Understanding Individual and Social Risk Factors Related to Priority Zoonotic Diseases in the Democratic Republic of the Congo

A Review of the Literature

Submitted to: United States Agency for International Development

Submitted by: Johns Hopkins Center for Communication Programs

October 11, 2019

Cooperative Agreement #AID-OAA-A-17-00017

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Suggested Citation: Sugg, K. (2020). *Understanding individual and social risk factors related to priority zoonotic diseases in the Democratic Republic of the Congo: A review of the literature*. Baltimore, MD: Breakthrough ACTION, Johns Hopkins Center for Communication Programs.

This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of Breakthrough ACTION and do not necessarily reflect the views of USAID or the United States Government.

Table of Contents

List of Tables

List of Acronyms

CCP	Center for Communication Programs
CHV	Community health volunteers
DRC	Democratic Republic of the Congo
EVD	Ebola virus disease
FGD	Focus group discussion
HCW	Health care worker
IDP	Internally displaced person
JEE	Joint External Evaluation
MPX	Monkeypox
NGO	Non-governmental organization
PPE	Personal protective equipment
PZD	Priority zoonotic diseases
SBC	Social and behavior change
USAID	United States Agency for International Development
WHO	World Health Organizations

Acknowledgements

Many individuals played an important role in the design, conduct, and analysis of this literature review. We gratefully acknowledge their contributions.

Breakthrough ACTION is a five-year project funded by the United States Agency for International Development (USAID) and led by the Johns Hopkins Center for Communication Programs (CCP). Breakthrough ACTION would like to acknowledge Katheryn Sugg for authoring the report, and Radha Rajan and Heather Forrester for reviewing it. This report was structured after a previous Breakthrough ACTION priority zoonotic diseases literature review focused on West Africa (Naugle et al., 2019). We also thank Chris Merritt and Marcela Aguilar for editing and formatting the report.

Executive Summary

Breakthrough ACTION is a five-year cooperative agreement from the United States Agency for International Development (USAID) to lead USAID's social and behavior change (SBC) programming around the world. Breakthrough ACTION is a partnership led by Johns Hopkins Center for Communication Programs (CCP).

Through the Global Health Security Agenda, USAID has supported the Government of the Democratic Republic of Congo to achieve the International Health Regulations obligations and comparable animal health capabilities to prevent, protect against, control, and provide a public health response to the international spread of infectious disease using the One Health approach. One Health recognizes that the health of people is connected to the health of animals and to the environment. It is a collaborative, multisectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes while recognizing the interconnection between people, animals, plants, and their shared environment. This approach builds upon the existing work by USAID and other U.S. government agencies working with Ministries of Health, Agriculture, Environment, and other key stakeholders to build capacity.

Supporting the development of functional risk communication systems requires an improved understanding of the individual and social behavioral risk factors related to priority zoonotic diseases.

This literature review summarizes the available published literature on behavioral determinants and sociocultural systems and norms that influence specific priority zoonotic diseases in the Democratic Republic of the Congo. It provides a starting point for further qualitative and quantitative investigation to inform the development of SBC resources and tools that may contribute to the development and maintenance of effective risk communication systems. The literature search was conducted across Embase, Scopus, and PubMed, and inclusion criteria for the articles were that they: (1) have a focus on any of avian influenza, arbovirus, monkeypox, and viral hemorrhagic fever; (2) were conducted in the Democratic Republic of the Congo (DRC); (3) were published between January 2008 and October 2019; and (4) describe individual, cultural, or social risk or prevention factors related to one of the priority zoonotic diseases specified above.

The literature search returned 16 articles that met the inclusion criteria, including 11 for viral hemorrhagic fever (including Ebola [8]) and arboviruses (yellow fever [3]), as well as 5 for monkeypox. This review summarizes key individual and community determinants of risk for each PZD.

Introduction

The World Health Organization (WHO) has led Joint External Evaluations (JEE) of country capacity to prevent, detect, and rapidly respond to public health risks. One of the parameters the JEE evaluates is risk communication, which includes disseminating timely information about health risks and events to the public through the appropriate channels in order to promote prevention and control actions at the individual, family, and community levels. In order to improve risk communication systems, governments must develop multisectoral communication strategies that provide the link between human health, animal health, and the environment. This approach, called “One Health,” explicitly considers the intersections between human health, animal health, and the environment, as well as how actions in one area affect the other two.

Supporting the development of functional risk communication systems requires a better understanding of the individual and social risk factors related to each of the priority zoonotic diseases. The purpose of this literature review is to provide a starting point for further qualitative and quantitative investigation to inform the development of social and behavior change (SBC) resources and tools. These resources and tools will contribute to the creation and maintenance of effective risk communication systems.

Specific objectives for the Breakthrough ACTION Global Health Security Agenda in DRC include: gaining an understanding of individual and social determinants of risk of infection and perceptions of risk of Ebola and other priority zoonotic diseases; strengthening the risk communication system and engaging the community to ensure ownership, viability, and sustainability of the communication system; and increasing stakeholders’ capacity to improve public awareness using mass media and improved communication tools.

Methods

This report provides a review of the published literature of individual and social risk factors related to four zoonotic disease groups in DRC. To be included in the review, articles had to (1) focus on one of the four zoonotic disease groups of avian influenza, monkeypox, arboviruses, and viral hemorrhagic fevers; (2) be about cases in the DRC; (3) be published in the last 12 years (2008–2019); and (4) describe individual, cultural, or social risk or prevention factors related to one of the aforementioned zoonotic disease groups. The search was conducted across three comprehensive databases of peer-reviewed literature—Embase, PubMed, and Scopus—between September and October 2019 and updated in January 2020.

Results

The literature search uncovered a total of 16 articles that met the inclusion criteria, including five for monkeypox and 11 for viral hemorrhagic fever (including Ebola virus disease [8]), and the arbovirus yellow fever [3]). These articles are described below, organized by disease group. There were no eligible articles returned for avian influenza.

Table 1. ***Summary of Results***

DISEASE	SOURCES	POPULATIONS	RISK FACTORS	INTERVENTIONS	BARRIERS
Ebola Virus Disease	Peer-reviewed articles (8)	General public Women Children Internally displaced persons (IDPs)/refugees Health care workers	Nosocomial transmission Consumption or preparation of bush meat Contact with bats Contact with infectious persons/corpses	Increase community engagement Reinforce health infrastructure through training and providing materials, including educating *tradipracticiens* (traditional healers)	Security concerns Poor health infrastructure Community resistance Population displacement Fear/distrust of Ebola response measures Belief that there was no threat because hunting/eating wild animals had been done for many years
Yellow Fever (Arbovirus)	Peer-reviewed articles (2) Conference abstract (1)	General public	High population mobility Porous border Cross-border trade	Increase cross-border surveillance Strengthen laboratory capacity Offer fractional dose of vaccine	Ineffective screening capacity at land ports Difficulty of diagnosis Vaccine shortage
Monkeypox	Peer-reviewed articles (5)	General public (especially unvaccinated)	Proximity to forested areas, particularly those	Implement active surveillance	Inconsistent reporting due to lack of training, transportation,

DISEASE	SOURCES	POPULATIONS	RISK FACTORS	INTERVENTIONS	BARRIERS
		Males under 20 Younger people (<15 years of age)	with cleared or disturbed areas Rope squirrel consumption or hunting Household transmission Not having received the smallpox vaccination	Train all levels of health workers in surveillance and care Provide surveillance tools and PPE to health workers Establish health education campaign on handling reservoir species Carry out targeted vaccination of HCWs Improve ability to diagnose/ confirm cases	and communication infrastructure Difficulty of diagnosis Cases may not present for care Reliance on bushmeat Decreasing herd immunity

Avian Influenza

One article was returned in the search for avian influenza. It did not meet the inclusion criteria.

Viral Hemorrhagic Fevers

Ebola Virus Disease

Table 2**. *Summary of Results, Ebola Virus***

DISEASE	SOURCES	POPULATIONS	RISK FACTORS	INTERVENTIONS	BARRIERS
Ebola Virus Disease	Peer-reviewed articles (8)	General public Women Children IDPs/Refugees Health care workers	Nosocomial transmission Consumption or preparation of bush meat Contact with bats Contact with infectious persons/corpses	Community engagement Reinforcement of health infrastructure through training and provision of materials, including education of *tradipracticiens*	Security concerns Poor health infrastructure Community resistance Population displacement Fear/distrust of Ebola response Belief that no threat exists because hunting/eating wild animals had been done for many years

Ebola virus disease (EVD) is a hemorrhagic fever that has been the cause of a number of outbreaks in equatorial Africa, with the largest epidemic taking place from 2014 to 2016 in West Africa. The second largest outbreak is currently ongoing in eastern DRC (Kasereka et al., 2019). According to the WHO, the latest count in the current outbreak was 3295 confirmed cases and 119 probable cases as of January 19, 2020. The case fatality in this epidemic is 66% (WHO, "External Situation Report 76," 2020). The probable animal reservoir of EVD is the fruit bat. The virus can be transmitted by hunting or handling dead animals found in the forest such as bats, as well as chimpanzees or other animals that may eat or interact with bats (Leroy et al., 2009). However, once in humans, EVD is spread by human-to-human contact through bodily fluids, secretions, mucous membranes, or broken skin, and via contaminated surfaces (Hoff et al., 2019). The current outbreak in eastern DRC is compounded by the fraught security situation in that country, which has weakened the health care system and resulted in the displacement of over one million people (Kasereka et al., 2019).

Risk factors

One notable aspect of the current outbreak in DRC is the high rate of nosocomial transmission, with one study finding that 16% of patients visited a health center 2-21 days before the onset of EVD symptoms (Ilunga Kalenga et al., 2019) and another finding that 25% of infections arose at health centers (Kasereka & Hawkes, 2019). Women and children may be at greater risk of nosocomial transmission than other groups, as they are more likely to attend health facilities for services unrelated to EVD, such as child or maternal care (Ilunga Kalenga et al., 2019). Health care workers are also at increased risk due to occupational exposure to bodily fluids, lack of infection control training, and a shortage of personal protective equipment (PPE) (Hoff et al., 2019; Kangoy et al., 2016).

One study also associated violent attacks with an increase in infection and mortality, as these attacks can result in the suspension of response activities, can create a culture of fear in which patients do not want to submit to examinations or visit health centers, and can cause contagious patients to flee to inaccessible areas where they and their contacts do not receive further monitoring (Ilunga Kalenga et al., 2019).

Finally, outbreaks are likely to occur in the wet season, in rural areas, and in areas that are in close proximity to equatorial forest. These findings are due to the high risk of transmission during activities such as hunting or handling dead forest animals, including the consumption of poorly cooked infected animals such as chimpanzees and bats (Kangoy et al., 2016). A case study of an outbreak in the Kasai Occidental province in 2007 showed strong temporal and spatial links between the start of the EVD epidemic and a massive annual bat migration during which many bats were killed and traded for eating (Leroy et al., 2009). Serologic evidence from asymptomatic individuals in non-outbreak zones also shows an association between seropositivity and entering the forest regularly (OR = 1.75, 95%CI [1.0 – 3.05]), as well as between seropositivity and exposure to rodents (OR = 1.77, 95%CI [1.02-3.04]) (Mulangu et al., 2018).

Knowledge, attitudes, and practices

Two studies by Kasereka et al. (2019) showed different levels of comprehensive knowledge surrounding EVD. In one study of vaccine acceptors and community controls, 67% of survey respondents had comprehensive knowledge of Ebola. These studies defined comprehensive knowledge as acceptance of two main concepts of prevention (avoiding body fluids and adopting handwashing) and rejection of three misconceptions (transmission can occur by ambient air or mosquito, and Ebola is preventable with hot baths in saltwater). However, in a different survey that defined comprehensive knowledge by the above criteria plus accepting the concept of avoiding infected corpses as a means of prevention, only 25% of general community member respondents had a comprehensive knowledge of Ebola (Kasereka & Hawkes, 2019). In the latter survey, comprehensive knowledge increased with higher levels of educational attainment. The differences in these results may be due to study sample differences, as vaccine acceptors may be more likely than the general population [AUTHOR: OR SHOULD THAT BE "than vaccine rejecters" OR SHOULD THAT BE MORE GENERALLY "than others"] to be directly educated about

EVD, have a lack of knowledge about infected corpses as a mode of Ebola transmission, or have high knowledge about prevention methods generalizable to many diseases.

The majority (53%) of respondents correctly cited forest animals as the origin of Ebola, while 6% of respondents cited supernatural causes, including witchcraft, magic, and a sorcerer cat. Identifying the origin of EVD as something supernatural did not preclude respondents' acceptance of biomedical transmission from body fluids and corpses, showing that these beliefs can coexist. Four in ten (38%) of respondents did not know the origin of EVD. Focus group discussions (FGDs) revealed that when people first began getting sick, the community considered Ebola to be the result of witchcraft. This perception shifted as the epidemic continued, although some community members (6% of respondents) maintained the idea that Ebola was supernatural. The belief that Ebola has supernatural origins was linked to the belief that traditional healers may cure it. Of note, traditional healers were more likely than the general population to believe they could cure Ebola (Kasereka & Hawkes, 2019).

In a prior epidemic in Kikwit, a rumor began that health care workers were killing people, as many of those who died did so after going to the hospital for help. This rumor led to demoralization of health care workers (Kangoy et al., 2016). Similarly, in the current outbreak many are suspicious and fearful of the Ebola response effort. Distrust of the government and response teams extends to state-sponsored facilities, meaning that the population often views private health care facilities and traditional healers as superior. Fear of attacks on health centers also prevents patients from seeking care. Armed escorts accompanying health workers and community-response teams increase suspicion and tension. Perceptions also exist of the epidemic as a political ruse to prevent people in affected communities from voting, and of the Ebola response as a business benefiting the wealthy and powerful (Ilunga Kalenga et al., 2019). In a survey, 40% of respondents expressed at least one resistant attitude toward control efforts, with 16% saying they would not take a family member to an Ebola treatment unit and 20% saying they would hide an infected family member from the authorities (Kasereka & Hawkes, 2019).

Although there is no licensed vaccine for Ebola, a ring vaccination trial conducted during the 2014-2016 outbreak in Guinea showed that the rVSV-ZEBOV vaccine can provide 100% protection against the virus (Henao-Restrepo et al., 2017). It is offered under the label of "compassionate use" to those at highest risk, namely contacts of cases and health care workers. In a study of vaccinated case contacts and unvaccinated controls (Kasereka et al., 2019), 86% of vaccine recipients would recommend the vaccine to others, despite 83% reporting side effects. Those reporting arthralgia (joint pain) were significantly less likely to recommend the vaccine to others. Among unvaccinated controls, 72% would want vaccination if the supply allowed (with 86% of those being willing to pay for it), while 25% would not want vaccination. Comprehensive Ebola knowledge was associated with greater vaccine interest (OR = 5.8, $p < .001$). Among unvaccinated controls, 17% said they would not accept an official burial team if a family member died of Ebola. There was a strong correlation between those resistant toward an official burial team that would provide a safe and dignified burial and those who said they would refuse the vaccine (OR = 17, $p < .001$).

Awareness of the zoonotic origin of EVD does not necessarily translate into preventive behaviors regarding bushmeat handling and consumption. While the majority of respondents in one survey was aware of the zoonotic origin of EVD, 39% of all respondents said they consume bushmeat (Kasereka & Hawkes, 2019). No statistically significant difference in acceptance of a zoonotic origin for Ebola existed between those who did and did not eat bushmeat. People in at least one cluster of villages reported that women of reproductive age were not allowed to eat bats, but that they were often the ones to butcher, prepare, and cook them and thus are exposed (Leroy et al., 2009).

Risk perception

Ninety-one percent of respondents in the study by (LeRoy et al. 2009) said they worry about Ebola. Despite a widespread understanding that humans can contract Ebola from dead animals, some respondents did not believe that to be true due to a long cultural history of hunting animals without epidemics ensuing. Health centers were seen as particularly high-risk places both by the community and by health workers who referred to examples of health workers avoiding patient examination due to fear of exposure to EVD (Kasereka & Hawkes, 2019). In a survey of vaccine recipients, 91% said their worry about EVD decreased post-vaccination, but 76% still recognized the importance of taking precautions to protect themselves (Kasereka et al., 2019).

Barriers

Distrust of the Ebola response is one of the main barriers to tackling the epidemic. Community resistance and armed conflict put health care workers in danger and stymie the Ebola response effort as community members avoid seeking care or refuse vaccination, and civil unrest has damaged the health care infrastructure. The mobility of the population also complicates the response effort, making it hard to identify contacts of patients (Ilunga Kalenga et al., 2019; Kasereka et al., 2019). A study modeling the effect of vaccination coverage on containment of the epidemic showed that delayed or incomplete coverage, either due to vaccine refusal or to the difficulty of tracking contacts, had significant effects on how effective the ring vaccination strategy could be on controlling the geographic spread of the disease (Wells et al., 2019).

Because Ebola symptoms are easy to confuse with endemic diseases such as typhoid and malaria (Hoff et al., 2019; Kangoy et al., 2016), confirming cases, especially at the beginning of an outbreak, can be difficult. In addition, long distances between health facilities and laboratories hinder laboratory confirmation of the disease (Ilunga Kalenga et al., 2019). Because trading and eating bushmeat is crucial to the livelihood and survival of many in the DRC, elimination of hunting and consuming bushmeat is difficult to accomplish, especially in populations with the fewest resources, and thus a barrier to preventing zoonotic transmission. In addition, people may not believe health messaging that targets hunting and bushmeat consumption as causes because many consume bushmeat without incident, and once the epidemic starts, human-to-human transmission is more likely and more dangerous (Kasereka & Hawkes, 2019). Finally, fruit bats constitute a source of protein that is not protected against hunting, unlike some other game, and is readily available during the bats' migratory periods (Leroy et al., 2009).

Recommendations

For maximum effectiveness, the Ebola response must be anchored in the community, as it needs social traction as much as biomedical solutions to work. Response teams and health centers should address other concerns, such as malaria, in a good-faith effort to show they care about saving lives and improving health, regardless of cause. Addressing multiple endemic diseases would result in decreased mortality and a lower burden of safe and dignified burials. It would decrease nosocomial spread of disease by reducing the number of patients at health facilities and would also build trust in health care workers and facilities (Ilunga Kalenga et al., 2019). Community education campaigns to convey the viral nature of Ebola and reduce rumors and false beliefs are also important to the Ebola response. In particular, public health authorities in the DRC and their partners should prioritize health education on hygiene, cooking bushmeat for long periods, and avoiding contact with biological fluids of those suspected to have hemorrhagic fever. While one article recommends establishing agencies and institutions to control hunting to reduce consumption of infected animals, other authors express concern about the focus on preventing bushmeat consumption given its central role in the livelihoods of low-resource populations (Kangoy et al., 2016).

Provider-side intervention is especially important given the high rates of nosocomial transmission and health worker cases in the current outbreak. It is essential to train health care workers and motivate them to follow infection control procedures, as well as to ensure that PPE and other medical materials are readily available, including in rural areas (Hoff et al., 2019; Kangoy et al., 2016). Establishment of laboratory facilities in each health zone can help with earlier detection of future outbreaks (Kangoy et al., 2016). After finding that vaccine recipients were more likely to recommend the vaccine to others if they did not experience arthralgia, Kasereka et al. (2019) recommended using analgesia for arthralgia when providing the vaccine to increase acceptance and word-of-mouth promotion. Finally, engagement and education of traditional practitioners should be a priority, as nosocomial transmission has been linked to visits to these centers. These *tradipracticiens* may have greater community trust than health facilities do, but are more likely to try dangerous treatments or lack proper PPE, facilitating the spread of disease (Kasereka & Hawkes, 2019).

Arboviruses

Arbovirus is short for arthropod-borne virus and, as such, these viruses transmit through the bites of arthropod vectors such as mosquitoes, ticks, midges, and sandflies. Human-to-human transmission can also occur with some arboviruses (Centers for Disease Control and Prevention, 2015). More than 130 disease-causing arboviruses can infect humans, including African swine fever, dengue, Japanese encephalitis, Rift Valley fever, tick-borne encephalitis, West Nile encephalitis, yellow fever, Zika, and chikungunya. However, little to no literature exists on the knowledge, attitudes, and practices regarding the majority of these arboviruses in DRC, with a literature review uncovering relevant literature for only yellow fever.

Yellow Fever

Table 3. ***Summary of Results, Yellow Fever***

DISEASE	SOURCES	POPULATIONS	RISK FACTORS	INTERVENTIONS	BARRIERS
Yellow Fever (Arbovirus)	Peer-reviewed articles (2) Conference abstract (1)	General public (unvaccinated)	High population mobility Porous border Cross-border trade	Implement cross-border surveillance Strengthen laboratory capacity Offer fractional dose of vaccine	Ineffective screening capacity at land ports Difficulty of diagnosis Vaccine shortage

Yellow fever is an acute viral hemorrhagic disease transmitted by the *Aedes aegypti* mosquito, causing epidemics when an infected person or people introduce the virus into areas with high mosquito density and incomplete vaccine coverage. It is preventable by an effective and affordable one-time vaccine that is routinely administered in DRC to children at > 9 months of age (WHO, 2019). One study (Casey et al., 2019) estimates rates of vaccine coverage in DRC between 50% and 70%. Worldwide, 15% of those infected develop serious illness that can lead to death. In Africa, the historic case fatality rate is about 20% (Otshudiema et al., 2017).

Risk factors

In a study looking at a spatial and temporal case history of the 2016 yellow fever outbreak in the Kongo Central province, 35 of 37 cases were imported from Angola. One market city, Lufu, with tens of thousands of border crossings on market days, accounted for two-thirds (23 of 35) of the laboratory-confirmed cases. Living in any of eight districts on the border with Angola was a risk factor during this epidemic. High population mobility, a porous border, and the magnitude of cross-border trade activities all contributed to the outbreak. During the rainy season the risk of transmission increases (Otshudiema et al., 2017).

Knowledge, attitudes, and practices

In an abstract published in a supplement to the *International Journal of Infectious Diseases*, Fu et al. (2019) look at attitudes towards an emergency outbreak vaccination campaign. Through post-vaccination exit interviews, FGDs, and a household survey the authors found high rates of satisfaction with service delivery contrasted with a lack of visual communication materials at clinics and insufficient instruction from clinic personnel.

Barriers

Yellow fever cases may be difficult to diagnose as the symptoms are similar to those of malaria, viral hepatitis, and typhoid fever. In addition, screening capacity at land ports of entry cannot keep up with the high population mobility of border communities (Otshudiema et al., 2017). Fu et al. (2019) cited incompatible working hours as a barrier to vaccination and Casey et al. (2019) identified the vaccine shortage and global supply issues precipitated by the Angola-DRC outbreak in 2015-2016 as other major barriers.

Recommendations

To prevent outbreaks, it is important to improve coordination between health surveillance and cross-border trade activities, as well as to strengthen laboratory and case-based surveillance (Otshudiema et al., 2017). As observed in the 2016 outbreak in Kongo Central province, a fractional dose of the yellow fever vaccine was acceptable and effective, indicating that fractional doses can be used in emergency situations with insufficient vaccine supply (Casey et al., 2019).

Monkeypox

Table 4. ***Summary of Results, Monkeypox***

DISEASE	SOURCES	POPULATIONS	RISK FACTORS	INTERVENTIONS	BARRIERS
Monkeypox	Peer-reviewed articles (5)	General public (especially unvaccinated) Males under 20 Younger people	Proximity to forested areas, particularly those with cleared or disturbed areas Rope squirrel consumption or hunting Household transmission Not having received the smallpox vaccination	Active surveillance Train all levels of health workers in surveillance and care Provide surveillance tools and PPE to health workers Health education campaign on handling reservoir species Targeted vaccination of HCWs Improve ability to diagnose/ confirm cases	Inconsistent reporting due to lack of training, transportation, and communication infrastructure Difficulty of diagnosis Cases may not present for care Reliance on bushmeat Decreasing herd immunity

Monkeypox (MPX) is a zoonotic virus that results in a febrile rash resembling smallpox. It is found in rain forest regions in West and Central Africa and can be contracted through infected wildlife or human-to-human transmission. Monkeypox has a case fatality rate of around 10% and became nationally notifiable in 2000 (Bass et al., 2013). Since its discovery in 1970, most reported cases of monkeypox have occurred in the DRC (Fuller et al., 2010). A 20-fold increase in monkeypox cases since the 1980s appears to be correlated with the termination of mass smallpox vaccination campaigns (Rimoin et al., 2010). The smallpox vaccine provides more than 85% immunity to monkeypox (Centers for Disease Control and Prevention, 2016). Rimoin et al. (2010) point out concerns that a decline in population immunity will result in an increase in human-to-human transmission that will allow sustained spread in human populations (Rimoin et al., 2010).

Risk factors

The risk of monkeypox is two-fold. Primary transmission occurs from animals to humans, as the result of spillover transmission from animal reservoirs, making contact with reservoir species and proximity to the species' preferred habitats an important risk factor (Fuller et al., 2010). Monkeypox cases are most frequent in human settlements near forests with rope squirrel habitats (Fuller et al., 2010; Rimoin et al., 2010) and in the northern and central regions of DRC (Hoff et al., 2017). Nolen et al. (2015) also observed that cases were more frequent in disturbed habitats as cleared land creates an environment where humans are more likely to have contact with forest animals due to the animals' loss of cover or human frequency of land use. In two studies, cases were more likely to be male, to be students, and to be younger than 15 years old (Nolen et al., 2015; Rimoin et al., 2010). In fact, school-aged males were the family members most likely to introduce monkeypox into the household (Nolen et al., 2015). This high incidence of MPX among males under 20 years old in forested regions overlaps with the demographic most likely to engage in hunting behavior (Rimoin et al., 2010). In addition, rope squirrel consumption is a risk factor (Fuller et al., 2010). Two families also reported anecdotal evidence associating incidents of children catching and playing with live squirrels with contracting the disease (Nolen et al., 2015). Strengthening this connection to zoonotic transmission from rodents is the finding that cases were more likely than controls to sleep on the floor ($p=.032$) while controls were more likely to live in houses with doors ($p=.012$) (Nolen et al., 2015).

Secondary cases occur when monkeypox is transmitted from one human to another. Household transmission was found to be an important risk factor for contracting monkeypox. Specifically, sleeping in the same room or bed with an infected person, or sharing the same dish or cup with one, were associated with an increase in risk (Nolen et al., 2015). There has been a decrease in herd immunity to poxviruses since the mass smallpox vaccination campaigns ended in 1980 (Hoff et al., 2017; Rimoin et al., 2010). Among those born before the end of the mass smallpox vaccination campaign in 1980, unvaccinated persons had more than five times the likelihood of contracting monkeypox compared to those who received the vaccine (Rimoin et al., 2010). For cases of both primary and secondary transmission, residents living further from their health zone's hospital are less likely to be seen by a provider who is familiar with identifying monkeypox and providing appropriate care than those who live closer to a hospital (Bass et al., 2013), and the cases are therefore less likely to be reported and may be more likely to continue to spread.

Knowledge, attitudes, and practices

A survey of health care workers in Tshuapa revealed near-universal understanding among health care workers of the need to isolate patients with suspected cases of monkeypox, but only 17.5% could describe all four symptoms (febrile prodrome, lymphadenopathy, deep-seated firm lesions, and well circumscribed lesions). Almost 90% mistakenly identified blood as the preferred specimen for diagnostic testing. Seventy-one percent of health care workers reported fear of monkeypox infection (Bass et al., 2013).

Barriers

There are a number of barriers to diagnosis, treatment, and reporting of monkeypox. Because most cases occur in forested areas with poor transportation and communication infrastructure, health care workers have trouble conducting surveillance of cases and case notification is inconsistent across health districts. In addition, most health workers have limited training in case recognition and reporting and cite safety concerns and logistical barriers such as a lack of supplies (case forms, sample kits, PPE), lack of vehicles (bicycles and motorcycles) and fuel, and difficult terrain. Only 45% of health care workers reported they always have appropriate PPE for collecting specimens. Added to these barriers, health care workers often do not receive any financial compensation or reimbursement of expenses when they travel around health zones to conduct surveillance activities. The lack of medicine available to treat patients and ameliorate symptoms likely contributes to the lack of motivation, as once they have surmounted hurdles to case recognition they are able to do little for the patient (Bass et al., 2013).

Other barriers include the difficulty of diagnosis and structural factors. It is easy to confuse monkeypox rash with varicella, and it can be difficult to find cases if the infected do not go to health facilities for care (Bass et al., 2013). Civil war and increasing poverty force communities to rely more heavily on monkeys, squirrels, and other rodents as food sources (Hoff et al., 2017; Rimoin et al., 2010) and the number of households with no members vaccinated for smallpox is increasing (Hoff et al., 2017; Rimoin et al., 2010). Immunity may also be decreasing in those who were vaccinated in the 1970s (Hoff et al., 2017).

Recommendations

Attempts to address MPX should include health education campaigns on handling animal reservoir species in endemic regions and targeted interventions for health care workers, promoting active rather than passive surveillance (Rimoin et al., 2010). Interventions should also include training for district and health zone personnel in monkeypox surveillance and patient care, including those not in supervisory roles, during routine field supervision. This training should teach health care workers to collect lesion-derived material rather than blood as the diagnostic specimen and provide simple surveillance tools, including training resources and quick reference guides at a level suitable for those without formal medical training, along with PPE for all health personnel. Enhancing the specificity of the surveillance case definition for MPX, collecting images of patients' rashes to see what providers are diagnosing correctly and incorrectly, and ensuring timely transmission of laboratory results back to health care workers to provide diagnostic feedback would all contribute to improving case detection (Bass et al., 2013). Interventions should provide education regarding infection control nursing practices, including isolation of infected patients (Rimoin et al., 2010). Finally, health care workers need targeted vaccination or re-vaccination with newer vaccines (Bass et al., 2013; Rimoin et al., 2010).

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