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# A Comparative Study of Challenges and Strategic Management: Lessons Learned from SARS, MERS, HIV & Ebola Outbreaks

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## Abstract

INTRODUCTION: The challenges related to several viral outbreaks spanning over the centuries have exceeded human resources and capacities of the health departments to deal with the consequent adversities. Each epidemic or pandemic faced has brought out the inequalities and gaps in our systems and infrastructure.
OBJECTIVES: The focus of the current paper is to do a comparative study of complex challenges faced and strategies adopted by governments during the SARS, MERS, HIV, and Ebola outbreaks.
METHODS: To achieve the objective, a comprehensive summary of the challenges that the world has faced, and lessons learned from the strategic management of these viral outbreaks were analysed.
CONCLUSION: An inclusive approach for the development of a multi-pronged strategic framework to benefit the concerned or affected stakeholders is discussed. These actions can guide health care workers and individuals to be aware of health hazards and complexities.

**Keywords:** Virus, COVID19, Strategic Management, Public Health, Epidemics.

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## 1. Introduction

In this study, some viral infections that have posed a threat to the community are examined. They are either communicable or have the capacity to spread rapidly through other media if left unchecked. The people directly involved in fighting or facing these illnesses have learned valuable lessons that need to be passed on and remembered for facing future epidemics or pandemics, like the year of 2020, with SARS-CoV-2, so that such viral illnesses can be controlled. It necessitates all the stakeholders, i.e. individuals, communities, local and central governments, international organizations, health care workers, scientists, and researchers, to remain vigilant about other novel or mutated viral illnesses take lessons from the past. An attempt was made to summarize the underlying aetiology of the different viruses (SARS, MERS, Ebola, and HIV), their spread, the challenges faced in tackling them, and the lessons learned. If left unchecked, an epidemic can disable

and scar entire communities for a very long time. The current work explores various strategies for public health policies to incorporate them in the provision of prompt and state of the art medical care. The viruses of interest in this paper, namely HIV, SARS, MERS, and Ebola, are all epidemic in nature [1]. Each of them has struck fear in the hearts of the global community and has unveiled the weaknesses or strengths of the public health care system, the respective governments, how active the global community is, and our flaws. Each of these viruses has the capacity of turning into an epidemic or a pandemic the moment the health care system stops being vigilant, or we stop observing proper hygiene standards for ourselves [2].

## 2. Discussion on different viral infections

### 2.1. The Ebola Virus

The largest and worst outbreak of Ebola, of the 16 outbreaks [3], happened in West Africa, March 2014, where 28,616 people were affected, and 11,315 died in 6 countries [4]. Ebola directly attacks the immune system of a human. The virus first infiltrates the dendritic cells, the brain of the immune system -taking it hostage and causing all the other WBCs to die as it infects and replicates them. It then starts spreading and invading the host's lymph nodes and vital organs, like the kidney and the liver, causing them to lose function. Ebola only exists in body fluids; that is, it cannot be transmitted through touch (e.g., Chickenpox), surfaces (e.g., SARS-Cov-2), or the air (e.g., Influenza virus), and can only be transmitted through saliva, blood, mucus, vomit or faeces. Therefore, even an infected person is unlikely to transmit the illness until he shows symptoms [5]. There is mounting cell death in the body, and this triggers an immune system overload or a 'cytokine storm'-an explosion for an immune response that leads to both internal and external bleeding. The extreme fluid loss and body complication can prove to be fatal in 6-16 days of the first symptoms. Ebola has a 100% death rate if the patients are not looked to properly. Proper rehydration, symptomatic treatment, and care can significantly reduce the mortality rate from 90% to 25% [6].

### 2.2. SARS

Severe acute respiratory syndrome-related coronavirus (SARS-CoV) was believed to be the main reason behind the SARS outbreak. To date, two strains of the SARS have caused outbreaks in humans. There are several other strains, most of which have been found in horseshoe bats proving it to be the major, or we might say the main host reservoir for these viruses. These coronaviruses are among the largest among all RNA viruses, being 30 kb positive-sense, single-stranded, and enveloped RNA viruses [7].

### 2.3 MERS-CoV

Middle East Respiratory Virus is classified into two clades (clade A and clade B). These are different from SARS. There are about 1,813 cases of MERS reported until 2016, with 645 deaths (mortality rate ~36%), in 27 nations worldwide [8]. MERS was first found in Saudi Arabia in 2012. This virus is also noted to have come from bats. Camels in Oman are also known to have developed antibodies against this virus. Ali Mohamed Zaki isolated the first strain from the lungs of the Saudi patient, and it was identified as an unknown coronavirus [9]. Cytopathic effects (CPE) were found in the isolated cells. These were round and of syncytia formation [10]. SARS-CoV uses the spike proteins (S-proteins) to bind with the angiotensin-converting enzyme 2 (ACE2) of the host cells to invade it. In contrast, MERS-CoV uses the dipeptidyl peptidase 4 (DPP4) in place of the primary receptor [11]. The SARS virus can lead to the lungs' failure by causing severe inflammation in the organ, finally leading to respiratory orders and fibrosis. The coronaviruses have made a massive impact on the mental health of the people affected by it and the people around them. Both the viruses had been present in other mammals such as bats, camels, pangolins, etc. for years and strains had been isolated, but more research wasn't done before the situation went out of control. Even when WHO had declared that the SARS might become a pandemic which it has now in the form of SARS-CoV 2, there weren't enough measures taken, and research was mostly focused on the previously essential subjects. Also, the health care alert wasn't imposed for a longer time. When the pandemic planning started back in the early 2000s, a better infrastructure to control a future outbreak was expected. Still, it wasn't found, resulting in more deaths due to mutations in the virus genome.

### 2.4. HIV

The human immunodeficiency virus, or HIV, at the primary level, strikes and knocks off the immune structure, exclusively the T cells. The active transmission of the deadly virus occurred mainly through bodily fluids like blood, semen, vaginal fluids, anal fluids, and breastmilk. Traditionally, HIV has mostly spread through unguarded sex, the sharing of used and contaminated needles used for drugs/ medicines, and can pass from HIV infected mother to child. Over time, HIV can obliterate many T-cells that the body can't brawl infections and diseases, ultimately resulting in the foremost relentless kind of an HIV contagion: acquired immunodeficiency syndrome, or AIDS [12]. Someone with AIDS is incredibly prone to cancer and critical infections, like pneumonia. Though there is no cure for HIV or AIDS, someone infected with HIV who receives treatment early can have a lifespan similar to someone without it [13]. There are majorly two types of Human Immunodeficiency virus found, namely HIV1 and HIV2, globally, HIV1 is mostly held responsible for the HIV outbreak rather than the HIV2 strain. This lethal strain of HIV1 is zoonotic, i.e., a pathogen transferred from an animal to humans. Thus, it is closely related to a virus found in chimpanzees, which are of the sub-species Pan Troglodytes inhabited in the dense forests of

Central Africa. In 1999, the scientists came with the hypothesis of the origin of this viral strain that underwent a lot of genetic mutations to be the HIV that we know of today. They came with the idea that the virus might have transmitted from the African hunters who shot Chimpanzees and ate their contaminated flesh [14].

## 3. Challenges faced by communities & public health department during viral outbreaks

A pandemic could be a global conflict that impinges on all sectors of society and places virtually every individual in jeopardy, autonomous of societal or financial status, racial origin, or gender [15]. Challenges emerging from epidemic infectious ailment outbreaks are more efficiently met if conventional public health is improved by sociology. The main focus is sometimes on biomedical facets, the surveillance and sentinel organization for infectious contagions, and what has to be done to restraint outbreaks. Social factors linked with communicable disease outbreaks are habitually deserted, and therefore the repercussion is ignored. These factors can hit epidemic severity, pace, and degree of reach, influencing the wellbeing of victims, their kin's, and their communities [16].

### 3.1. Testing, tracing, and isolation

Through observation and continuous surveillance, the adequate information, required to contain a contagion menace is collected, and the general public is notified. It further provides early caveats, describes transmission incidence, attributes, frequency, occurrence, and supports a targeted rejoinder & response. Fast diagnosis, isolation of infected cases, tracing the source, screening the contacts, medical reporting, contact tracing, contact listing, and active monitoring are its key features. Usually, public health officials should collect an individual's consent before conducting any clinical tests, and focused education can help persuade susceptible to comply with discretionary testing. There are also exceptional times when obligatory testing is crucial to enhance the general public health care sector [17] [18]. Communities that suffered from pandemics have closed public places (schools, colleges, malls, occupational centres, mass transit, airports, and ports) and avoided almost all public events (sports, extra-curricular activities, examinations, conferences, meetings). Steps that are as coercive as self-quarantine, seclusion or confinement, should only be used when an ailment is acknowledged by substantial scientific study to be transmittable and may be limited to people that have been exposed to the ailment [19] [20].

### 3.2. Herd immunity

Herd Immunity is the phenomenon of acquired immunity among at-risk populations due to few individuals becoming immune to the infection through vaccination or natural infection, thereby reducing the susceptibility of infection among high-risk individuals. If the population or individuals achieve acquired immunity, then the risk of infection is reduced significantly [21]. Herd immunity against these viruses is critical since preparing every individual in a community to fight against such viruses would stop the spread [22] [23] [24]. While there is a vaccine for diphtheria, measles, mumps, pertussis, polio, rubella, smallpox, and influenza, Ebola vaccines, although proven effective, are not being used due to questions on the effectiveness of the vaccine over a long period, and also the vaccination would be costly. Several patients who were tried to be vaccinated in West Africa during the Ebola outbreak refused to vaccinate [25] [26]. There is also no vaccine developed to date for the coronaviruses like SARS and MERS. It is essential to educate people to save people against viruses by making a scheme and investing more funds for medical purposes.

### 3.3. Availability crises of primary health care

Access to primary health care possesses significant challenges in saving lives. Lack of coordination among concerned stakeholders at various levels of government brings out glaring deficits in primary health care in most underdeveloped & developing nations. Limited medical supplies, medicines, ventilators, oxygen cylinders, masks, goggles, shields, PPE kits for front care providers of healthcare services, paralyzes the healthcare department due to constant exposure to viruses. Proper infrastructure at primary health care settings is instrumental in reducing mortality rate and data collection for control of the disease. Initial inadequate supplies of protective gear led to the spread of SARS, and similar was the situation with other global pandemics [27] [28]. Ebola virus paralyzes healthcare facilities in most affected African countries, continuously struggling with financial resources and advanced medical setups to provide accessible medical care at affordable costs. Most of the patients in Liberia faced a humanitarian crisis amidst pandemic due to the exhaustion of government health facilities [29].

### 3.4. Health crises-infection transmission in medical staff & sanitation workers

There is an excellent chance for the healthcare personnel (HCPs) to get infected with the virus. About 1 to 27 percent, 11 to 57 percent, and 2.5 to 12 percent of the HCPs in the cases of MERS, SARS, and Ebola are reported to have been affected [30]. The fatality rate is also high in most cases since the HCPs have to stay close to patients of all stages. So, the early detection of those suspected of infection with these kinds of viruses, preparing against any outbreaks at both national and international levels, and publishing proper guidelines to fight against the infections is vital.

### 3.5. Policy issues in public health

Governments must share factual data to save humanity from virulent outbreaks. Sharing such data at regular intervals by countries with vast populations and the shortage of resource centres can be a massive global challenge. There must be coordination between research and its implementation, as the time lag makes the research redundant and expensive. Governments need to promote healthy practices that remove cartel formation among pharma companies and hospitals, leading to expensive life-saving drugs and vaccines. The deficit of public trust for government services is also a significant lacuna in public health policies [31].

## 3.6. Policy issues in mental health

Governments worldwide are scrambling to take whatever precautionary steps are required to keep the coronavirus from spreading and transmitting to more individuals. A global lockdown and calling in almost all medical and health care workers to the front line is one step that is common worldwide. However, with the global attention focused on the rising number of infected patients and the frontline responders, a silent illness spreads its roots in households and individual people's lives worldwide. The number of people suffering from mental health conditions in less developed countries is as high as 80% [32]. Needless to say, that people suffering from mental health conditions are even more vulnerable now that they are away from their loved ones, friends, family members, caregivers and are unable to reach out to therapists effectively. Even under normal circumstances, India has a scarcity of mental health professionals. There is > 1 mental health professional per 100,000 individuals in India [33]. Therefore, it is evident that these services will become even scarcer during pandemics, causing these patients to spiral more profoundly into the web of debilitating mental illness as the governments around the world almost forget this collateral. Apart from this, even those without a history of mental illness may experience mental health problems such as anxiety or even depressive disorders in extreme cases. It could be due to several reasons: isolation, shortage of money, loss of a month or more, loss of a job, stress, etc. [34] [35].

## 3.7. Policy issues related to socio-economic challenges

The communication between commune stigma, consequences of isolation, the shortage of economic assets, and other blockades reveal that these factors must all be addressed collectively, to cut down their collective impact and perk up HIV/AIDS prevention and treatment in rural areas. Certifying enhanced awareness in metropolitan & urban settings will necessitate a fresh accent on reinforcing capacities to handle outbreaks and other health emergencies and pandemics. Countless efforts are pertinent across all settings, urban or otherwise, like having a decent indulgence of the neighbouring socio-economic and cultural milieu and a vigorous association of communities and native influential leaders in both scheduling, planning, and implementation [36][16]. Lockdown creates several problems, not just for the citizens but also for the economy of the country. Tourism and other exports and imports are put to a halt, which affects several people involved in trade and commerce and travel and tourism. A large number of families who were previously well settled, face a crisis of food due to a fall in the family income. While most of the ones from the below poverty level get help from the government and the rich ones already have enough, it's the middle class that suffers the most.

## 3.8. Geographical barriers

Travel time is principally crucial in getting prompt medical help to at-risk populations [37]. It is vital to identify primary care facilities and hospitals near the vicinity for diagnosis and early treatment. Most of the ailments can be cured if the patients can get medical help on time. Countries and local governments with advancements in satellites and mobile location tracking apps should improve their plans to extend new treatment benefits to rural and remote areas where geographical barriers of landscape and climate limit building of permanent infrastructures. Long-distance mobility is challenging for critically ill patients and pregnant women, thereby increasing the mortality rate. Lack of intensive care units (ICU) and trained staff put a spotlight on the severity of the situation. Need for capacity –building in limited environments, training medical staff, virtual lab & critical care units, and adapting research-based international guidelines cannot be further ignored when humanity is fighting to survive against a novel virus [38].

## 3.9. Crises of lost employment

Human resource management is also a significant control measure to be followed. During epidemics, the economy of a country is negatively affected. Thus, planning the recovery of human resources should be included in the control measures. Pandemic results in loss of human lives, but a shrinking economy would aggravate the situation further due to hunger. Private and public companies should take the initiative to inform its employees about any pandemic situations and any warnings from WHO on any pandemic situations. Planning and management of the work should be present, and there should already be a system to handle works without meeting in person and to keep the salary of the employees stable. The primary sectors need more attention than the rest since the entire country's wellbeing depends on them. Agriculture, fishery, and others should not stop because an imbalance in these industries might result in a more significant crisis. Also, those involved with such industries mostly belong to the poverty level. While dealing with the pandemic, the system should pay attention to the patients and other citizens at the same time.

## 3.10. Integration of information & communication

Risk communication and integrating adequate information has an imperative key role in curbing a future epidemic. The circulation of necessary information regarding the virus's pathogenicity, epidemiology, public health management, risk perception, and proactive control measures can reduce the incidence of a viral outbreak and significantly control the transmission rates. The framing of risk communication is such that it must be lucid, crisp, and timely and should deliver credible facts with utmost clarity, empathy, and accuracy. It must provide an insight into the underlying fears that are less spoken about, and should be strong enough to counterattack all the rumour shrouding it. The public's perception of the information depends on factors like ethnicity, literacy rates, awareness about the scientific principles and theory, etc. Rumours, misinformation or half-information can slow down disease control and management. Individuals tend to believe in the misinformation more than the correct information since it feeds into their pre-existing notion of an idea about the viral outbreak [39] [40].

## 3.11. Priority setting

Priority setting is also crucial in case of such outbreaks. Often the lack of such measures leads to the infection is fatal. The early diagnosis and research on the control of the disease are vital to control the number of cases during such outbreaks. Diseases like Ebola are likely to occur suddenly without any prior warning, so the control safety of the infection must be followed to prevent any such outbreak. Health care facilities should be ready to treat people as soon as the first case arrives [41]. For the SARS and the MERS, more research is required to maintain the conditions. In the case of AIDS, a multi-criteria decision analysis (MCDA) is advised to consider several criteria for resource allocation [42].

## 3.12. Access to health services for comorbidity treatment

The majority of the viral outbreaks like HIV, Ebola, influenza, and SARS or MERS worsen situations in individuals with comorbidities, i.e., existence and appearance of two or more ailments or conditions in an individual simultaneously due to pre-compromised immunity. Complex medical management, psychological issues, poor quality of lifestyle, and inflated health costs add to the increased mortality rates. The four parameters for identifying the comorbidities in an individual, are the nature of the clinical health condition, the relative significance of the co-occurrences of the ailments, the chronological re-appearance/presence of the ailment and expanded conceptualizations leading to a better understanding and analysing the clinical conditions. The hurdles in treating and impeding the transmission rates of a viral outbreak are the lack of adequate infrastructure, knowledge, and expertise in rural areas. The lack of a classification system having comorbidity indexing, morbidity burden rates, patient complexity, and other constructs pose a challenge to understanding the causes of co-occurrence of the ailments and its consequences on public health services [43][44].

## 3.13. Social beliefs & taboos:

Reports say that about 60% of the cases of Ebola in Guinea can be traced back to traditional burial practices. There were incidents where prayers were conducted by the high-ranking church members resulting in a gathering, leading to the spread of the disease. Also, there were many reported cases where herbal medicines were tried or somewhat rubbed on the body of those infected with Ebola, resulting in more complications since the traditional healers practicing such activities were themselves infected. These techniques involving religious and social beliefs failed to solve the matter and worsened the situation [45]. The practice of consuming bats by a particular community, even after some coronavirus strains were already found, is a significant reason for the outbreak of the SARS and the MERS. It has also been said that information was also not shared during the SARS before it took a significant role in affecting other parts of the world. This secrecy and ignorance led to the social transmission of the infection [46]. In the cases of AIDS, it is mostly found that the communities are uneducated and unprepared to face such situations, thus ending up marginalizing and isolating the patients instead of providing proper care. Also, the proper knowledge regarding the use of protection or rather sex-education is lacking in most of these cases. Pregnant women face more problems due to social ignorance [47].

Table 1. Challenges faced during prior viral outbreaks

| Challenges | SARS/MERS | Ebola | HIV |
|---|---|---|---|
| 1.Testing, tracing & isolation | Early identification of infectious cases to reduce the risk of super spreaders was vital [48]. Unfamiliarity with the transmission patterns and clinical manifestations led to an outbreak in Hong Kong, Mainland China, and other areas. A strong epidemiological surveillance system was required for early detection and control [49]. | Initial identification was made fairly quickly, however testing and tracing became difficult later due to growing social taboo, poverty, lack of infrastructure [5] and geographical barriers [50]. | There are many tests to identify HIV, but back in 1985, the first commercial blood test was discovered [51]. The lack of proper awareness, adequate knowledge, infrastructure, economic constraints can also contribute to a barrier. |

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| 2. Herd immunity | Researchers are trying to make a vaccine, but the number of cases for coronaviruses was so less before the present year that priority was not being given to vaccination [52] [53]. | The Canadian government supported its scientific team's efforts in carrying out the clinical trials and sponsored the development of the "rVSV-ZEBOV" vaccine for the Ebola virus [54]. | The progress in the development of vaccines for STI prevention (Sexually Transmitted Infections) has been slow. Due to heterogeneity in the spread of such infections, clinical trials of uninfected individuals may increase both expenses and scale of trials [21]. |
| 3. Availability crises of primary health care | The SARS & MERS both spread quickly through contact & continuous exposure to aerosols. Lack of infrastructure and specialized medical staff in infectious diseases increased the complexity of the situation [27 55]. | Congo (country of origin) has few hospitals and suffers from low quality of infrastructure - 0.2% of the population are medical doctors [56]. Inaccessible and unaffordable primary healthcare facilities was a significant factor in increased morbidity rates [57] in many African countries. | The shortage of primary health care workers and inadequate clinical infrastructure are significant challenges in the treatment of HIV positive and AIDS patients, despite all the government's efforts. [58]. |
| 4. Health crises- infection transmission in medical staff & sanitation workers | The effect on the healthcare workers and the sanitation workers is vast since the virus that is present on surfaces might infect them as they are in regular contact with patients [59]. | This virus transmits if one comes in contact with an infected person's body fluid. Health workers dealing with patients and bodies of the infected tend to get infected easily as a result [60]. | The viral transmission from the patient to the healthcare worker can occur through the exchange of bodily fluids, as they are the first person to be in contact with the patient. The clinical instruments like scalpel, scissors, and needles are at higher risk of contamination while treating an HIV positive patient. Pregnant healthcare staff is at a higher risk of developing this viral contamination through body fluids, even saliva, and the baby is also at risk of getting infected. [61] [62]. |
| 5.Policy issues in public health | Acquiring reliable epidemiologic data on the transmissibility of deadly viral outbreaks are a global concern [63] [64] [65]. Coronaviruses require a worldwide investigation on the role of wet animal markets in its pathogenicity [66]. | The international support to the Ebola crisis was lackadaisical due to limited capacity and expertise in handling epidemics. Such situations require compelling efforts in policy overhauls and various humanitarian measures [67] [68]. | Inadequate training and insufficient knowledge is the primary barrier regarding public health. The pre-existing policies and infrastructure do not allow frontline clinical and public health workers for consultation and counselling. [69]. |
| 6. Policy issues in mental health | Psychological stress was seen in the patients as well as their families. Confusion, depression, excessive anxiousness, and even insomnia were seen. | For friends, family, and survivors: facing stigma and taboo from society. For health care workers: watching the devastating effects of the virus first hand, worrying about contracting the disease themselves and high work stress, all of which compounded and resulted in severe anxiety, depression, or even PTSD [70]. | Depression, anxiety, and sleep disturbance are a few mental health disorders that the HIV infected person goes through due to discrimination from society. The healthcare workers near the HIV patient's vicinity sometimes go into a mental breakdown [71]. |
| 7. Policy issues related to socio-economic challenges | As we know, bats, camel, pangolins, and many such animals are the top carriers of the coronavirus, and consumption of these needs to be stopped. Even after the two outbreaks of SARS and MERS and the carriers being known, people have continued consuming these animals [72]. | Transmission of the Ebola virus becomes easier in places with low hygiene standards, mostly seen among those with poor economic or social backgrounds [73]. Economically backward and resource-constrained economies suffered more from the transmission of Ebola than high SES communities. | Poverty, unemployment weakens family, and societal support systems. Lack of participation of the youth in the educational and awareness programs leads to social crises and economic burdens [74]. |

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|---|---|---|---|
| 8. Geographical barriers | Due to fast mutations and the virus being spread through surfaces if touched, there is a possibility of the infection crossing geographic barriers [75]. | During an Ebola outbreak, it was challenging to reach some towns/villages due to its isolation from civilization. It also gets difficult to trace the virus in such cases as dead primates are often found in forests, and the people usually maintain low hygiene [76]. | Rural communities and the individuals in remote areas have difficulties accessing the costly and specialized treatments of HIV provided by the medical care unit [77] [78]. |
| 9. Crises of lost employment | The developing countries owing to overpopulation and limited resources, face more issues with unemployment. The private sectors facing huge losses tend to reduce the workforce, especially the travel & tourism industry [79]. | An already weak economy now affected by Ebola and coronavirus has caused a massive loss in employment - 1 in 2 people are unemployed in Liberia [80]. | The HIV pandemic outbreak affects the people in the peak of their productive, earning, and reproductive stage. The years of productivity are lost, and unemployment grasps the family's backbone [81]. |
| 10. Integration of information & communication | Both the outbreaks were a result of latency in information transparency and proper communication [82]. | Misinformation, fake news, and rumours can have grave consequences amidst viral outbreaks. They can be fear-inducing or fuel social taboos. However, governments and public domain coders always endeavour to rectify it [81]. | Many taboos and facts had gone unchecked, leading to feeding the prejudices and ill-treatments towards the HIV positive patient. [84] |
| 11. Priority setting | Due to the vast number of patients requiring medical help during the SARS outbreak, an increase in the hospitals and medical professionals' strength is needed to treat patients to stop the spread [85]. | Most affected countries also suffer from recurrent famines, terrorism, poverty, and other epidemics co-occurring [86]. In such a situation, it is difficult for the government to prioritize any one grave event over another. | Adequate information, knowledge, and resources are not available to develop an extensive and effective intervention for prioritizing care of critically ill patients [42]. |
| 12. Access to health services for comorbidity treatment | The outpatient treatment capacity, availability of ICU, ventilators, and emergency departments are overwhelming in dealing with a significant pandemic to extend resources for both grave and general illnesses. There is a shortage of medical staff, doctors, nurses, and laboratory technicians other than safety equipment and medicines leading to severe outcomes [87]. | In an already stressed healthcare system, facing Ebola cripples it and makes it unavailable to others who need it. However, in 72% of 90 patients, malaria, and another 2% of 90 patients, diabetes was found as a comorbidity with Ebola [88]. | The outbreak of HIV was usually associated with other disorders like AIDS, pneumonia, depression, alcohol abuse, neurocognitive disorders, cancer, etc. The access to health services for a comorbidity treatment is often blocked by poverty, lack of infrastructure, and expertise in many developing or under-developed areas [89]. |
| 13. Social beliefs & taboos | It has been reported that the survivors and their families were treated poorly and isolated from society even after they have been cured of the disease; in some cases, even the shopkeepers denied to provide daily equipment to the family of former patients [90]. | People often shun survivors of Ebola virus, do not come up for check-up fearing social stigma, or even fear healthcare workers for they are afraid and link them to the spread of Ebola. It made treating and tracing Ebola even more difficult [45]. | HIV has a stretched account of the stigma attached to it, much of which stems from the dearth of knowledge about the ailment and its spread [91]. |

## 4. Strategic Management: Lessons Learned from SARS, MERS, EBOLA & HIV Outbreaks

The growing population in developing economies has led to a shortage of land, inequitable distribution of income, accessibility to reasonable, and good health care. Incessant urbanization has led to the clustering of people in certain cities or states [92]. These cities or zones become hotspots for incubation or the spread of diseases. Similarly, there are villages with remote access to quality healthcare, necessary facilities, or regular communication networks. Taking lessons from the Ebola Viral Disease (EVD) outbreak in Zaire (Congo) and later the fatal second wave in Guinea, Liberia and Sierra Leone spiralling out of control, the lacunas of public health systems at local, the national and international

level have been glaring. The responses from the global health community like WHO and Red Cross Society had also been too little and delayed in the diffusion of medical equipment, masks, medicines, PPE kits for health care workers, ventilators, etc. and adequate monetary fund [93].

In the winter of 2002, SARS was first reported in the Guangdong Province. Due to a lack of awareness and complacency of the government, the infection spread to countries like Toronto, Vietnam, Hong Kong & Singapore [94][95]. WHO issued a global warning around March to alert the general public about the risks of a fast-spreading virus [96] [97]. The governments and International organizations failed to develop public trust due to pneumonia's erratic findings on the lungs. The most vulnerable was that of health personnel due to aerosol droplets remaining in the ward's environment with infected patients. It activated the need for advanced protective measures and cooperation at the international level.

## 4.1. Structured networks for management of public health systems

Stochastic models help in estimating the probable trajectory of the spread of infections in a community based on random variations in one or more inputs. The selection of network models depends upon the population under surveillance and their social behavior. It should also consider how the infection spreads through close physical proximity, transmission through sexual contact, or aerosols. The most common network model is the SIR model, also known as Susceptible-Infectious-Recovered. An appropriate model studies diseases and their context to reduce the spread by various public health measures like community vaccination, testing, and treatment [96].

The two models - "Discrete-Time Model" and "The continuous-time Markovian epidemic on a network" were discussed [98]. The "Discrete-Time Model" randomly selects one case as infectious and considers the remaining population in the network as susceptible. In a specific period (period of spread of infection), most people then fall in either of the categories, i.e., susceptible or infectious. The other model, "The continuous-time Markovian epidemic on a network," differs from the discrete model in taking the latent period between acquiring infections and becoming infectious. It also dynamically covers a time range, without affecting the final size or the last person to get infected [98] [99]. It also discusses the strategic inclusion of individuals with "global contacts" who are at higher risk of spreading infection (super spreaders).

## 4.2. Social awareness programs

Many mathematical models have proved how awareness can change the risk perception followed by specific behavioural changes within a population that reduce their chances of susceptibility. News media, government programs, distribution of pamphlets fosters adherence to various initiatives taken by the public health department. Social networking sites serve as an excellent platform for the collation of all the adequate information about an epidemic and related awareness, thus working upon lowering of incidence rate, increasing the risk perception rate, and, therefore, constraining the sickness [100]. Social distancing norms should be followed strictly. The lessons learned from the outbreaks during the SARS and the MERS needs to be applied to stop any further outbreaks [101].

## 4.3. Testing and treatment

Testing and Treatment of any viral outbreak is included under diagnostic virology. For successful viral detection and isolation, diverse disciplines like microbiology, serology, clinical biochemistry, pathology play an imperative key role. Efficient viral identification is needed to prevent viral transmission, accurate screening of the pathogen, to monitor the response of the treatment provided which leads us to a better pandemic preparedness in the future with an insight on the aspects of resistance to therapy and immune escape profiles that might be due to rapid genetic aberrations in the viral genome. But in most cases, like, for example, during the HIV outbreak, due to lack of risk perception and stigmatization around or more than 60% of the cases were undiagnosed [102].

## 4.4. Identification of high-risk groups

The population at higher risk of getting infected from an already affected person is termed high-risk. Higher risk or vulnerability can be related to factors like the nature of the occupation, socio-economic deprivation, low-risk perception, ethnicity, compromised immunity, and others. Public health care workers, pregnant women, infants, and individuals above 70 years of age fall under high-risk groups. This clear demarcation of the high-risk groups in a population is always used while constructing mathematical models that can be used to develop a healthcare infrastructure strategy for the ongoing outbreak and future lethal pandemics.

Health care workers are always under an ethical obligation to provide safe treatment to the ailing patients, though fully aware that they have a high personal risk of getting infected and passing that onto their family [103][18].

## 4.5. Management of traditional burial practices

Studying local traditions is necessary to understand the dynamics of transmission and, subsequently, control illnesses. They can be brought about by local religious leaders or even the government who should urge safe, hygienic and clean practices - prohibiting/ discouraging large gatherings, usage of gloves, usage of materials that can be quickly disinfected, maintaining constant hand hygiene to not come in contact with any bodily fluids [45][104].

## 4.6. Identification of asymptomatic carriers

Individuals infected by a pathogen or virus but do not manifest any sign or symptom of that infection or disease is termed asymptomatic carriers. They are sufficiently potent of transmitting the disease to a healthy individual, although itself being unaffected. Thus unintentionally participating in public gatherings or public places, they potentially boost the viral transmission cycle and are a dangerous viral source. They might later develop the symptoms but initially serve as a carrier or conveyor of the ailment. They have played a crucial role in the transmission and propagation of viral outbreaks, namely, HIV, influenza, SARS, and MERS. Necessary curbs were placed on air and railway travel to interstate and international destinations to limit citizens' movement [105].

## 4.7. Contact tracing

A close surveillance on the individuals who were in close contact with an infected patient (alive/dead) and providing them with clinical guidance, evaluation to prevent spreading the ailment onto other healthy individuals, since they are potent through intentional/unintentional means, is termed as contact tracing. Systemic assessment and interviewing the people who were in direct/indirect contact with the infected patient is a targeted approach towards intensified pandemic control measures. It involves majorly three steps- contact identification (identifying the high-risk category of the contacts who were in direct or indirect vicinity of the infected person), Contact listing (enlisting the high-risk group of contacts and notifying them on further details of what is to be done consequently and maintenance of social distancing norms), contact follow up ( a competent team of officials keeping a watch on the enlisted contacts, basically following them up for their basic needs, guidance and preventive measures). Immediate evacuation and keeping the potentially infectious contacts under observation for more than 15 days is practiced [106] [107].

## 4.8. Availability of essential services

The government should ensure that the public is provided with the necessary commodities so that they might not face difficulties or travel long distances for their daily needs. Food and water, transportation, banking, healthcare, and other things should be taken care of for public convenience. Essential workers like the medical staff and electric and water suppliers should also be on duty [108]. The vital services also include sanitation items. Lifesaving medicines must be made readily available. The control of the pandemic should not lead to more deaths due to the unavailability of other necessary drugs. These drugs include opioid analgesics, midazolam, diazepam, and others [109].

## 4.9. Patient isolation and care

The separation of patients is vital since they can spread the disease to others. The hospital and the wards having patients should be closed to other patients and should take a limited number of cases that can be treated with proper care, maintaining adequate distance [110]. The patients should not be treated with apathy. They should also have specialists to overcome depression since most patients during a viral outbreak suffer from frustration, anxiety, and depression, mostly in cases of HIV [111]. The patients and the family members should be kept under home quarantine for 14 days.

## 4.10. Environmental measures-regular cleaning of exposed surfaces

The environment plays a significant role in the spread of infections. For example, Ebola might spread due to water pollution, while the SARS and MERS due to the harmful particles present in the air might damage the lungs. In a project taken up by the United Nations, the focus has been made to a One-health approach to stop the spread of the virus from animals to humans. The idea is to keep the environment clean so that the waste from the infected human bodies cannot transfer the infections to the animals, which again moves it to another healthy human. The throwing of domestic wastes in the water bodies needs to be stopped, and there should be proper management of human excreta [112]. A study conducted in Italy found that a high number of cases are directly or indirectly related to air pollution for 71 of its provinces [113].

## 4.11. Data collection and collating for informed research

Establishing and strengthening a global surveillance network for predicting, controlling, and assessing the ongoing outbreak or developing strategies for future viral pandemics [114] [115] is crucial. Data needs to be maintained not just for the public health, but also about the health of the animals closely related to the people daily, for example, cattle, dogs, cats and other animals used for food. Such data might help trace a pathway of the virus and its host (or hosts) [116]. A proper study of food chains or webs is essential. The use of better methods to identify a viral disease should be used. For example, nucleic acid amplification tests (NATs) can be used in place of the antigen-based methods popularly used for the rapid detection of respiratory diseases caused by a virus [117].

## 4.12. Public-private investment in public health research

Dearth of investments in healthcare facilities and infrastructure in developing countries expose them to pandemic outbreaks and thereby scarring psychosocial ethos

of the community. In the case of Ebola, there was a failure to recognize the risk of an epidemic despite previous epidemics both by the global and local communities and an increase in transmission rate. Investment for the development of healthcare systems, both mental and physical, should come in, as it will not only check the spread of this severe epidemic but also stop it from crossing national and international borders and communities. Though some organizations are interested in rebuilding health systems in West Africa, the global community must show commitment to building such health systems that are better prepared for the future [118]. For HIV, however, there has been considerable funding and research curated by major global health initiatives in public health research by organizations like WHO, GFATM, UNAIDS, etc. Even when WHO had declared that the SARS might become a pandemic which it has now in the form of SARS-CoV 2, there weren't enough measures taken, and research was mostly focused on the previously essential subjects. Also, the health care alert wasn't imposed for a longer time. When the pandemic planning was started back in the early 2000s, then a better infrastructure to control a future outbreak was expected but wasn't found, resulting in more deaths due to mutations in the virus genome.

Table 2. Strategies for Early Prevention or Control Management during the Recent Viral Outbreaks

| STRATEGIES/ PLANNING | SARS/MERS | EBOLA | HIV |
|---|---|---|---|
| 1. Structured networks for management of public health systems | This type of approach can be used to target the identification of susceptible individuals and their immediate connections. It will connect more people and help those in remote areas who need it the most. The case history and the travel history of the patients are also critical [119]. | Proven success in the past, example: poliomyelitis epidemic, even for Ebola, an active surveillance and response system will continue to be extremely useful for tackling the illness, more than expenditure on vaccine/medication research and treatment [120]. | Social network-based strategies and interventions are significant to influence communities and populations that are unable to access the health services that combat HIV. It is a cost-effective approach to reach large masses with the correct knowledge and make the services accessible to the needful [121]. |
| 2. Social awareness program | The WHO guidelines must reach the maximum population to educate people about the SARS, the MERS, and other coronaviruses. | Doctors, local health care workers, local leaders should promote awareness and advertisements should also be spread concerning public health and hygiene. | Social awareness programs in coordination with the NGOs, schools impart a strong message towards precautionary measures about the sexually transmitted diseases, AIDS & HIV [122]. |
| 3. Testing & treatment | A regular supply of testing kits and keeping the infected individual into quarantine for a minimum of two weeks is a must. | Constant surveillance by public health workers and government organizations is necessary - They carry out tests on suspected cases and screen the population regularly [123]. | The early testing and treatment intervention approach is the best way to screen the target population, where the diagnosed patients are cured at an early stage so that the spreading can be stopped much earlier [124]. |
| 4. Identification of high-risk groups | The death rate due to such infections is high for children and those above 60. People with weak immunity and damaged lungs face critical problems, while for some, the symptoms might be very tough to be detected [125]. | Lack of infrastructure, reusing needles because of scarcity in villages, unavailability of healthcare centres nearby, etc. affect economically weaker sections the most. Another aspect is the low hygiene standards maintained by these people - the leading cause of transmission [126]. | Epidemiologists have hypothesized that age patterns mostly add up to the transmission of the HIV outbreak. Age targeted intensified treatments, that may be primary or secondary, would yield better results in curbing the root of the problem [127]. |

| | | | |
|---|---|---|---|
| 5. Management of traditional burial practices | There have been several rules related to burial practices that include gloves, proper clothes, masks, and so on. Those making the kits associated with the burial should make sure that the materials should be made of products that can undergo easy disinfection [128]. | Specific and strict regulations are maintained while embalming and post mortem procedures by the morgue attendees. Local religious/cultural leaders should be urged to bring about a change in practices that may unknowingly be the cause of further transmission of the disease [129]. | Disposable gloves, pants, gowns are worn to avoid any contact with the bodily fluids like blood or saliva, which can be responsible for transferring the disease, according to Canadian centre for occupational health and services (CCOHS) |
| 6. Identification of asymptomatic carriers | Although the asymptomatic carriers are known to affect healthy individuals, the effect is weak in most cases [130]. The carriers still can transmit the infection through sputum since it spreads through mucus. | Ebola is a severe illness, and till now, no study has been able to prove the existence of an asymptomatic patient [131]. | The asymptomatic carrier stage is the most vulnerable in an HIV positive patient showing clinical latency, which can even last up to 10yrs in some patients. They are highly potent in transferring the viral infection to a healthy person through the virus is present in an inactivated state [132]. |
| 7. Contact tracing | All the individuals in physical contact with the patient during the incubation time were traced to isolate them and stop any further spread of infections. Through mathematical models, epidemiological and intervention parameters were studied to identify the susceptible individuals [19]. | The measure used to trace and identify those that have been in contact with the patient through mobile health tools helped reduce the risk of transmission in the population. Although a useful measure, its success ultimately depends on the trust developed between authorities and the public lest they interfere or block the work out of fear [133]. | It offers the healthcare system to reach the patients that are likely to be affected for faster testing and clinical counselling without further transmission. From that list, the vulnerable persons who were at a chance of getting infected through the transfer of bodily fluids or unprotected sex will be monitored [134]. |
| 8. Availability of essential services | Essential services include proper food, medicines, and other daily necessities that should be available regularly at multiple outlets to avoid crowds. A steady supply of essentials at doorsteps was maintained to support people under isolation and quarantine [135]. | It is difficult for people to get adequate food or essentials in places that are severely affected; hence the government should look to it. Currently, several organizations like the WHO and UNWEP are working towards this goal [136]. | HIV positive patients do not require strict isolation and quarantine precautions. Thus the availability of essential services must be provided without any stigma or discrimination. [137]. |
| 9. Patient isolation & care | The patient and family members are kept in complete isolation. The real treatment is still unknown, and the virus can cause multiple-organ failure, so existing procedures are based on vital signs and symptoms [138]. | Three-pronged strategies were used. The patients were isolated, and protective equipment was provided to health workers and members of the Red Cross Society. The patient was educated to take ample precautions for themselves and their family [139]. | Body substance isolation (BSI) is also taken care of, i.e., no bodily fluids are allowed to contaminate the premises regardless of the patient being suspected confirmed being HIV positive [140]. |
| 10. Environmental measures-regular cleaning of exposed surfaces | Disinfecting of the surfaces exposed should be done, and proper hygiene should be maintained to stay healthy against the virus [141]. SARS or MERS both may shed on to the dry surface and contaminate patients' or caregivers' hands. | Some scholars have detected the presence of Ebola virus strains in the environment around patient wards. However, they were yet to determine if they were virulent and infectious. They encourage the usage of PPEs and their proper disposal [142]. | Environmental pollution and degradation in the quality of air and water can bring upon air or water-borne ailments in HIV positive patients, thus making them susceptible to opportunistic pathogens [143] |

| | | | |
|---|---|---|---|
| 11. Data collection and collating for informed research | The current situation of the global pandemic shows that lessons of timely disseminating crucial information were not followed. However, measures related to patient isolation and quarantine, use of PPE kits were followed [144]. | One of the most important aspects of dealing with an outbreak that is followed by doctors and scientists alike to trace the origin of the disease, collect samples, study patients carefully, and their culture and environment as well [145]. | The goal is to reduce the number of deaths every year fewer than 500,000 by approximately 2020. The data systems must keep the clinical report documents at a patient level, build and promote an environment of quality assessment. [146]. |
| 12. Public-private investment in public health research | The "One Health" concept focuses on healthy, cyclical growth of the environment, animals, and humans. This approach was suggested during SARS/ MERs pandemic when the suspect virus was caused due to animal mutations. At the international level, socioeconomic investment is needed for regular monitoring and timely response to any such outbreaks [147]. | International communities need to invest, send volunteers, and help African countries cope with the disaster they're facing in combating the disease, train their locals, and increase their skilled resources [148]. | Major Global health initiative has curated increased capital collection, resource drives, and social awareness programs for the HIV outbreak. The scaling up of public health research has been working to overcome the equity concerns regarding the accessibility of health care to the most vulnerable and marginalized section of the society [149][150]. |

## 5. Limitations in public health management

Often people fail to maintain proper hygienic conditions, mostly from the overpopulated developing countries. So, population control measures should also be maintained so that the government and the healthcare centres can take proper care of the individuals. Any communicable disease requires necessary steps to be taken while handling a patient. These measures are often ignored, and reusing medical equipment meant for one-day use, and improper disposal leads to more affected individuals.

Preparation for any pandemic is a responsibility that involves multiple collaborators, sectors, and different strata of the final public. Training and skill among all stakeholders must be undertaken transparently and comprehensively, to certify equitable & impartial allocation and optimally benefit from regular supplies of antiviral drugs and vaccines. Rising infection toll may disturb essential services across all sectors of the globe, and healthcare amenities are also besieged with gravely ailing patients. Unless healthcare workers are protected, they'll suffer disproportionately, which could lead to shortages of trained healthcare professionals and aggravate the risk.

The limitations of funds are also a significant barrier. The economic conditions worsen during these times, but the maintenance of healthcare systems and proper monitoring is much required to fight against the disease. In the developing countries, the problem is worse since the number of citizens depending on the government for help is enormous. Proper distribution of funds is too important since, to provide one facility, the other cannot be put to danger. Thus, the challenges during pandemic situations are many, which need both time and human resources. Any warning regarding a pandemic situation should never be ignored, and socio-economic infrastructure should be equipped to deal with them.

There is an urgent need to distribute the workload among the district and state levels of government. We often find a clash of ideas and rules imposed on the citizens by different government bodies. The services to be provided and the care given should be appropriately distributed among the district, community, and personal levels. There are techniques to avail of the local government's facilities while following the terms of the national government. Not just on a national level but also steps should be taken from international levels. All the countries and their governments should join hands in making policies to fight against a common enemy, the virus, since it does not just harm the systems of a state in particular, but other countries related to it in trade and commerce as well.

## 6. Conclusion

The world is grappling with fears of COVID 19 pandemic since late 2019. It is a universal consensus to develop national repositories for multiple types of meaningful data to provide timely public health support. A hybrid multiscale proposition consisting of timely and accurate data from various localities, including communities with different social practices, will enable the development of dynamic mathematical models. With an example of the Ebola Virus (EBOV), the results suggested that the age & structure of the population, the distribution patterns & the mobility rate of individuals can be understood through

appropriate network generated models. These probabilistic algorithm models support the governments with a new and structured vigilance system to control the outbreak with minimum loss. Identification of high-risk individuals among the community is crucial for control measures. A better realization and understanding of asymptomatic carriers is imperative towards pandemic preparedness and the public healthcare sector to mitigate the viral outbreak by designing the exact transmission routes.

A systematic method of collecting data, collating it, and later analysing for public health surveillance is instrumental for diffusing critical information through media and social networks. Engaging communities for management of viral outbreaks is one of the predictors in the successful handling and planning of 360-degree national health and safety policies committed at the rural and urban levels. An arrangement of social awareness drives on susceptible viral diseases (offline or on social media) does not only lower the rate of incidence of the ailment instead prevent it from turning into a global outbreak. Cooperation, coordination, and communication among states and centre through multiple channels at regular intervals are required. States have to depend upon the centre for fair sharing of knowledge and resources.

In contrast, central systems rely on the local, district level, and thereby state authorities for reliable and timely data sharing. Various modes of transport and accessible traveling facilities have led to the surge of viruses at an unfathomable rate. These diseases do not respect economic growth or geopolitical barriers. Many such viral outbreaks can also be directly or indirectly linked to the environment. Thus, the maintenance of the environment is highly essential. It has become evident that diseases like Coronavirus, SARS, MERS, Ebola, etc. require fast track public health systems with the sharing of knowledge and scientific progress at the international level.

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