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The Role of Smart Technology in managing Infectious Diseases in the Developing World. The Case of Covid-19 Pandemic in Kigali City - Rwanda

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Abstract

This study examines the effectiveness of smart technology in managing the Covid-19 pandemic in Kigali City - Rwanda. Data were collected through interviews by the use of structured questionnaires addressed to 4 administrative officers in the health sector. Also, 32 out 96 residents were randomly selected in each district. Results have shown that Drones (UAVs) were more used by 95% as opposed to Robots and cameras to warn and inform the community to take precautions. In addition, they were used to distribute medical items whereby 500,000 face masks and 1,000,000 gloves were distributed. Also, 43,379 blood samples were collected; other light medical equipment were transported by drones within the city within a period of 3 months saving 158 out of 287 people who had been affected. Limited finance, lack of qualified and skilled personnel to operate drones and robots during these times jeopardized the effectiveness of smart technology. We conclude that the use of smart technology should be a national agenda to improve management of pandemics. This aligns with training of community to handle health crisis during and even after the Covid-19 pandemic. Also, the establishment of the department for innovative ideas to fight current and future pandemics is inevitable.

Keywords: Smart Technology; Covid-19; Developing World; Kigali City

1. Introduction and literature review

Infectious diseases have a long history in human lives and have caused serious fatalities. One of the first known recorded pandemics is the Plague in 542 CE which occurred in the 14th century and claimed millions of lives and the Black Death (McNeill, 1998). Another in the list was Smallpox that killed people in numbers that exceeded those of any who have fought in wars in history. To this date, however, Smallpox is the only disease that human beings have been able to eradicate completely. In the 19th century, Cholera erupted and it remains a concern and still does not have a complete cure (Seshaiyer and McNeely, 2020).

Although the foregoing infectious diseases impacted several million people, it was not until the 1918 influenza pandemic and it forms one of the greatest "natural disasters" in the 20th century infectious diseases with a death count estimated to be more than 50 million (ibid). The unexpected urgent rapid spread of global novel H1N1influenza Virus has created the tensions and confusion on the explanation of the Word "Pandemic" since early 2009 (Morens et al., 2020). Following this disaster, several countries and leading organizations increased funding and attention to finding cures for infectious diseases in the form of vaccines and medicines - particularly for those diseases that are

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categorized as re-emerging infections, those that are spread through sexual transmission such as HIV, those that are spread through vectors such as mosquitoes such as Malaria or Dengue, those that can spread through both sexual and vector transmissions such as Zika, and those which can be spread by viruses, including SARS and MERS (Seshaiyer and McNeely, 2020).

Currently, Coronavirus is considered to be the third Pandemic in 21st Century which is among the highly transmissible disease portends worldwide human living. This virus has connection with Wuhan Seafood market in China during the unknown pathogen was discovered by hospitals among a group of Covid-19 patients who are familiar to pneumonia. Originally it was pointed out that patients affected by coronavirus might have been in Wuhan, the place where animals are sold. Finally, Chinese researchers discovered human to human transmissible virus before naming the novel virus Wuhan or 2019 novel Coronavirus or simply the 2019 nCoV (Prasetyo et al., 2020).

The Covid-19 is, however, categorized as a super-spreader based on the disproportionately fast rate and large (and growing) number of infected persons. For example, data from the SARS outbreak in 2003 showed a spread rate from one to three people on an average, while the super-spreader Covid-19 can spread from one to more than 10 people (Trafton, 2020). Furthermore, Seshaiyer and McNeely (2020) note that not only the pandemic spreads quickly having already resulted in at least 3.5 million cases across the world and over 250,000 deaths, it has also impacted the economy, education, workforce, and much more, pointing to its significance for broader questions of sustainable development and societal well-being at a global level.

Fighting pandemics is not a new initiative in the world since the eruption of such pandemics. Although effective interventions have occurred for some priority health problems, overall progress towards quality health care for all remains slow. While there has been an increasing consensus that stronger healthcare systems are needed to achieve improved health and wellbeing, little agreement exists on how to strengthen healthcare systems. In the period of 2000-2015, the United Nations (UN) declared Millennium Development Goals, which attempted to address the importance of basic healthcare coverage (Travis et al., 2004). Moreover, the subsequent 2030 agenda for sustainable development goals (SDGs), established by the UN in 2016, explicitly identified good health improvement and attainment as both an outcome and indicator of progress for the success of the 2030 agenda as a whole (Sachs, 2012; WHO, 2015). The third in the list of seventeen SDGs, "Good Health and Well-Being" (SDG-3) refers to the critical need to "ensure healthy lives and promote well-being for all" for global sustainability and development (UN, 2020). As such, the Covid-19 pandemic is a particular and immediate concern with regard to SDG-3, with implications for all of the SDGs (Seshaiyer and McNeely, 2020). Following the eruption of Covid-19 pandemic, WHO provided guidance on how to control and manage the quick spread of the disease which include hand washing, the use of face masks, gloves and social distancing. However, many countries have devised their own ways of detecting the infections and controlling them. This paper investigates how Rwanda in its capital city, Kigali, has used Smart Technology in managing the Covid-19 pandemic.

The smart city concept is currently been a pronounced tool to enhance the potential city-level governance systems due to the rapidly growing urban population (Kummitha and Crutzen, 2017; Lee and Lee, 2014). Concerning governance of smart cities, Kummitha (2018) argues that the level of technology adoption is determined either by the technology or by human driven approach which cities adopt. While the techno-driven approach refers to the enhanced use of technologies largely using a top-down method in which governments enforce technologies on cities and citizens, the human driven approach refers to educating and enhancing the potential of communities that help create and promote their own technologies based on the local needs. For the last decade, Europe, North America and China have engaged in transforming their cities into smart cities. Since the identification of the cause of the outbreak of Covid-19 in late 2019 and its pandemic designation in March 2020, research and development activities have been evolving into a broader understanding of the epidemiology of the novel coronavirus as a "super-spreader" of infectious disease. Along with these efforts, several pharmaceutical and non-pharmaceutical interventions for infection prevention and control have been recommended by major health agencies, such as the World Health Organization (WHO) and United States Centers for Disease Control and Prevention (CDC) to mitigate the morbidity and mortality associated with Covid-19 (McNeely and Seshaiyer, 2020). In this paper Chinese Cities are used to underscore how smart technologies have helped control the spread and infection of the Covid-19 pandemic.

1.1 Smart Technology against Covid - 19 in China

The interest in the use of smart technologies in China for governance dates back in the early 2000s when the overall shift in the country's innovation policy began due to rapid urban population (Liu et al., 2011; Ling and Naughton, 2016). For instance, in 2015, the urban population in China accounted for 56% of the total population and given the improved living standards and new employments opportunities in cities, it is expected to increase exponentially in the next two decades to 76% (Wu et al.,2018). In response to the growing population, China has taken an active role building smart cities where technologies have been used significantly to aid urban governance. Mak (2020) estimates that there are about 500 world – class smart cities present in China, Wuhan City being the most affected in the current Covid-19 outbreak. China stated its commitment to building smart cities in the 12th Five-Year Plan published in 2010 which set up a blueprint for the socio, economic and political goals for the next Five Years. The National New Urbanization Plan which came into effect in 2014 and the latest in 2020 has largely taken charge of constructing new smart cities and remodeling existing ones into smart cities (Zhu et al., 2019). In addition, the former premier of China, Li Keqiang, emphasized that smart city and smart technologies are the two major priorities in the development of the country in 2015. The 13th Five-Year Plan takes the smart cities vision even more seriously with the aim of not only promoting them but also creating inter-city infrastructure and partnership building (Dameri et al., 2019).

2. Methods, techniques, studied material and area descriptions

2.1 Overview of the study area

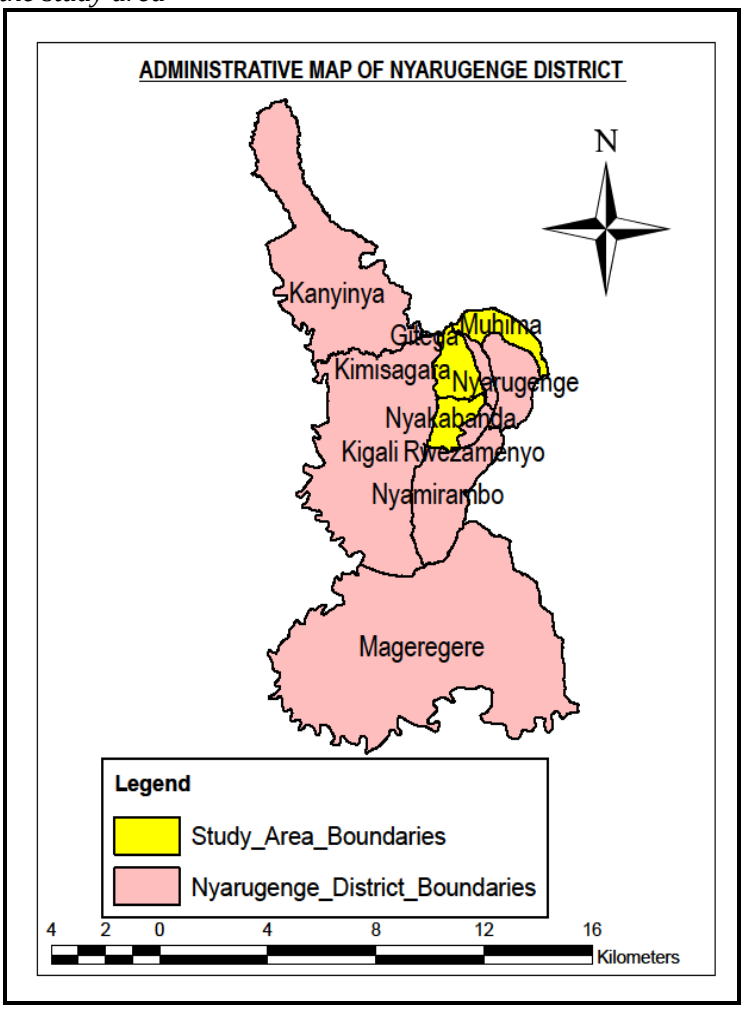

Figure 1: Location Map of Study Area
Source: Author, 2020

Rwanda is facing rapid urbanization and development after 1994 Genocide happened against Tutsi. The City of Kigali, being the main capital of Rwanda and the leading city among Rwandan cities, is also having outstanding changes in terms of infrastructure including technological innovations. These activities are mostly done especially in business areas, construction of new buildings for offices, industrial and tourism areas. All these together conform with the policy of clean city where the city of Kigali is ranking the first cleanest city in Africa. During colonial period the city of Kigali grew slowly where it had only 6,000 inhabitants congested only on a small area of 2.5 km^2 at the top of Nyarugenge hill during 1962. Currently, the city of Kigali is the biggest urban cluster of the country whereby in 2012 it had only 1,132,686 people living in the city. According to NSR of 2012 and 2018 the population of Kigali increased up to 1,631,657 in 2017 over the area of 730 km^2. Therefore, Kigali city is one of the five provinces located in the middle part of the country between 29°44'0''E longitude and 29° 43'0'' latitude. Additionally, the city of Kigali is subdivided into different administrative entities established in 2005; provinces (Intara), districts (Uturere), sectors (Umurenge), cells (Akagali) and villages (Umudugudu). Thus, Kigali is placed at a provincial level and it is divided into three districts namely Nyarugenge, Gasabo and Kicukiro. These districts are further divided into 35 sectors while the sectors are also divided into 161 cells and 1,061 villages (Manirakiza et al., 2019). Fig. 1 shows the selected research study area in Nyarugenge district within Kigali city which are Nyakabanda, Muhima and Kimisagara.

2.2 Data collection procedures and analysis

Based on the objectives of this study which is to explore the use of smart technology in the fight of Covid -19 and challenges faced throughout the use of this emerging technology, we used field observations, 32 structured questionnaires and four (4) formal interviews. While field observations aided collection of primary data especially live events particularly on how this technology is physically used to help combat Covid-19, structured questionnaires and formal interviews helped to acquire community points of view on the use of this emerging technology to control and manage the Covid-19 pandemic. In fact, data collection from field observations were intended to support primary data obtained during both formal interview and structure questionnaire. These worked out while gathering data from different smart technologies which were applied during the pandemic in Kigali City. Questionnaires were composed of both open and closed questions administered to Kigali City residents in the three Sectors of Nyakabanda, Muhima and Kimisagara and four (4) Officials in the Rwanda Biomedical Centre (RBC). Regarding ethical issues, considerations were made at each stage in the data collection process. It is for this regard that all Kigali city residents were briefed concerning the objective of the study and confidentiality of their answers before the start of data collection. Additionally, community participation in this research was voluntary; no one was forced to answer questions.

Qualitative data were analyzed by generating themes through SPSS and Excel while quantitative data were analyzed by using statistical tools to generate %ages and frequencies.

3. Results

3.1 Socio-demographic characteristics of respondents

Results which were obtained from the field revealed that with the study area had people with different backgrounds in terms of their sex, age, marital status, education level and occupation as presented in Fig. 2. Based on their sex, 69% of those who were interviewed were females while males made 31% of the people who were interviewed. Out of these people, 78% were married and the rest 22% were single. In terms of age, the largest group made 42% of the total population had between 39 and 48 years while the smallest group had people with under below 18 years making 6% of the total population. Closely tracked by the largest and smallest groups was those people who had more than 48 years (about 23% of the total population) and a group of people with 19 to 28 years of age (10% of the total population) respectively. Moreover, 19% of all people in the study area had between 29 and 38 years. Education wise, field results have indicated that majority of people (47% of the total population had secondary education, 27% had primary school education, 17% had university education and only 9% had not attained any formal education. These results indicate, therefore, that those who

participated in this research were able to give their opinions and had sufficient knowledge of the prevailing Covid- 19 pandemic and how smart technology was used to tackle and manage the disease. According to their occupations the private sector employed more people than any other sector for 57% of people in the study area are employed by the private sector especially as drivers while public employees made 28%. Other people were employed in the service sector especially food shoe makers and repair and hairdressers who comprise 7%. Above all, 5% declared to have not been employed in any category while students made 5% of all people in the study area.

S/N	Variable	Category	Frequency	% (%)	Total
1	Sex	Female	69	69	100
		Male	31	31	
2	Marital Status	Married	78	78	100
		Single	22	22	
3	Age	Under 18	6	6	100
		19-28	10	10	
		29-38	19	19	
		39-48	42	42	
		48 above	23	23	
4	Occupation	Public employees	28	28	100
		Students	3	3	
		Unemployed	5	5	
		Service Sector (Shoe makers, Hairdressing)	7	7	
		Private Sector (Drivers etc...)	57	57	
5	Education Level	None	9	9	100
		Primary Education	27	27	
		Secondary Education	47	47	
		University Education	17	17	

Figure 2: Background Characteristics of the study participants
Source: Fieldwork, 2020

3.2 The Discovery of Covid-19 pandemic in Kigali City

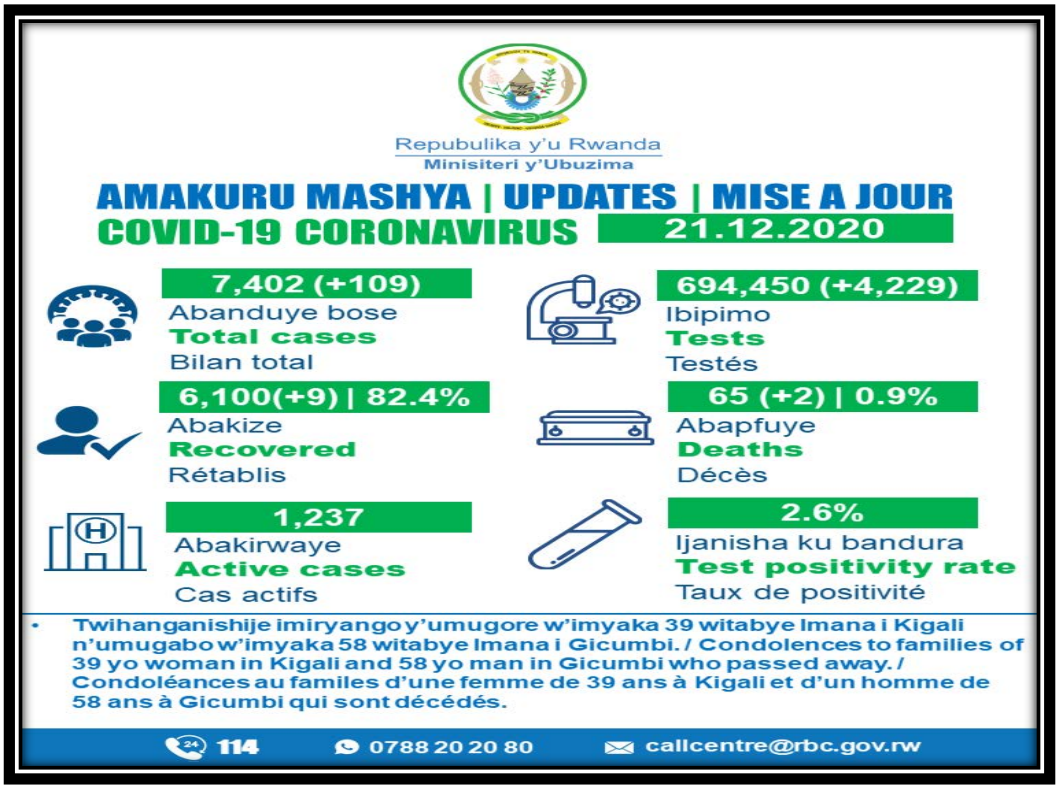

Figure 3: Rwanda Covid - 19 Updates Sheet
Source: Rwanda Ministry of Health, 2020

According to the Rwandan Ministry of Health (MOH), the country confirmed the first case of Coronavirus from an Indian person who landed in Kigali City from Mumbai –India on 8th March 2020. During his arrival, the victim had no symptoms but he had to report himself to the health facility on the 13th December. This brought Rwanda to 19th country in Africa to report the presence of Coronavirus. Therefore, since that time until now coronavirus has spread in the entire country and the country has, since then, been taking measures of fighting the pandemic. The situation increased to be worse as days went in and out in as Fig. 3 represents. As it can be seen from the Figure, the number of deaths reached 67 by December 2020 while the affected people by Covid-19 that time were 7,511 and 6,109 people recovered out of 694,450 tested persons. These tests were taken in some of the areas in the city of Kigali.

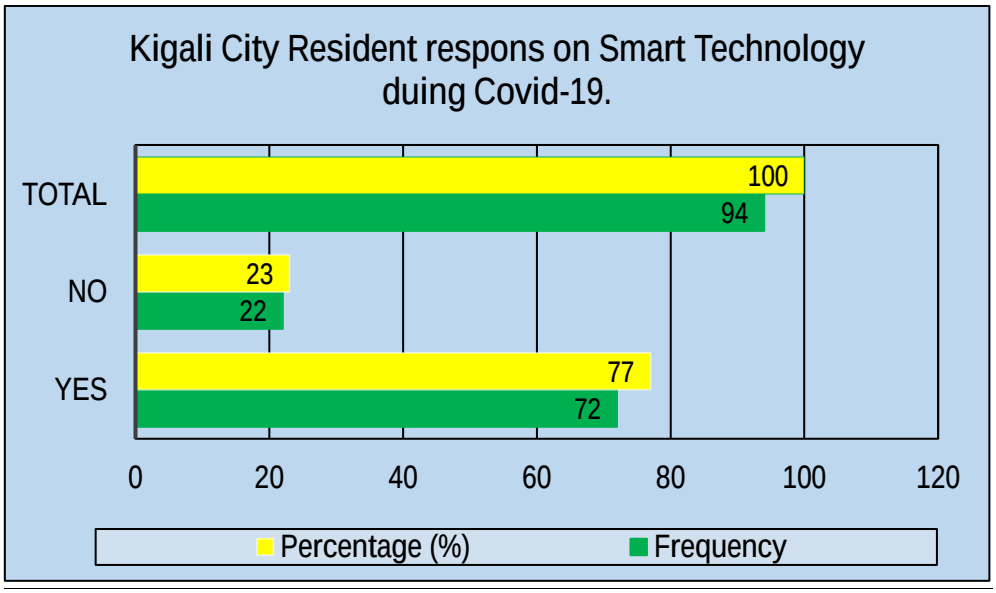

Figure 4: Resident Opinion on using Smart Technology to fight Covid-19
Source: Field work, 2020

4. Smart technologies used to fight Covid-19 in Kigali city

4.1 Drone Technology (UAVs)

Drone technology is among the emerging technologies which had a big impact in community as well as in the development and disaster risk management. its importance and popularity came into the fore during Covid - 19 era and lockdowns in Rwanda. Results from official interviews with the Ministry of Health and police officers revealed that 95% of all the efforts to combat the pandemic were directed on the use of Drones. In this regard, the Ministry of Health and the Rwandan National Police (see Fig. 5) with the help of Charis UAVs Drone Company in Rwanda started to monitor lockdown situation as well as community awareness of the pandemic. Since drones have the capability to fly a large space and deliver message compared to tradition methods, for instance, the use of cars while people use PA systems (the use of microphones or megaphones), had a substantial contribution to enable the community prevent themselves from and fight against the Covid - 19 pandemic. Apart from the Charis UAVs, the Zip line Rwanda which participated in this event also had a great contribution in the delivery of light medical materials to those people who were affected by Covid – 19. The service was further extended to other places and in hospitals like at the Cancer Hospital in Northern Province to deliver medicines because during these times people couldn't travel from one place to the other. These imply that Drones were very useful and helpful to save peoples' lives in Rwanda as it also applied in other countries in Africa, Asia, Europe and America.

Figure 5: Police Officers during the launch of Drones on Covid-19 Preservative measures
Source: The New Times, 2020

4.2 The use of Robots during Covid - 19

In further attempts to fight against the pademic, the country of Rwanda luanched anti-epidemic Robots to increase the fight of Covid-19 especially in treatment centers especially for the delivery of food and medecines to patients (see Fig. 6). It was on 19th May, 2020 where these high technology robots were launched at Kanyinya Covid - 19 treatment centre in partnership with Ministry of ICT and Inovation of Rwanda, Rwandan Ministry of Health and the United Nations Development Programme Rwanda (UNDP). These high technology Robots were manufactured by Zora Bots which is the company specialized in Bots solutions in Belgium.

Figure 6: Launching the anti-epidemic Robots to boost the fight against Covid-19
Source: Rwanda Ministry of Health,2020

Based on various advanced features of these robots, they helped medical doctors and nurses to monitor, manage and control patients' temperature, screening and keeping all Covid - 19 patients medical information. For better management and identification of these robots, they were given names including Urumuri, Ngabo, Ikizere, Mwiza and Akazuba. The delivery of food and medecines to patients was not only made in hospitals but also in other places like hotels where people locked themselves or they were locked down by the government or relatives for the sake of not spreading the disease beyond those who had been affected. On the case of deliveries in hotels, the arrangement based on the financial capacity of the owner of the hotel to buy a robot or the customer to hire it from the owner. These robots have capacility to serve between 50 to 150 people per minute. The robots are also capable of capturing data and inform officials on detected abnomalies for better case management as well as timely responses. This increased effeciency during the fight against Covid - 19 and minimized time for health workers being exposed to Covid- 19 patients or infections.

4.3 Thermal fever detection cameras at the airport

The cameras are mounted on the ceiling at the Kigali International Airport and they are particularly used during passengers' arrival and departure to scan and detect fever as Fig. 7 clearly illustrates. After screening, travelers go for Covid-19 test at Covid-19 test center to facilitate or speed up Covid-19 testing. Social distancing marks are also provided to direct passengers where they must stand while waiting others from checking in and out. Notebooks are used to record travelers' information during their arrival and departure in order to make sure that each traveler's information is recorded to avoid any Covid -19 cases which might enter through the airport. Results normally are received at designated hotels booked by passengers before their arrival at Kigali International airport.

Figure 7: Fever Detection at the Airport
Source: Field work, 2020

4.4 Road, social distancing and bus cameras

Some CCTV cameras are mounted on selected roads within the city as postulated on Fig. 8 to monitor the traffic situation. During Covid - 19 era these cameras also helped to monitor and control community social distancing on the road particularly displaying those who put on and off face masks. Similarly, cameras were installed in the buses. Basically, before the pandemic these cameras were used to monitor rear door passengers, cabs and drivers, rear road and front door passengers as well. But during Covid -19 these cameras contributed a lot where drivers were able to monitor social distancing in the buses and be in better positions to know who wanted to board or get off the bus and automatically open bus doors as opposed to manual operations of doors. This really nailed the concept of smart city where most of urban areas in the near future will be installed cameras on the road, buses

and buildings to monitor and give real time information in case needed or to solve city or neighborhood problems.

Figure 8: Community social distancing on roads and in buses
Source: Fieldwork, 2020 Source: Taarifa, 2020

4.5 Residents opinions on the use of smart technology

Based on Kigali City's residents' opinion on how smart technology solutions are helping in the fight against Covid-19 pandemic in the three sectors which are Nyakabanda, Muhima and Kimisagara, 74 out of 96 respondents (nearly 77%) acknowledged that the emerging technology like the use of Drones and Robots had a huge contribution in the health sector during the pandemic as it helped health workers combat this pandemic. In this regard, during household interviews, 90 out of 96 respondents (about 94%) said that the current technology was useful during the pandemic and they opined that the technology must be adopted in other sectors like agriculture, construction and education. Fig. 4 clearly shows the percentage and number of respondents who were in favour or against the application of smart technology in controlling the spread of Covid – 19 and their ideas on whether there is a need to upscale the adoption and application of smart technology in other sectors. They thence, had an opinion the adoption and application of smart technology especially the use of drones in agriculture will help farmers increase their production while monitoring their crops for future better food production.

5. Discussion

The role of smart technology in managing infectious disease in Kigali city complied with the WHO's recommendation to identify, isolate and quarantine those who are infected (WHO, 2020b).

Like in Chinese cities which were affected by the Covid – 19 pandemic, the Kigali experience shows same traits based on a techno-driven perspective where its well established technological ecosystem has been mobilized to impose technological solutions (see also Hu and Zheng, 2020).

Field results from Kigali have generally shown that drones were largely used than robots and other means of controlling the pandemic. They have also revealed how smart technology had positive impact to minimize, control and manage the Covid – 19 as it also had impacts in developed countries including Wuhan city in China, where the genesis of the virus stems from, as well as in other Asia and European countries. Andrelini (2019) and Kummitha (2020) acknowledge that China made use of its well-established surveillance system and placed cities under complete quarantine using a draconian approach to control the spread of the virus particularly serious investments in identifying infected patients.

To cement on the importance of cameras to monitor the pandemic, Shenzhen smart city had 159 cameras per every 1,000 residents, while the Shanghai smart city installed 113 cameras, the Tianjin smart city with 93, and the Jinan smart city with 73 cameras, all per every 1,000 people (Kummitha, 2020). Concerning the installation of cameras at the airport, in buses and hotels for controlling social distancing, Kharpal (2020) emphasizes that during the quarantine in China, the government even installed CCTV cameras on apartment doors to ensure that residents would not leave their quarantined houses. Some of these cameras include AI technology and facial recognition to identify people who were infected with the coronavirus (Keegan, 2019).

Moreover, the Kigali experience has not shown the use of apps as they are being used in China particularly the Alipay and WeChat and have become popular in China, helping the government to track down those who are infected (Kupfesrchmidt and Cohen, 2020). Such an approach allows citizens to voluntarily come forward to communicate their health data and download dedicated mobile apps to share their health updates and location histories (Kummitha, 2020). In the same line of thought, the Rwandan government has not started using mobile apps as a way of communicating news related to the Covid – 19 pandemic to its citizens as opposed to Chinese and the Western democracies governments. Failure to use multiple technologies might have contributed to the speed at which the pandemic still affects the country and its citizens as a whole taking into account the number of cases in the study area. In this regard, concerning the use of mobile apps by the governments as a tool to control the pandemic, Hollands (2008) and Komninos (2008) provide that in the Western democracies smart technologies (mobile apps inclusive) are used by governments to inform decisions and to find ways in which problems can be addressed. Also, while these countries have freely shared the data about the virus transmission and allowed everyone aware about the growing trends, China has been accused of concealing information from public and international community (Kummitha, 2020).

6. Conclusion and recommendations

This research which aimed at exploring the role of smart technology in managing and controlling infectious diseases, particularly the Covid – 19 pandemic, in developing countries especially in Kigali City. Basing on the results presented, we conclude that the use of emerging or smart technology has been very instrumental in the struggle to fight against the pandemic. While the drones are largely used in the struggle, other technologies especially the use of robots and detections cameras are pivotal. The challenge which emerges is the availability of qualified personnel to operate and apply these technologies. Moreover, other contemporary and easy to apply technologies especially mobile apps which may be used by the government to inform its people about the spread have never put into practice in Rwanda. This makes it difficult for citizens to get current information about the pandemic, making them respond or find solutions later than it would be if they had prior information. Above all, Rwanda has not established formal structures and instruments to mainstream the adoption and application of smart technology in the country. As such, it lacks qualified professionals to spearhead smart technology and link it to the citizens.

Basing on these conclusions we argue that for better controlling and managing infectious diseases and pandemic threats, *first*, the adoption and application of smart technology must be a national agenda. This will also include the application of mobile apps so that the government can use them to collect data about the pandemic and actively share the information with its citizens. This will not only apply to controlling and managing pandemics like Covid -19 but any other type of pandemic which

might arise after coronavirus and also in various sectors such as agriculture. *Secondly,* the establishment of department in charge of innovative ideas to fight current and future pandemic is inevitable. This goes hand in hand with training the community to solve health crisis during and even after Covid-19 pandemic. *Lastly,* in order to speed the implementation of the Smart City Concept, the establishment of the institution in charge of financial assistance during pandemics like Covid - 19 is highly recommended.

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