Mandated Actions, Legitimate Role-Bearers and Expected Actor Networks in the Management of Infectious Disease Epidemics: The Case of Marburg Virus Disease in Uganda.

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Abstract

Background
In many Sub-Saharan Africa (SSA) countries, epidemic management is characterized with inaction, confusion and friction among a multitude of participating organizations. This is partially attributable to the inability to customize international epidemic management actions and guidelines to local institutional architecture, agencies and relational contexts. This results into poor coordination and suboptimal epidemic management outcomes.

Using the case of Marburg Virus Disease (MVD) in Uganda, we explored how to clarify responsibility and collaboration across a multitude of inter-dependent actions and actors during epidemic management.

Methods
In July 2018, we reviewed MVD management literature and documents to identify key expected actions and actors/agencies. Data was summarized by phase and action area of MVD management. In March 2019, a 2-round Delphi survey was then undertaken to;
1) validate the identified actions and 2) assign legitimate role-bearers to each of the validated actions in accordance to the agency mandates in Uganda. Finally, we used NetDraw in UCI Net to elaborate the expected network structure among legitimate role-bearers across all the phases and four selected action areas of MVD management.

Results

We validated 304 mandated actions and 79 legitimate role-bearers in MVD management in Uganda. Across the four phases and selected action areas of MVD management, there is a high variation in the identity and number of mandated role bearers. Overall, Ministry of Health headquarters (MoH-HQs), National Task Force (NTF), District task Force (DTF) and National Rapid Response Team (NRRT) are expected to be the most central agencies during MVD management. Across the four phases and the selected action areas, actors are expected to be networked using a core-periphery network structure.

Conclusions

There is a multitude of agencies required to work inter-dependently to accomplish the mandated actions for MVD management in Uganda. MoH-HQs, NTF and DTF are most central to assume coordination of MVD management in the Ugandan context. It is imperative to build/maintain the information processing, decision making and command and control capacity of these central agencies. The study findings can be used as the basis for exploring compliance and deviation in mandated actions in future MVD epidemics. The methodological approach could be replicated to other infectious disease epidemics in Uganda and beyond.
**Key words:** Epidemic Management, Coordination, Actor-networks, Mandated-actions, Role-bearers, Uganda

**Background**

*The burden of infectious disease epidemics*

Infectious disease epidemics are on the rise in Sub Saharan Africa (Fenollar & Mediannikov, 2018). In 2018 alone, over 95 new outbreaks were reported to World Health Organization (WHO) by member states of the WHO African region. In this same year, Uganda reported the highest number of new epidemics to WHO. These included Cholera, Rift Valley Fever (RVF), Crimean-Congo Hemorrhagic Fever (CCHF), Avian Influenza (HPAI), Marburg Virus Disease (MVD), Meningitis and Anthrax (Mboussou et al., 2019). Frequently, these epidemics are recurrent, in more or less the same location with similar or even greater magnitude. For example, since the year 2000, Uganda has experienced six Ebola Virus Disease (EVD) and five MVD epidemics (CDC, 2020). The last outbreak of MVD in Uganda was in September 2017. More than 40 organizations were drawn to participate in the response. Among others, these included WHO, United States Centers for Disease Control (US-CDC), Médecins Sans Frontières (MSF), Uganda Virus research institute (UVRI), United Nations Children's Fund (UNICEF), United States Agency for International Development (USAID), European Union (EU), Uganda Red Cross Society (URCS), World Vision Uganda (WV), Infectious Diseases Institute (IDI), African Field Epidemiology Network (AFENET), Family Health International (FHI360), Joint Mobile Emerging Disease Clinical Capability...
During the response, the following observations were made; 1) some actors had conflicting roles, 2) some actions were being supported by more than one actor, yet, 3) other actions were left unsupported. At some point during the response, unnecessary friction was also observed; to the extent that some actors were temporarily recalled from the response frontline. This is not unique to the 2017 MVD response in Uganda. Such inaction, confusion and friction have been observed in disease epidemic responses elsewhere in SSA and other Low and Middle Income Country (LMIC) settings (Olu et al., 2016; Ross, Welch, & Angelides, 2017).

The inherent challenges with management of infectious disease epidemics in LMICs

Broadly, epidemic management in LMICs faces a coordination problem as a result of following related challenges; a) narrow focus on surveillance and response and b) limited clarity on mandate, roles and actors. First, the Integrated Disease Surveillance and Response (IDSR) framework; the strategy through which the majority of LMICs aspire to achieve their epidemic management goals is suboptimal. The framework is premised on a medical model of disease management (Ssendagire, Tuhebwe, Kayongo, & Ssengooba, 2018). The framework emphasizes epidemic detection and response actions with little attention to the equally important mitigation, preparedness and recovery interventions. After response to an epidemic, little or no attention and resources are dedicated to recovery and prevention of future epidemics. Instead, the
system waits to detect and respond to the next epidemic, creating a vicious cycle of epidemic detection and response. By design, therefore, the IDSR framework does not build health systems’ resilience to infectious disease epidemics, which we define as the capacity of the health system to prevent, prepare for, respond and recover from the effects of infectious disease epidemics (Kruk, Myers, Varpilah, & Dahn, 2015).

Secondly, in many LMICs like Uganda, there is no published guideline on how tasks/mandates are allocated during epidemic management. When epidemics occur, the commonly observed practice is either to reactively ask available potential actors to indicate the actions they are willing to support or to randomly allocate actions to those physically available actors. This practice does not perfectly match actor competences to specific response actions. It also does not effectively allocate the available resources to all the critical epidemic response actions. Commonly, the required epidemic management actions are not comprehensively defined. Even where attempts to define these actions have been made, the legitimate role-bearers have not been explicitly assigned (MoH, 2012). This creates the inaction, confusion and friction observed during epidemic management. This culminates into poor coordination and suboptimal epidemic management in LMICs, preventable escalation of epidemics, diversion of resources from other critically important health priorities, more suffering, death, social disruption and loss of revenue due to trade and travel related aversion behaviors associated with escalated epidemics (Frieden & Damon, 2015; Gostin & Friedman, 2015).

**Theoretical Framework**
We identify three (3) theories as appropriate for the exploration of the challenges of sub-optimal epidemic management in LMIC settings. These are; 1) Coordination Theory, 2) Network Theory and 3) Comprehensive Emergency Management Theory.

Coordination Theory
Coordination theory can be applied to predict, understand and influence the process and outcomes of managing dependences between multiple actors. When multiple dependences in form of actions and in form of role-bearers are required to deliver on a single outcome, efficiency of the outcome will likely be constrained. To reduce the likelihood of such constraints, certain structures and processes must be in place before and or during the execution of interdependent actions by multiple role-bearers. These structures and processes are generally referred to as coordination mechanisms. Broadly, there are three coordination mechanisms. These are; 1) Hierarchy (which includes Standardization of required inputs and processes, authority, command and control), 2) Speeding-up information flow (for example through formal and informal networking) and 3) Increasing the capacity for information processing (for example centralization of information processing). To maximize the performance of inter-dependent relationships, the positive contributions from these three broad categories of coordination mechanisms needs to be maximized (Crowston, 1997; Malone & Crowston, 1994; Melin & Axelsson, 2005).

Network Theory
A network is a collection of multiple actors and the relationships that bind them together, and broadly a coordination mechanism also. There are a set of principles that can be
applied to predict, control and explain the functionality of networks. Provan and Kenis describe three (3) major types of network forms; Shared governance, Lead Organization and Network Administrative Organization (NAO) (Provan & Kenis, 2008). These network forms correspond to four (4) major network structures; Centralization, Closure, Brokerage and Core/Periphery as described by Nowell and colleagues and as shown in figure 1 (Nowell, Steelman, Velez, & Yang, 2018).

![Network Structures Diagram](https://example.com/network_diagram.png)

**Figure 1: Types of Global Network Configuration Structures as described by Nowell and colleagues (Nowell, Steelman, Velez, & Yang, 2018).**

Provan and Kenis also contend that different types of network structures are likely to be more effective than others depending on certain contingencies. Such contingencies include the level of trust among actors in the network, the number of actors in the network, the level of goal consensus among the actors in the network and the capacity of these actors to operate in a network (Provan & Kenis, 2008).

**Comprehensive Emergency Management Theory**

Comprehensive Emergency Management Theory is premised on the coordination mechanism of standardization (Whittaker, 1979). Standardization as a coordination mechanism requires prior identification of all the required emergency management
actions, allocation of these actions to specified role-bearers and developing the capacity of these role-bearers to deliver on their mandated actions. This is the theoretical underpinning of the Emergency Management Cycle (EMC) Model (Waugh, 1999; Whittaker, 1979), which has been found effective in the management of natural disasters like floods and earthquakes (Banipal, 2006; FEMA, 2001).

The EMC model specifies four phases of modern emergency/disaster management. These are; 1) Mitigation (actions that prevent a disaster and reduce the chance of it happening, or lessen its damaging effects); 2) Preparedness (actions taken before impact, including development of response plans), 3) Response (actions taken during the initial impact of a disaster, including those to save lives and to prevent further damage to property) and Recovery (actions taken after the initial impact, including those aimed at achieving a return to normality). When the required/mandated actions and the legitimate role-bearers for each of the EMC phases are agreed upon a priori, coordination of emergencies/disasters tends to be more effective compared to when this is not done in advance. Prior assignment of roles creates collaboration, preparedness and clarity; which are all critical to effective emergency management.

The study makes a contribution to improved coordination of multiple actions and actors during epidemics management in LMICs. The study addressed three questions. 1) What are the mandated actions in the comprehensive management of MVD in Uganda? 2) Who are the legitimate role-bearers for these mandated actions? 3) How should the legitimate role-bearers be networked?

Methodology
The three methodological approaches used were; 1) Review of MVD management related literature and Documents (July-August 2018), 2) A Delphi survey (March 2019) and Social Network Analysis (SNA).

Review of MVD management related literature and Documents

To identify the documented mandated actions and legitimate role-bearers in the comprehensive management of MVD in Uganda, we conducted a search and review of MVD management literature and documents.

Search strategy

We searched online databases using multiple online search strings constructed by combining the terms Marburg, Virus, Disease, Mitigation, Prevention, Preparedness, Response, Recovery, Stakeholders, Actors, Actions, Uganda, WHO, CDC, Outbreak, Epidemic and Resilience. The databases searched included Google, Google Scholar, Pub-Med and Medline. The official websites for WHO, CDC, UNICEF, MSF and MoH-Uganda were also searched for official MVD management related documents. The Uganda Public Health Emergency Operations Centre (PHEOC) also provided documents that were collected during the 2017 Joint External Evaluation (JEE) of International Health Regulation (IHR) core capacities for Uganda.

Screening of retrieved Literature and Documents

The process and outcomes of screening of the retrieved literature and documents is summarized in Figure 2. First, all the retrieved documents we put into one folder, removed duplicates and screened for relevance of each document by reading their abstracts/executive summaries only. Sixty (60) documents were maintained for full
reading. The 60 documents were each reviewed separately by two independent researchers (NR and TKA) who abstracted MVD management actions and any role-bearers indicated in these documents.

![Flow Diagram for identification of documents reviewed as part of the study methodology](image)

Any data discrepancies between the two reviewers were resolved by conducting a joint review of the source documents in question. The abstracted data was summarized in excel into a single action-actor matrix with descriptors of phase (Mitigation, Preparedness, Response and Recovery) and action area (as reflected in column 2 of table 3) of MVD management.

The Delphi survey

We then conducted a 2 round Delphi survey (Giannarou & Zervas, 2014; Habibi, Sarafrazi, & Izadyar, 2014) with 30 purposively sampled local experts in MVD management.
management drawn from multiple fields to validate and customize the action-actor matrix developed from literature and documentary review. The details of the 30 member Delphi panel are summarized in table 2.

Table 2: Characteristics of experts consulted to validate and customize MVD actions and actors identified from reviewed literature and documents

| Variable                                | Values            | n   | %  |
|-----------------------------------------|-------------------|-----|----|
| Practice Domain                         | Academia          | 5   | 17 |
|                                        | Policy development| 15  | 50 |
|                                        | Implementation    | 10  | 33 |
| Parent Ministry                         | Health            | 9   | 30 |
|                                        | Prime Minister    | 3   | 10 |
|                                        | Agriculture       | 12  | 40 |
|                                        | Wildlife          | 3   | 10 |
|                                        | Education         | 3   | 10 |
| Years in current Position               | ≥10               | 8   | 27 |
|                                        | ≥5                | 14  | 46 |
|                                        | <5                | 8   | 27 |
| Gender                                  | Males             | 18  | 60 |
|                                        | Female            | 12  | 40 |
| Highest Level of Training               | PhD               | 3   | 10 |
|                                        | Masters           | 24  | 80 |
|                                        | Graduate          | 3   | 10 |
| Experience in MVD management (years)    | ≥5                | 25  | 83 |
|                                        | <5                | 5   | 17 |

First Delphi Survey round

Round one of the surveys was a face to face half-day workshop. During this survey, the action-actor matrix generated from reviewed literature and documents was divided into sub-matrices corresponding to the 4 phases (Mitigation, Preparedness, Response and Recovery) of comprehensive MVD management and pinned on the wall to create four respective stations. The workshop participants moved across the 4 stations; adding relevant or deleting irrelevant actions and actors, and indicating the lead and other actors for each of the actions. This was later followed by plenary discussion facilitated
by a research team member experienced in facilitating stakeholder deliberations (SF).

The workshop outputs were summarized into draft “customized” action-actor matrices for each of the 4 phases of MVD management in Uganda.

Second Delphi Survey Round

In the second round of the survey, the draft customized matrices were shared by electronic mail to each of the 30 panel members who were asked to send any feedback/adjustments within 2 weeks. All the panel members responded within the stipulated time and their feedback was used to produce the final customized action-actor matrices for comprehensive management of MVD in Uganda. No additional survey rounds were conducted because of the high levels of consensus among panel members after the second round of the survey.

Social Network Analysis

To explore how the multiple legitimate role-bearers should be networked/aligned to each other during MVD management in Uganda, Social Network Analysis was employed (SNA) (Butts, 2008; Hanneman & Riddle, 2005). The validated matrices acted as input data. SNA approaches using (NetDraw in) UCINET software were used to visualize the expected interdependencies between the legitimate role-bearers for all the phases of MVD management combined, each of the four phases of MVD management separately and 4 out of the 26 MVD management action areas. The structures of visualized networks were compared to those described by Nowell and colleagues (Nowell et al., 2018). The ego-centric quality of the visualized networks was determined using
degree centralization and density. This enabled comparison of the network attributes across the 4 phases and selected action areas.

Ethical approval for this study was provided by the Institutional Review Board (IRB) of MakSPH (HDREC Protocol number 580) and granted permission from Ministry of Health Headquarters was also granted (Ref Number ADM.105/309/16). We determined the judicious use of agency names in the findings using the overriding principle of do no harm, practical application of the study and the need for relationship management with known agencies that play key roles in MVD management in Uganda. Participation as a Delphi panel member was voluntary. Informed consent was also sought and documented. We shared the study findings at a national level stakeholder dissemination workshop.
Results

Introduction

Overall, we identified, validated and customized a total of 304 unique mandated actions and 79 unique legitimate Role-Bearers during MVD management in Uganda. Below, we stratify the actions and legitimate Role-Bearers by phase and selected action areas of MVD management.

Mandated Actions and Legitimate Role-Bearers per phase of MVD management in Uganda

We identified, validated and customized 21, 166, 96 and 21 mandated actions under the Mitigation, Preparedness, Response and Recovery Phases of MVD management in Uganda respectively. These are summarized in table 3. These actions were assigned to 36, 51, 55 and 28 legitimate Role-Bearers in the Mitigation, Preparedness, Response and Recovery Phases of MVD management respectively. These are summarized in table 4.

Mandated Actions and Legitimate Role-Bearers for selected action areas of MVD management in Uganda

Further, the 304 mandated actions were categorized under 26 action areas of MVD management. These action areas are reflected in table 3. We report on the results of 4 out of all the 26 action areas. The 4 selected action areas are Coordination, Surveillance, Resource Mapping and Risk Communication. We identified, validated and customized 86, 16, 3 and 10 mandated actions under Coordination, Surveillance, Resource Mapping and Risk Communication respectively, as summarized in table 4.
**Table 3: Summary of MVD management mandated actions and their lead legitimate role-bearers**

| Phase         | Action Area       | Actions | Main Actors (No of actions)                                                                 |
|---------------|-------------------|---------|-------------------------------------------------------------------------------------------|
| Mitigation    | Capacity Building | 1       | Line Ministries(1)                                                                         |
|               | Guideline Development | 4     | Line Ministries(4)                                                                         |
|               | Guideline Implementation | 6     | DTF(4), HWs(3)                                                                             |
|               | Risk Assessment   | 8       | OPM(4), Line Ministries(3)                                                                 |
|               | Social Mobilization | 2       | DTF(1), Line Ministries(1)                                                                  |
| Preparedness  | Advocacy          | 6       | DTF(5)                                                                                     |
|               | Capacity Assessment | 6      | DTF(3), DHT(3)                                                                             |
|               | Capacity Building | 16      | DHT (13), DTF(2)                                                                            |
|               | Capacity Monitoring | 2       | ESD(2)                                                                                     |
|               | Coordination      | 33      | NTF(12), MoH-HQ(19), DTF(7), DRRT(9)                                                       |
|               | Guidelines Update | 37      | Line Ministries(4)                                                                          |
|               | Guideline Dissemination | 4     | MoH-HQ(4)                                                                                   |
|               | Laboratory Strengthening | 9     | NTF(7), MoH-HQ(6)                                                                           |
|               | Partner Mapping   | 2       | NTF(2)                                                                                     |
|               | Policy Implementation | 2     | Line Ministries(8)                                                                          |
|               | Resource Mapping  | 3       | NTF(3)                                                                                     |
|               | Resource Mobilization | 16     | NTF(17)                                                                                    |
|               | Risk Assessment   | 4       | OPM(4), Line Ministries(3)                                                                  |
|               | Risk Communication | 9       | UNPHLS(4), PHEOC(6)                                                                        |
|               | Simulation Exercises | 1     | PHEOC(1), DTF(1)                                                                            |
|               | Surveillance Strengthening | 16   | ESD(10), EOC(9), UVRI(5)                                                                    |
| Response      | Case management | 14      | DTF(4), DRRT(4), NTF(2)                                                                     |
|               | Coordination      | 53      | NTF(12), MoH-HQ(19), DTF(7), DRRT(9)                                                       |
|               | Laboratory        | 7       | NTF(7), MoH-HQ(6)                                                                           |
|               | Resource Mobilization | 1     | NTF(17)                                                                                    |
|               | Social Mobilization | 5       | NTF(4), DTF(1)                                                                              |
|               | Surveillance      | 16      | WHO(11), ZDCO(5), PHEOC(3), UVRI(3), RRT(5)                                                |
| Recovery      | Reactivation of routine services | 1       | DHT(1)                                                                                     |
|               | Rehabilitation    | 1       | DHT(1)                                                                                     |
|               | Response Evaluation | 5      | DTF(2), MoH-HQ(2)                                                                           |
|               | Risk Communication | 1       | UNPHLS(4), PHEOC(6)                                                                         |
|               | Routine Surveillance | 4      | DHT(3)                                                                                     |
|               | Systems Strengthening | 9      | MoH-HQ(4), DTF(2), DHT(1)                                                                   |
Networks of legitimate Role-Bearers during MVD management in Uganda

Multiple actor networks were determined. These include an overall actor network, a network for each of the 4 phases of MVD management and a network for a selection of 4 (Coordination, Surveillance, Resource Mapping and Risk Communication) of the 26 action areas of MVD management in Uganda. These are shown in figure 3, figure 4 and figure 5 respectively. The quality of these actor networks in terms of degree centralization and density is summarized in table 4.

Table 4: Selected quality metrics of expected actor networks in the different phases and selected action areas of MVD management in Uganda

| Phase       | Most Connected Actors | Unique Actors | Total Connections | Degree Centralization | Density |
|-------------|-----------------------|---------------|------------------|-----------------------|---------|
| Mitigation  | MoH-HQs, DTF, NOHP    | 51            | 36               | 0.35                  | 0.04    |
| Preparedness| MoH-HQs, DHT, NTF     | 179           | 51               | 0.64                  | 0.07    |
| Response    | NTF, DRRT, NRRT       | 132           | 55               | 0.5                   | 0.04    |
| Recovery    | MoH-HQs, DTF, NOHP    | 35            | 28               | 0.63                  | 0.05    |
| Coordination| MoH-HQs, DTF, DDRT    | 106           | 50               | 0.44                  | 0.04    |
| Surveillance| WHO-CO, UVRI, NNRT    | 96            | 38               | 0.38                  | 0.07    |
| Resource Mapping Risk Communication | NTF, DTF | 45 | 18 | 0.99 | 0.06 |
|             | UNPHLS, EOC, NTF      | 45            | 26               | 0.49                  | 0.07    |
Figure 3: Network of expected actors during MVD management in Uganda; all phases and action areas combined
Figure 4: Expected actor networks per phase (mitigation, preparedness, response and recovery) of MVD management
Figure 5: Expected actor network for selected action areas (MVD Coordination, Surveillance, Resource-Mapping and Risk-Communication)
Discussion

Introduction

In Uganda, just like it is in many LMICs, management of epidemics should be collaborative endeavor. This is because no single Ministry, Department or Agency (MDA) has the required jurisdictional authority, legitimacy, resources and technical capability to effectively assume command and control of epidemic management alone. By extension, government entities require collaboration with non-state actors such as development partners, private sector and civil society organizations. The requirement to operate interdependently however comes with the inherent challenge that interdependence often reduces the efficiency of outcomes – partly due to increase in inter-agency transaction costs (Williamson, 1981). To reduce the likelihood of outcome inefficiency, the mandated actions, their legitimate role-bearers and the mechanisms for coordinating the multitude of legitimate role-bearers ought to be clear ex ante (Crowston, 1997; Malone & Crowston, 1994; Melin & Axelsson, 2005; Nowell et al., 2018). Using the case of Marburg Virus Disease (MVD), we identified, validated and customized the mandated actions, their legitimate role-bearers and expected actor networks in the management of MVD epidemics in Uganda.

Mandated actions and legitimate role-bearers during MVD management in Uganda

We identified, validated and customized a total of 304 actions expected to be implemented across the four phases of MVD management in Uganda. All the synthesized actions (304) were assigned to specific legitimate lead and led (other) role bearers. We were not able to find any published literature against which to compare
whether the determined number of MVD actors (and actions) was small, medium or large. Also, we were not able to find any evidence from Uganda or other LMIC setting on comprehensiveness of allocation of the multiple actors to all the required actions for management of MVD or any other epidemic. Elsewhere, previous studies have however indicated that prior identification of actors and clarification about their mandated roles increases cross-institutional preparedness and response to complex health emergencies including but not limited to MVD and other infectious disease epidemics (De Vries et al., 2019; Isken et al., 2008; Joustra, Meurs, & Fresco, 2012).

Expected networks of legitimate Role-Bearers during MVD management in Uganda

We elaborated and visualized the expected actor networks by the four (4) phases (Mitigation, Preparedness, Response and Recovery) of MVD management in Uganda. This elaboration was also applied to four action areas (Coordination, Surveillance, Risk Communication and Resource Mapping) selected out of the 26 pragmatic action areas (as reflected in table 3). We indicated the actors who are expected to be central (and peripheral) for each of the four (4) phases and each of the 26 action areas of MVD management in Uganda. Previous studies have underscored for need for prior clarity on the relationship between multiple actors involved in the management of complex situations, especially on the structures and channels of decision making and communication respectively. This facilitates a more coordinated management of complex crises (Moynihan, 2009; Wimelius & Engberg, 2015).

Available literature on global social networks identifies four main types of structural configurations for aligning the actions of multiple stakeholders involved in the same
problem space (Nowell et al. 2018). These are; 1) centralized, 2) closed, 3) brokered/decentralized and 4) core/periphery. Centralized networks are networks in which actors are linked together through a single central actor. Closed networks refer to a network in which there is a high level of connectivity across all actors in the network. Brokered or decentralized network are the ones characterized by sub-networks of actors that are connected together through a series of brokers. A core-periphery network is one characterized by dense connections among a central subgroup of actors at the core of the network surrounded by a peripheral set of actors with more sparse connections (Nowell et al., 2018).

Our findings indicate that all the actor networks across the four phases and the 26 action areas of MVD management in Uganda conform to the Core-Periphery structure than any other global social network structure. From our findings, the actors at the core of MVD management in Uganda are NTF, DTF, MoH-HQs, DDRT, NRRT, EOC, WHO-CO and UNPHLN. The actors making up the periphery are highly variable. The Core-Periphery structure of network governance has several advantages (including better coordination) over all other structures. By inference, the coordination of MVD management in Uganda could be considered more effective, because of the core-periphery structure for aligning the actions of multiple actors during MVD management (Johnson, Boster, & Palinkas, 2003; Provan & Lemaire, 2012). We however do not have any evidence yet as to whether this expected core-periphery structure of network governance is observed during actual MVD management in Uganda.
Provan and colleagues argue that there are certain critical contingencies that can be used to predict which type of network governance structure would be more effective. These are; 1) The total number of actors involved, 2) The level of trust among the actors involved, 3) The level of goal consensus among the actors involved and 4) the competency of the actors involved (Provan & Kenis, 2008). On the number of actors involved, Provan and colleagues argue that if the number of actors involved is moderate to many, then the core-periphery structure is expected to be the most effective structure to deploy. Apart from resource Mobilization, our findings reveal that the number of expected actors in each of the 4 phases of MVD management and in each of the other 26 action areas of MVD management is greater than 25. To the extent that is interpreted as a moderate to large number of expected actors, and if MVD management in Uganda is relatively more effective (Mbonye et al., 2014; Okware, 2016), then our findings conform to the propositions stated by Provan and colleagues that if the number of actors is moderate to large, the core-periphery structure of network governance is expected to result into more effective coordination of multiple actors working in the same problem space (Provan & Kenis, 2008).

The expected quality of actor networks during MVD management in Uganda

The ego-centric quality of expected networks in the comprehensive management of MVD in Uganda was determined. In ego-centric Social Network Analysis (SNA), there are multiple metrics that can be used to report on the quality of a social network. We opted for centralization and density; some of the commonly used metrics in ego-centric SNA. Density is perhaps the most well-known network metric and represents the degree...
to which all actors are connected to all other actors in the network, the notion of network

closure. Centralization focuses on the degree the network is organized around a single
actor or set of actors (Hawe, Webster, & Shiell, 2004).

The expected core actors across all the visualized MVD management related networks
are NTF, DTF, MoH-HQs, DDRT, NRRT, EOC, WHO-CO and UNPHLN. Core actors
were connected to the largest number of actors and therefore expected to be the most
critical actors in the MVD management networks in Uganda. If resources and mandate
to coordinate MVD outbreaks is built among these core agencies, inefficiencies in the
functionality of the whole network of actors can be improved. By practice and
observation, these actors have always been at the core of MVD management in
Uganda. The overall density and centralization of the MVD networks ranged from 0.04-
0.07 and 0.35-0.99 respectively. The density was low because the networks are
predominantly core-periphery with few core actors and many peripheral actors (Provan
& Lemaire, 2012). For the same reason, centralization of the expected MVD
management actor networks is high.

Development of basis for exploring stakeholder deviations from mandated actions
during MVD management

We recognize that the actions elaborated in this paper will likely be more constant than
the elaborated actors. We also recognize that the elaborated actor interlinkages during
the four phases and 4 of the 26 action areas of MVD management need not to be rigid.
In fact, in the face of a rapidly changing complex emergency, ad hoc structures of actor
management are sometimes more efficient, resulting into a more effective crisis
response (Huizer, Kraaij-Dirkwager, Timen, Schuitmaker, & van Steenbergen, 2015; Weick, 2005). The findings from this study provide a basis for exploring compliance and deviations from expected action and actor inter-linkages during the management of future MVD outbreaks in Uganda.

**Conclusion**

Mandated actions and legitimate role-bearers during MVD management in Uganda are multiple and highly inter-dependent. The inter-dependencies are mostly mediated by MoH-HQs, NTF and DTF as the most central and legitimate agencies across all the phases and action areas of MVD management in Uganda. These are therefore expected to play a leadership role in information processing, information sharing, decision making and command and control during MVD management in Uganda.

**Recommendations**

The study findings can be used as the basis for exploring compliance and deviation in mandated actions and legitimate role-bearers during the actual management of future MVD epidemics in Uganda.

To improve the effectiveness of MVD management, it is important to build the capacity of the agencies at the center of MVD management in the core mechanisms of coordination.

The methodological approach employed in thus study could be replicated to other infectious disease epidemics in Uganda and beyond to aid the management and resilience of health systems in the face of future epidemics.
### List of Abbreviations

1. AFENET: African Field Epidemiology Network
2. AMREF: African Medical and Research Foundation
3. CAA: Civil Aviation Authority
4. CAHWS: Community Animal Health Workers
5. CBOs: Community Based Organizations
6. CCHF: Crimean Congo Hemorrhagic Fever
7. CDC: Centers for Disease Control and Prevention
8. CHWs: Community Health Workers
9. CoVAB: Collage of Veterinary and Agricultural Business
10. DGHS: Director General of Health Services
11. DHT: District Health Team
12. DRRT: District Rapid Response Team
13. DSFP: District Surveillance Focal Person
14. DTF: District Task Force
15. DVO: District Veterinary Officer
16. EMC: Emergency Management Cycle
17. ESD: Epidemiology and Surveillance Division
18. EU: European Union
19. GOARN: Global Outbreak Alert and Response Network
20. HDPs: Health Development Partners
21. HFs: Health Facilities
22. HDREC: Higher Degrees Research and Ethics Committee
23. HPAI: Highly Pathogenic Avian Influenza
24. HWs: Health Workers
25. IDI: Infectious Disease Institute
26. IDSR: Integrated Disease Surveillance and Response
27. IHR: International Health Regulations
28. IMF: International Monetary Fund
29. IMT: Incident Management Team
30. IRB: Institutional Review Board
31. JEE: Joint Enteral Evaluation
32. JMEDICC: Joint Mobile Emerging Disease Intervention Clinical Capacity
33. LMICs: Low and Middle Income Countries
34. MAAIF: Ministry of Agriculture Animal Industry and Fisheries
35. MakSPH: Makerere University School of Public Health
|   | Acronym   | Description                                      |
|---|-----------|--------------------------------------------------|
| 1 | MoD:      | Ministry of Defense                              |
| 2 | MOFP&ED:  | Ministry of Finance, Planning and Economic Development |
| 3 | MoH-HQs:  | Ministry of Health Headquarters                  |
| 4 | MSF:      | Médecins Sans Frontières                         |
| 5 | MUWRP:    | Makerere University Walter Reed Project          |
| 6 | MVD:      | Marburg Virus Disease                            |
| 7 | NADDEC:   | National Animal Disease Diagnostics and Epidemiology Center |
| 8 | NAO:      | Network Administrative Organization               |
| 9 | NAPS:     | National Action-Plan for Health Security          |
| 10| NGOs:     | Non-Governmental Organizations                    |
| 11| NMS:      | National Medical Stores                          |
| 12| NRT:      | National Rapid Response Team                      |
| 13| NT:       | National Task Force                               |
| 14| OHCEA:    | One Health Central and East Africa               |
| 15| OPM:      | Office of the Prime Minister                      |
| 16| P&R:      | Predict and Respond                              |
| 17| PHEOC:    | Public Health Emergency Operations Center         |
| 18| RRT:      | Rapid Response Team                               |
| 19| RVF:      | Rift Valley Fever                                |
| 20| SNA:      | Social Network Analysis                          |
| 21| SSA:      | Sub Saharan Africa                               |
| 22| UCRS:     | Uganda Catholic Relief Services                  |
| 23| UNCST:    | Uganda National Council of Science and Technology |
| 24| UNICEF:   | United Nations Children Education Fund           |
| 25| UNMEER:   | United Nations Mission for Ebola Emergency Response |
| 26| UNPHLS:   | Uganda National Public Health Laboratory Services |
| 27| URC:      | Uganda Red Cross                                 |
| 28| USAID:    | United States Agency for International Development |
| 29| UVRI:     | Uganda Virus Research Institute                   |
| 30| UWA:      | Uganda Wildlife Authority                        |
| 31| WB:       | World Bank                                       |
| 32| WHO:      | World Health Organization                        |
| 33| WHO-CO:   | World Health Organization Country Office          |
| 34| WHO-RO:   | World Health Organization Regional Office         |
| 35| ZDCO:     | Zoonotic Disease Coordination Office              |
Declarations

Ethics approval and consent to participate: Ethical approval for this study was provided by Makerere University Higher Degree Research and Ethics Committee (HDREC Protocol number 580) and granted permission from Ministry of Health Headquarters was also granted (Ref Number ADM.105/309/16). We determined the judicious use of agency names in the findings using the overriding principle of do no harm, practical application of the study and the need for relationship management with known agencies that play key roles in MVD management in Uganda. Participation as a Delphi panel member was voluntary. Informed consent was also sought and documented. We shared the study findings at a national level stakeholder dissemination workshop.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analyzed during for our study are available from the corresponding author upon reasonable request.

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

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Authors' contributions: SS, TD, BS, SA and SF conceptualized the study. KJ and MI acquired the documents for the literature review. SS, TD, NR and TKA conducted the data abstraction, analysis and synthesis. SS, TD, NR, TKA AND SF facilitated the Delphi survey. SF facilitated the engagement after the first round of the Delphi survey. KJ and MI mobilized the Delphi panel participants and hosted the Delphi survey at the Public Health Emergency Operations Center. SS prepared the first draft of the manuscript. All the authors revised the various drafts of the manuscript. All authors read and approved the final manuscript.

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