC-trained workers, and 22% of health centres had no IPC-trained workers. An IPC score above median was positively associated with the number of trained staff; health centres with two or more IPC-trained workers were eight times as likely to have an IPC score above median, while those with one IPC-trained worker were four times as likely, compared to centres with no trained workers. Health centres that implemented IPC cascade training to untrained medical staff were five times as likely to have an IPC score above median.	Implementation	The authors suggest that the 'Ring IPC strategy' - which consists of providing rapid, intensive and short-term (21-days) support to healthcare facilities and communities in areas of active Ebola transmission - had a good impact in Guinea and Liberia. Throughout the EVD outbreak in Guinea, individual healthcare workers (usually 1 or 2 per healthcare facility) were selected to take part in an intensive five-day IPC training with a focus on EVD, organised by the Ministry of Health and partners (WHO, CDC and others). The participants were strongly encouraged **to organise cascade training**, i.e. training to other medical staff within their respective healthcare structures, following guidelines developed by the Ministry of Health and as previously described [10].
Mobula [6]	2020	Lessons Learned from the Ebola Virus Disease Outbreak in the Democratic Republic of the Congo	The tenth outbreak of Ebola virus disease (EVD) in North Kivu, the Democratic Republic of the Congo (DRC), was declared 8 days after the end of the ninth EVD outbreak, in the Equateur Province on August 1, 2018. With a total of 3,461 confirmed and probable cases, the North Kivu outbreak was the second largest outbreak after that in West Africa in 2014–2016, and the largest observed in the DRC. This outbreak was difficult to control because of multiple challenges, including armed conflict, population displacement, movement of contacts, community mistrust, and high population density. It took more than 21 months to control the outbreak, with critical innovations and systems put into place.	Implementation	Implemented ring IPC with supervision (IPC focal point at health facilities) and frequent evaluations (use of IPC score card). A standardized package for IPC/water, sanitation, and hygiene was established to ensure a coordinated IPC strategy. Supervision (establishing an IPC focal point at health facilities) and frequent evaluations (use of an IPC score card) were put into place. Evaluations helped in developing plans to fill gaps andmonitor response progress. Traditional healers and pharmacists were involved in IPC training, albeit late, as they played an important role in the spread of Ebola. Triage systems set up in health facilities helped to ensure health service continuity, allowing access to health services for regular health care.
Nyenswah [4]	2015	CDC report on controlling the Last Known Cluster of Ebola Virus Disease — Liberia, January–February 2015	The last cluster of Ebola in Liberia included 22 cases, with three generations of transmission. Through enhanced control efforts, patients in successive generations were admitted to Ebola treatment units more quickly, mortality decreased, and community transmission was interrupted.		The last chain of transmission was controlled because of successful implementation of known strategies to control Ebola, including early detection of new cases; identification, monitoring, and support of contacts in acceptable settings; effective triage within the health care system; and rapid isolation of symptomatic contacts.
			In contrast to earlier in the Ebola epidemic, sector-based intensified contact tracing and in-depth case investigation, widespread infection prevention and control efforts (3), and coordination of case investigation and contact tracing activities between Montserrado and other counties (6) were key to stopping this final chain of Ebola transmission.	Implementation	The authors suggest that decentralization of sector management presented initial communication and coordination challenges, the enhanced sector-based efforts resulted in more complete contact tracing, more prompt isolation of symptomatic patients in the second and third generations of transmission, increased survival, and reduced transmission in the community.
Lewnard [8]	2014	Dynamics and control of Ebola virus transmission in Montserrado, Liberia: a mathematical modelling analysis	Our findings show that the effectiveness of new EVD treatment centers can be maximized with concurrent acceleration of case ascertainment.	Implementation	Accelerated case ascertainment is needed to maximize effectiveness of expanding the capacity of EVD treatment centers.
Yamin [11]	2015	Stochastic transmission mode	The isolation of 75% of infected individuals in critical condition within 4 days from symptom onset has a high chance of eliminating the disease.	Implementation	The results underscore the importance of isolating the most severely ill patients with Ebola within the first few days of their symptomatic phase.

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