Exploring the Current and Future Role of ICTS in HIV/AIDS Intervention Programs in South Africa

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***Abstract*--At 10.0% of the population in 2013, South Africa has the highest percentage of people living with the HIV/AIDS virus in the world, with the total number of people living with the HIV/AIDS virus in South Africa estimated at 5.63 million. Although the mortality rate of the epidemic is on a steady decline, the HIV/AIDS epidemic has adverse impacts on the socio-economic development status and human capital of South Africa.**

The key aim of this article is to gain a thorough understanding of the potential benefits of employing Information and Communication Technologies (ICTs) in HIV/AIDS intervention programmes. We review the status quo of the implementation of such technologies for selected interventions in the Service Delivery and Care HIV/AIDS value chain and provide suggestions made by ICT specialists on how activities along the HIV value chain can be strengthened through ICTs.

Quantitative and qualitative data was gathered to conduct this study. A survey was completed by managers of 20 HIV/AIDS intervention programmes followed up by semi-structured in-depth interviews with these respondents. A further 5 in-depth interviews were conducted with experts in the ICT area for exploring how ICTS can be used to strengthen activities along the HIV/AIDS value chain.

Through the research we discovered that the level of ICT implementation in HIV/AIDS programmes are still nascent due to the existence of some infrastructural barriers, inadequate access to funding, inadequate ICT implementation policies, governance and structures and a low level of maturity of the country's eHealth system.

I. INTRODUCTION

The severe effect of the HIV/AIDS (Human Immunodeficiency Virus/Acquired Immuno Deficiency Syndrome) epidemic is a prominent global health concern. The prevalence of the HIV/AIDS epidemic in South Africa is at an alarming level. South Africa is believed to have the highest percentage of people living with the virus worldwide, with 10.6% of people living with the disease.

As far as HIV prevalence is concerned, table 1 above illustrates that there is a slight increase in the prevalence rate of the adult population in South Africa, from 15.2% in 2006 to 15.9% in 2013. The devastating effect of the HIV/AIDS epidemic is not only evident on the reduced life expectancy of the country but also on the country's economy and on the human capital of the country [1], [2], [3]

The HIV/AIDS epidemic in South Africa is entwined with the unequal terms and circuits on which power, opportunity, value, and authority are distributed [4]. The driving factors of the HIV/AIDS epidemic in South Africa are embroiled in the development route that shaped the country [4]. Therefore, the difficulties and opportunities in South Africa's fight against the disease can be viewed from the political context, healthcare context, and the technological context:

Political context

The role and contribution of the political context in the fight against the HIV/AIDS epidemic is evident in the "Denialism" in the 1990s [4], poor management of the pandemic on the governmental level, [5], misconceptions of the benefits of the ARV treatment and the resultant undermining of ARV rollout [5], and inequality in the distribution of power, inequality in authority [4].

TABLE 1: HIV PREVALENCE ESTIMATE AND THE NUMBER OF PEOPLE IN SOUTH AFRICA LIVING WITH HIV 2002 – 2013

Year	Prevalence				Incidence Adult 15 – 49 (millions)	Total population (millions)
	Women 15-49 (%)	Adult 15-49 (%)	Youth 15–24 (%)	Total population (%)		
2002	15.9	15.1	13.6	8.7	1.26	4.00
2003	16.0	15.1	12.8	8.9	1.25	4.10
2004	16.1	15.1	12.0	8.9	1.28	4.18
2005	16.2	15.1	11.4	9.0	1.32	4.25
2006	16.4	15.2	10.9	9.1	1.29	4.34
2007	16.5	15.3	10.5	9.2	1.21	4.46
2008	16.7	15.4	10.1	9.3	1.12	4.59
2009	16.9	15.5	9.7	9.5	1.03	4.74
2010	17.1	15.6	9.3	9.6	0.98	4.88
2011	17.2	15.7	9.0	9.8	0.95	5.01
2012	17.3	15.8	8.7	9.9	0.87	5.13
2013	17.4	15.9	8.5	10.0	0.85	5.26

(Source: adapted from Stats SA, 2013)

Social and Economic context

The role of the socio – economic context in the surge in the epidemic's prevalence rate is seen in the following factors:

- High unemployment rate and endemic poverty [6]
- Inequality in opportunity and value due to low levels of education and poor service delivery in municipalities outside large centres contributes to inequalities [6]
- HIV/AIDS is highly stigmatised [6], [7]
- Historically insufficient funding was made available to address the epidemic [6], [8]
- Fragmentation of society, destruction of social capital, globalisation [6]

Healthcare context

The contribution of the healthcare sector in the prevalence rate of the epidemic are traceable to the limited and unequal access to required, quality healthcare services and human resources [6], [9], [10], [11], and geographical inequities in the provision of healthcare financing [11].

Technological context

According to a report by Sorensen in 2008 [12], there was little evidence on the utilization of ICT based HIV/AIDS intervention programmes in South Africa. Apart from major health management information systems (HMIS) and electronic health records (EHR), no other ICT systems at that stage had been utilized in response to the epidemic in South Africa [12].

South Africa has been deemed as having the most advance ICT platform in Africa and ranked as the highest country in Africa in terms of availability of latest technologies. Despite the technological advances, the existence of digital divide between the urban and rural settings [13], [14]; disparate eHealth maturity levels across and within provinces, lack of cohesion between existing systems, unequal provision of eHealth services and expenditure across provincial and national departments of health, expensive and inadequate access to broadband connectivity, unavailability of a national master patient index, unavailability of a unique patients identification index, and limited implementation capability within the public sector has marred the effective utilization of the ICT sector in managing and monitoring the epidemiology of the pandemic [15], [16]

In 2012, South Africa's Department of Health, the Medical Research Council (MRC), and the provincial health department co-developed an eHealth strategy for the country [15]. Despite the huge amount incurred in implementing the healthcare ICT and Health Information System (HIS), the lack of technology regulations and policy frameworks strained the effectiveness and productivity of the ICT and HIS within the Health System. Thereby, incapacitating the healthcare system in generating adequate data and information to manage, monitor, control, and evaluate the performance of the national health system.

In order to reduce the effect of the HIV/AIDS pandemic and the stigma attached to it on society, the roles and benefits of supporting activities in the health sector with technological mechanisms has been argued for by various authors. Geers and Page [17] stated in their report that, the innovative use of ICT solutions should be examined for creating an environment that improves the quality of life of people living with HIV/AIDS (PLWHA), thereby giving them an opportunity to play an active role in managing their own situation and protecting their privacy.

The aim of the research study is to identify and assess ways in which ICTs are currently being implemented in South Africa in response to the HIV/AIDS epidemic, and to explore how the delivery of health services can be supported by ICTs.

A. Research Question

The aim of the research study is to identify and assess ways in which ICTs are currently being implemented in South Africa in response to the HIV/AIDS epidemic, and to explore how the delivery of health services can be supported by ICTs in the future.

The research questions that were answered during the research study are stated below:

Research Question 1: What are the theoretical benefits (as outlined in the literature) that the implementation of ICTs can achieve in the reduction, prevention and treatment of the HIV/AIDS epidemic?

The importance of considering this question provides insight into the development of a program theory for considering the utilisation of technology for improving effectiveness of programmes. A service delivery and care value chain mapping is conducted to unpack the various activities along the HIV/AIDS management system value chain after which a theoretical model is developed to represent the theoretical areas of improvement through ICTs.

Research Question 2: What is the status quo of ICT implementation in selected South African HIV prevention programmes?

Here, we consider the range of ICTs being implemented on selected programmes as well as the barriers to use and further role out of ICTs.

Research Question 3: In what forms could the Implementation of ICT be used to enhance the efficiency in reduction, prevention and treatment of the HIV/AIDS epidemic in these selected programs in South Africa?

By mapping suggestions that have been made by HIV/AIDS intervention programme staff as well as ICT specialists, we draw some conclusions on how activities along the HIV value chain can be strengthened through ICTs.

A. Literature review

According to the 2011 progress report released by the UNAIDS, the UNAIDS and WHO proposed a new five year strategy (i.e. from 2011 – 2015) that aims to build on the progress accomplished on the constant battle on HIV/AIDS epidemic to date and establish a target for 2015, which are, zero new infections, zero discrimination and zero AIDS-related deaths. The proposed strategy focuses on four strategic directions: optimization of HIV prevention, diagnoses, treatment and care; utilisation of HIV responses in leveraging broader health outcomes; building capable and maintainable health and community systems; and removing any barriers to accessing services and reducing vulnerability [18].

The effectiveness of any HIV prevention programme is dependent on the appropriate selection of intervention mechanisms, and the extent to which the intervention reaches the target audience [19]. In order to accomplish the above stated objectives of the WHO, the selection of an appropriate mix of HIV prevention programmes to deploy must be designed based on an in-depth understanding of and mapping of the epidemiology of HIV. This needs to be done to ensure that effective interventions can reach the areas and populations where HIV is spreading most rapidly and where people are most affected by the disease [18].

Much attention in the literature is given to the achievement of radical behavioural change towards the HIV epidemic to reduce HIV transmission. Behavioural interventions aim to reduce the behaviours that increase the vulnerability of being infected, or infecting others, with the virus [20]. Behavioural interventions are needed to support both providers and consumers for acceptance and diffusion of biomedical innovations, adherence to protocol, and sustainable prevention of infection with other STDs [21].

Most of the existing interventions are based on the postulation that providing accurate information about transmission and prevention of the virus will lead to behavioural change. Thus far, research has proven that education alone is not adequate to effect the desired behavioural change among most individuals [22]. This broadens the importance of the effective integration of ICT infrastructure in fighting the HIV/AIDS epidemic. That is, the development of technology-based HIV intervention programmes.

There are a growing number of technological devices and systems that can be used as a valuable tool in HIV interventions. This includes the Internet, PDAs, computers systems, mobile devices such as cell phones or smart phones, and other evolving technologies. With the steady decrease in the prices of these technologies, some of these tools have become universal and accessible even in resource-constrained settings, and their uses are just being effectively explored in depth [23].

Katherine & Helen [24], stated that there exist vast opportunities in South Africa for adopting mobile technologies to aid initiatives in the HIV/AIDS sector. As the total number of cell phone users continues to increase in South Africa, there are several creative ways in which mobile devices can be used to guide and assist treatment, distribute information, provide anonymous counselling, and collect data and provide a link between patients and services.

As stated in the introductory section, South Africa has the most advanced ICT platform in Africa. To accomplish the desired results in the fight against HIV/AIDS, we postulate that more consideration to the various areas of implementing ICTs should be given. The utilisation of these technologies may provide a user-friendly, confidential and easy accessibility mechanism to access the required information about the HIV/AIDS epidemic [25]. It also has the potential to change the delivery mechanisms for the HIV response and to accelerate the development and implementation of productive HIV prevention solutions [26], thereby strengthening and providing adequate support to the HIV/AIDS value chain.

1) Unpacking the HIV/AIDS Management Value Chain

The aim of utilising the HIV/AIDS management value chain value chain framework is to ensure a productive delivery of quality lifesaving and health enhancing resources dedicated to preventing and treating the epidemic [27].

> *"The care delivery value chain (CDVC) is a systemic analysis value creation tool for mapping and analysing the full set of activities needed or required to care for a medical condition"* [28].

Aligning the integrated product and services management system model proposed by Weeks [29] with the value chain phases and activities identified by Porter [30] we propose that the healthcare service categories in response to the epidemic can be divided into the following phases: Awareness, HIV testing (disease diagnoses), prevention and intervention therapy, disease management, and treatment programmes. Whereas, the other elements such as the healthcare systems and processes, Technology support systems, human and social-cultural systems, legal systems, and financial systems aims to provide relative support to the value chain, in order to achieve high patient satisfaction. In the section below we unpack the various phases and the corresponding activities of the value chain in depth.

The *prevention activity* phase seeks to permanently prevent the transmission of the HIV/AIDS virus from an infected individual to an uninfected individual [28], [31]. The following activities are covered in the prevention and screening phase of HIV/AIDS management [30]: identifying high risk individuals, conducting HIV test, promoting risk reduction strategies, modifying behavioural risk factors, connecting patients with primary care systems and creating medical records.

This *diagnosis and staging* phase provides a detailed result of the individuals HIV/AIDS status, the stage of the infection is determined, and the derived information will be used to guide treatment decisions [28], [31]. The aim of this

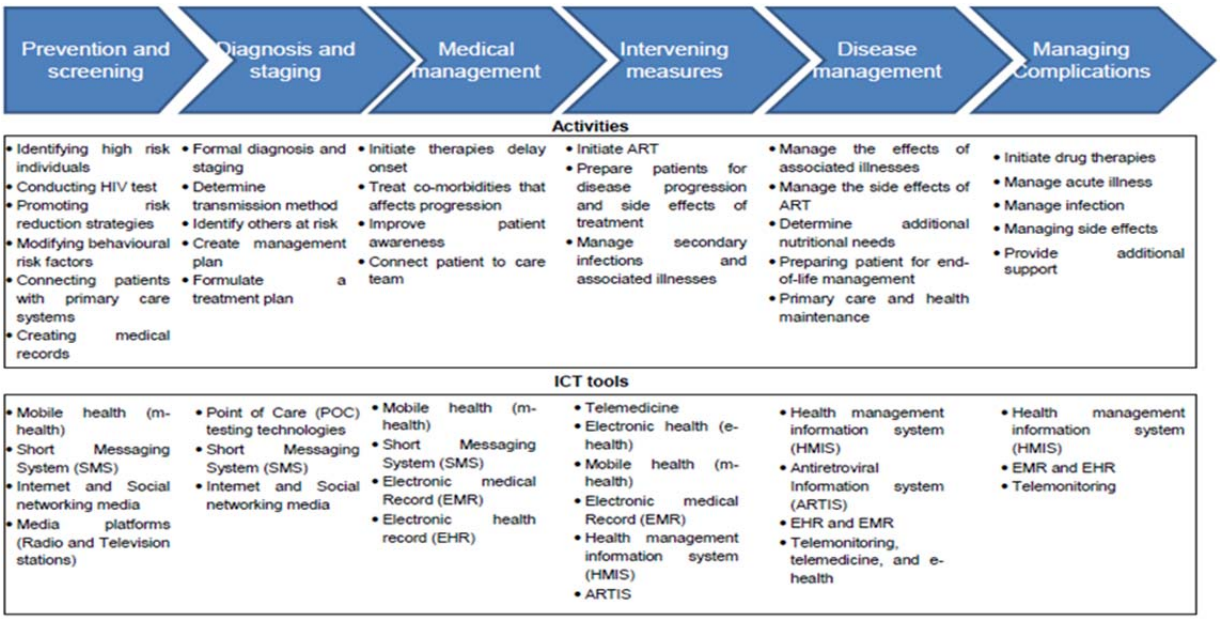

Figure 1: The HIV/AIDS Value chain for service delivery and care (Source: Adapted from Porter 2010: 26)

stage is to device a treatment management plan for the individual. The following activities are covered in the diagnosis and staging phase of HIV/AIDS management [30]: Formal diagnosis and staging, Determine transmission method, Identify others at risk, Create management plan and formulate a treatment plan [30].

This *medical management* stage aims to provide an adequate medical intervention management plan that reduces the progression of the disease, through nutritional interventions, and a rapid prevention and intervention of opportunistic infections [28], [31]. The activities covered in the stage are [30]: Initiate therapies delay onset, treat co-morbidities that affect progression, improve patient awareness and connect patient to the care team [30].

The goal of the *intervening measures* phase is to promote early intervention plans for the infected individual, by improving adherence to first-line drug therapy, and to slow the emergence of drug resistance [28], [31]. The activities covered in the stage are to initiate ART, prepare patients for disease progression and side effects of treatment and to manage secondary infections and associated illnesses [30].

The *continuous disease management* phase provides continuous plans and support for PLWHA on patient's adherence to medications, need for social assistance, nutritional support, patient's clinical status, and monitors the risk of transmitting the virus to an uninfected person. The activities covered in the disease management stage are to manage the effects of associated illnesses, manage the side effects of ART, Determine additional nutritional needs, Preparing patient for end-of-life management and Primary care and health maintenance [30].

The *managing complications* stage provides required care to the PLWHA to facilitate recovery from deteriorations in the patient's clinical status, and to provide additional support to PLWHA. The activities covered in this stage include initiating drug therapies, managing acute illness, managing infections, side effects and the provision of additional support [30].

The ICT tools indicated in figure 1 above are distributed according to their employment in each phase of the HIV/AIDS value chain, and these are further elaborated in figure 2 below. The figure depicts the proposed eHealth framework for an effective HIV/AIDS service delivery and care**.**

2) Technology support system

Due to the critical shortage of medical practitioners and caregivers in South Africa which could hamper the success of any intervention and prevention programme, the potential for utilising ICTs is investigated to support practitioners in delivering quality care and preventative services to South Africans. The technology support system includes the healthcare service delivery systems and infrastructure [32], and it is one of the vital components required in the healthcare services delivery system in response to any insurgent epidemic [33]. The systems that are vital to the successful implementation of HIV/AIDS prevention and intervention are further explained below.

Technology is defined as the application of theoretical and practical knowledge in accomplishing a task using technical processes, skills and artefacts. In the context of the research study a technology is defined as '*'the integration of people, knowledge, tools and systems with the objective of improving peoples lives*''. [34]. The latter definition explains technology as support systems in ensuring the delivery of good healthcare services.

In the context of this work, ICT can be defined as a unified communication platform, which comprises of radio, television, satellite systems, telecommunications networks, computer hardwares and computer networks, and software programs, which also includes various services and applications such as: videoconferencing and distance learning, which facilitates access, storing, transmission and manipulation of information by users.

The framework illustrated in figure 2 below depicts the relationships between the spectrum of technologies and platforms of the eHealth perspectives within the proposed ICT–based HIV/AIDS intervention programmes. In the framework, eHealth is depicted as the core element in ensuring a development of an effective ICT based intervention programme, while the inner layer illustrates the basic components of the eHealth platforms, and the outer layer shows other adapted technologies useful in facilitating the delivery of quality services and care to both PLWHA and uninfected individuals. The components of the framework are further explained in the section below.

Electronic health (e-health)

The electronic health (e-Health) embodies the utilization of ICT for health purposes [16], and it ascribes to the delivery of quality health care with support from diverse ICT platforms, such as EHR, EMR, telemedicine, m-health, and other similar technologies often cited with the 'e' prefix. *E-Health* is a collective term that refers to the delivery of health-related electronic services which delivers a range of connectivity, content, and clinical care [35]. The e-health perspective of healthcare management involves governance, clinical and education facets of healthcare [32].

According to figure 2 above, eHealth is the key element in developing and implementing an effective ICT – based HIV/AIDS intervention schemes. The National Department of Health (NDoH) highlighted in their report that a well developed eHealth strategy will help in producing four major outputs in South Africa [16]:

1. Strengthen the effectiveness of South Africa's health systems
   - It will strengthen the Health Information Systems (HIS)
   - It will facilitate a productive re-engineering of the primary health care (PHC)
   - It will facilitate the compliance of the health service facilities
   - It will provide a proper means to effectively monitor and evaluate the financial expenditures
   - It will also improve Healthcare financing by promoting the implementation of a National Heath Insurance (NHI)
2. Increase the life expectancy rate of the citizens
3. Facilitate a decrease in maternal and child mortality rate
4. Provide an effective means to combat HIV/AIDS and TB
5. Enhance research and development by promoting collaborations with research institutions and higher education institutions (HEIs)

If effectively implemented, e-health could be useful in improving the efficiency and delivery of quality healthcare and promoting cost efficiencies [35], [36]. E-health promotes access to comprehensive informational contents, and advanced services which include scheduling appointments and refilling prescriptions [35], [36]. It also has the potential to improve existing transactions or new means for patients to access and obtain quality care [36].

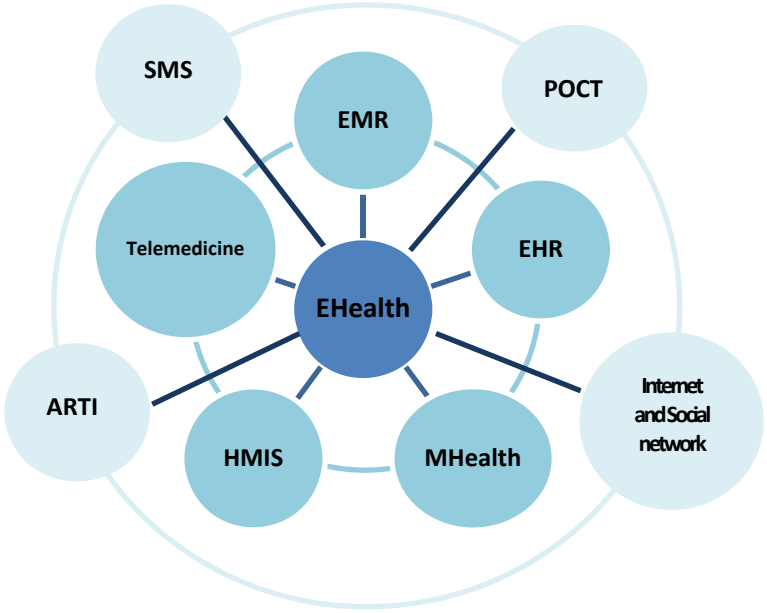

Figure 2: Proposed eHealth framework for HIV/AIDS service delivery and care

Electronic medical record (EMR)

Electronic medical record (EMR) "*is the record of patient health information generated by encounters at one particular healthcare provider"* [38]. EMR is a tool used for assessing the quality of healthcare provided to the community, it can be used by caregivers to capture information about medical encounters and it also contains information on developing a treatment plan, and prescribing medications [37]. EMR is the electronic replacement of the paper based medical records.

According to an article by Weeks [39], EMR system assists in providing effective patient management, by improving access to laboratory data irrespective of the distance, and it can also be utilized in tracking patient outcomes, and monitor patients adherence to therapy. It can also be used to disseminate information in a less expensive way compared to the paper-based medical record [37].

Electronic health record (EHR)

The Electronic Health Record (EHR) *"is a record of a patient's long-term and aggregate health information generated by one or more encounters in any healthcare delivery setting*" [38]. EHR *is an electronically maintained information about an individual's lifetime health condition and health care* [40]. EHR according to the Healthcare Information and Management Systems Society (HIMSS) was defined as a "longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting". It is the medical record derived by the interoperability and integration of multiple healthcare service providers.

The benefits of an effective implementation of EHR in the healthcare sector include: minimization of costs by integrating new and existing information systems across the provincial and national levels, it promotes transparency and efficiency of health service delivery, enhanced quality of care by tracking patients for continuing health care and monitor patient's health care behaviours, the improvement of evidence-based medicine and record keeping, and mobility. It reduces medical errors by providing easy access to patients' medical records, and also improving surveillance methods [41], [42].

Telemedicine

The term 'telemedicine' has been used in various contexts, and there are several definitions with respect to the different contexts covered. According to an article by Kekana *et al* [43], the WHO and HPCSA's definition of telemedicine is given below:

> WHO defines telemedicine as *'the practice of medicine over a distance, in which interventions, diagnostic and treatment decisions as well as recommendations are based on data, documents and other information transmitted through telecommunication systems'*.
>
> HPCSA defines telemedicine as *'the exchange of information on health care at a distance for the purpose of facilitating, improving and enhancing clinical, educational and scientific health care and research, particularly to the under-serviced areas in the Republic of South Africa'*.

Telemedicine embodies the use of ICTs in delivering medical information and services from different locations; it includes diagnoses, consultations, medical care delivery, treatment, and education of staffs and patients [32]. Implementing telemedicine could facilitate good socio-economic benefits for the management of epidemics in South Africa; the likely benefits of utilising telemedicine include better quality of care, improved access to quality health services by increasing rural health care services in the remote locations and access to scarce medical specialists, cost-effectiveness, improved educational opportunities by facilitating research over a broad geographical area, increased health outcomes, better quality of life and enhanced social support [44].

Mobile health (m-health)

Mobile health (m-health) is the emerging mobile network and communications technologies for the healthcare systems [45]. It entails the use of mobile computing and mobile communications devices, such as PDAs, mobile sensors, mobile phones, patient monitoring devices, and other wireless devices to support the delivery of quality health care and medical services [45], [46]. O'Connor [46] posited that if m-health technologies are fully implemented in the healthcare services, it can enhance the quality of healthcare being delivered to the people living in deep rural communities, it can also be used in gathering data for HIV counselling and testing [16].

According to the Global Information Technology report [47], mobile technologies can improve access to health services within the healthcare sector, enhance self-care, address rising costs, increase productivity, and help address the increasing demands of chronic disease and an aging population. It can empower people to improve the quality of their lives by enabling an active participation in understanding and managing their own health and wellness [47].

Health management information system (HMIS)

Health management information system is an essential element of any health care system [48]. It provides the framework which facilitates adequate data collection, data processing, data analysis and reporting of health information. It also facilitates the evolution of appropriate health care index for monitoring, evaluating and controlling the outcome of the health care system [48]

HMIS is useful in providing timely and accurate analysis for effective decision making, and it is a vital component in making adequate pronouncement about the health status of the country's population at relevant geographic locations of the country [49].

Short Messaging system (SMS)

Short message system (SMS) is a communication method that sends short messages of 160 characters through the mobile communications networks. SMS can be used to improve the delivery of medical services through patient's appointment and medication reminders, and it also enhances communication between patients and healthcare practitioners [45]. It could therefore promote prevention, diagnosis, treatment and rehabilitation by enhancing adherence to required medication, medical interventions, and for monitoring illness [45].

Mukund-Bahadur and Murray [45] in their research article concluded that, if effectively used, SMS has the potential to enhance the quality of healthcare service delivery, while promoting the reduction of noncompliance and the delivery of affordable health outcomes.

Internet and Social networking media

The Internet and social networking media possess great potential as an affordable method of promoting prevention, diagnosis and treatment programme, by enhancing a social awareness, disseminating useful and preventative information to the community, and promoting a good behavioural and social change in both PLWHA and the uninfected individuals [50]. Its usage is also highly instrumental to the development of an effective treatment plan [23].

Point of Care technologies (POCT)

POCT is an electronic system that makes HIV screening and testing available to people living in resource poor settings [51]. The overall goal of the POC is to reduce the total process time of HIV testing, and to provide a better service by replacing centralized laboratory testing. POC testing promotes early enrolment of infected people into Antiretroviral therapy (ART) treatment programme [52].

Antiretroviral information system (ARTIS)

The pressing need to manage and offer an effective service delivery and care to the PLWHA, has given rise to the emergence of the implementation of electronic information systems from the existing paper-based information systems that exists is response to the epidemic [53]. Antiretroviral information system (ARTIS) is the software infrastructure developed to manage ART.

ARTIS is used to track and monitor PLWHA and provide adequate reports on the effectiveness of the treatment programme, and provide a means to manage the diverse resources required in response to the epidemic [53]. ARTIS basically covers patient enrolment, patient assessment, recruitment, and management and treatment outcomes.

3) Benefits & Implementation of ICT Techniques

The most important assets to healthcare systems are the healthcare providers, to ensure the care given is of high quality they need to be 'connected' to up to date knowledge and information. ICT possess the potential to have a profound impact on the management of the HIV/AIDS epidemic. It gives us the ability to plan and monitor epidemics through the utilization of mapping systems, it has the capacity to inform and educate those in developing countries about the treatment and prevention of the HIV/AIDS epidemic through available technology platforms such as television, radio, cell phones and computer software, and social networks, and it also provides an opportunity to promote rapid delivery of feasible materials and resources through effective supply chain management methods.

Implementation of ICT can help reduce HIV-related discrimination by complementing HIV awareness campaigns and help avoid preventable AIDS-related deaths through the strengthening of patient-health provider relationships [54]. The benefits of utilising ICT infrastructure in response to the HIV/AIDS epidemic are:

- Ensuring the privacy of PLWHA by providing anonymous counselling.
- It ensures a feasible and convenient means of delivering lifesaving care and resources to the populace,
- Greater intervention fidelity (i.e. intervention is delivered as designed);
- It provides enhanced flexibility in the dissemination of information.
- It facilitates timely and accurate collection of data.
- It serves as a platform in linking patients to the required health care services.

In order for the ICT based HIV/AIDS intervention to be implemented, the various challenges hindering South Africa's existing interventions should be identified, and probable intervention should be devised to eliminate the identified problem area. Table 2 below aims to illustrate the identified problem areas with their possible ICT – based interventions.

The following section gives a detailed explanation on the proposed conceptual model of the ICT – based HIV/AIDS intervention.

II. PROPOSED MODEL OR CONCEPTUAL METHOD

In figure 3 below, the HIV support system conjoins the inventory management, supply chain management (SCM), information, education and communication (IEC), the existing intervention programmes, the devised intervention mechanisms which are healthcare services with the value chain, and the ICT tools and platform. The aim of the devised HIV support system is to provide adequate services that meet the expectations of the patients, by increasing the quality of life by rendering intensive care and support to PLWHA, ensuring constant availability of lifesaving resources, and ensuring the effective dissemination of useful information to the populace.

TABLE 2: PROBLEM AREAS AND POSSIBLE ICT INTERVENTIONS

Problem area	ICT based intervention	Resources to be put in place	Comment
Stigma on HIV/AIDS. Discrimination and isolation.	Empowerment of PLWHA by providing a means for communicating with peers.	HIV/AIDS newsgroup, forums Content databases (preferably in the local language of PLWHA).	By providing PLWHA Internet access and required services such as HIV/AIDS forums and newsgroups, effective data bases with information on HIV/AIDS in the local languages, the PLWHA are able to exchange and share their experiences with peers, social and health care workers and be in a suitable position to manage their life.
High incidence rate of HIV/AIDS infection.	Proper distribution of HIV/AIDS information through effective distribution of ICT based learning and information materials at community centres and schools.	ICT based Learning materials.	The utilisation of local languages in spreading preventive information is a major factor in fighting HIV/AIDS. Attractive ICT based e-learning materials should be developed in the local languages and be made available at all educational levels (i.e. primary, secondary schools) and community centres.
Insufficient availability and accessibility to drugs and inadequate information about drugs.	Effective global inventory database(s) management system and effective on-line ordering system.	Efficient database platform with regularly updated databases maintained by the various organizations.	Only a very small number of the PLWHA do have access to ARV treatment because of improper developed logistics ensuring the constant availability of ARV drugs at specific supply points that is easily accessible by the population. ICT can be an influential element of a (redesigned) supply chain for drugs distribution.
Inadequate information on HIV/AIDS Incidence.	Data gathering and monitoring system.	Thematic Geographical Information System (register for HIV/AIDS attributes).	A voluminous and regularly updated information and description of the HIV/AIDS situation and increase in available resources is a basic condition for efficient, coordinated and effective strategies to be developed and implemented by the various stakeholders.

(Source: Bert Geers and Sara Page 2007)

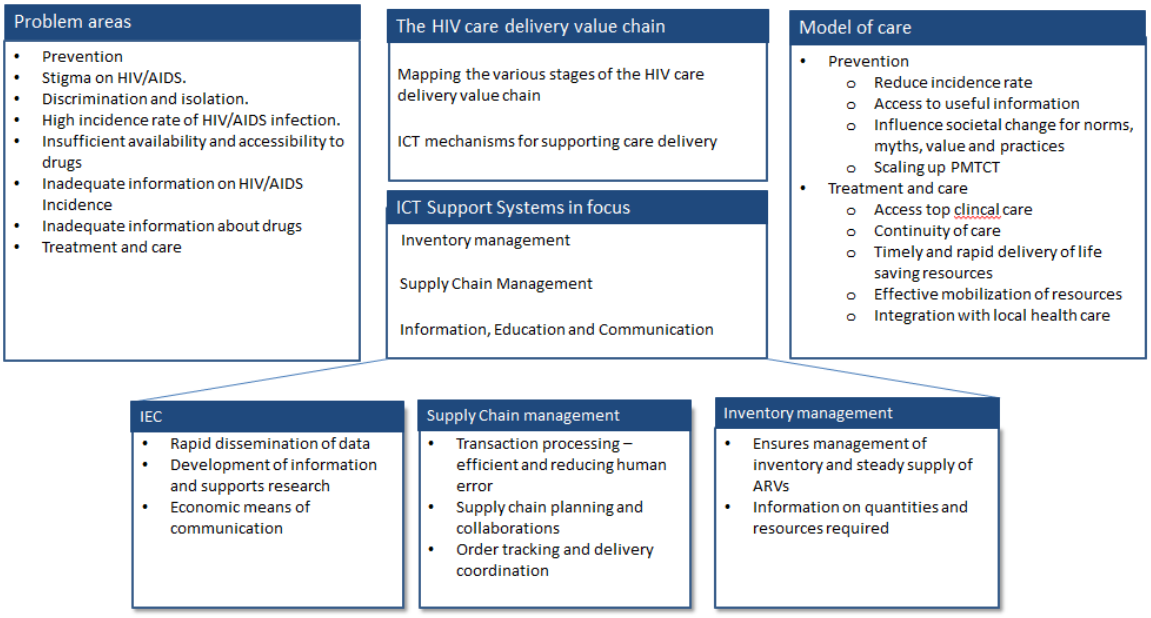

Figure 3: Conceptual framework for the role of ICT in response to the HIV epidemic

A proposed investigative conceptual model indicating the importance of utilising ICT in response to the HIV/AIDS epidemic is given in figure 3.

The conceptual model is designed to address the proposed outcome and objectives of the research study:

- To understand the factors that lead to the increase in the HIV incidence rate in South Africa.
- To analyse existing intervention methods and how ICT can improve the quality of services rendered by the programmes.
- To explore the usefulness of ICT in conjunction with IEC (Information, Education, and Communication) to bring about effective awareness, and promote a behavioural change towards the epidemic.
- To explore the importance of ICT in conjunction with SCM and inventory management to aid the rapid delivery of life-saving resources.
- To explore how the continuous utilisation of ICT in conjunction with existing platforms and programmes leads to an effective HIV management and intervention programme, and the benefits of an effective HIV management programme.

A. HIV Support system: Conjunction of ICT with Existing Intervention

In the conceptual model, there is a relationship between the causes of HIV incidence and existing intervention programmes, and the bidirectional link between the existing intervention programmes, and the ICT frame, this shows that the collaboration of the existing programmes with the ICT infrastructure can help produce an effective HIV/AIDS intervention programme that provides adequate services to PLWHA, produces a good assessment of the quality of the intervention programme, and the quality of services rendered by the programmes in response to the epidemic.

The proposed contributions of the technology-based intervention programme are as follows [23]:

- ICTs can help PLWHA to self-manage their treatment regimens, and it also provides a platform for psychological support.
- ICT can potentially serve as a powerful medium for training clinicians and other HIV/STI workers through the use of digital resources, which are delivered via CD-ROMS, e-mail lists, and via the Internet.
- ICT infrastructures can be used in creating a cost-effective infrastructure to disseminate new intervention models to service providers worldwide.
- Usage of ICT through Electronic Health Record System can lead to uniformity in data collection and to facilitate the retrieval of patient data for clinical care and research.
- Computer-based patient's record can be used as a tool by physicians to gain easy access to patients' information, simplified reporting, guidelines that improve the quality of care, and methods to facilitate adherence to guidelines.

B. HIV Support system: Conjunction of ICT with IEC

Information, Education, and Communication (IEC) is a component of an effective HIV/AIDS prevention programme. It can be an effective intervention in bringing about appropriate behavioural changes, especially within populations with high risk behaviour [55].

According to the conceptual framework illustrated above, the relationship between the existing HIV/AIDS prevention programmes, and the ICT infrastructure, shows that the proper combination of the existing intervention platforms with the ICT infrastructure will help in better accomplishing the desired goal of providing adequate awareness programs that educates on the HIV/AIDS epidemic.

The benefits of conjoining the IEC framework with the ICT infrastructure are given below:

- It provides a platform for faster and rapid dissemination of information to the target population.
- It provides faster development of useful information which promotes effective behavioural change.
- It creates an economical means of communication, by utilising the existing ICT infrastructures.

C. HIV Support system: Conjunction of ICT with SCM

In the conceptual model given above, the link between the cause of the HIV incidence and the supply chain management (SCM), shows that the existence of the causes requires a continuous and timely delivery of resources from the HIV/AIDS inventory system to the existing intervention programs. Also the bidirectional link between the ICT infrastructure, the support system and the SCM shows the result of the implementation of the ICT with SCM to produce a highly effective HIV intervention program.

According to a report by Aurumo *et al* [56], there are three functions of for using ICT with SCM:

1. Transaction Processing: - ICT is used in SCM to increase the efficiency of repetitive information exchanges between supply chain partners, to eliminate human errors, and to reduce the cost of transaction.
2. Supply chain planning and collaboration: - ICT is used to share planning information such as inventory information, demand forecasts, and production capacity information, with the intent to increase the supply chain's effectiveness.
3. Order tracking and delivery coordination: - the role of ICT in SCM is to monitor the orders or shipments, with the aim of coordinating their delivery or conveying timely information of their present location.

D. HIV Support system: Conjunction of ICT with Inventory management

According to the proposed conceptual model given above, the link between the cause of the HIV incidence and the inventory management system shows that the existence of the causes requires a constant availability of resources from the inventory system to the existing intervention programs. Also the bidirectional link between the ICT infrastructure, the support system and the SCM, and the inventory system shows the outcome of implementing the ICT with the inventory system to produce a highly effective HIV intervention program.

The benefits of incorporating ICT platform with the inventory system are given below [57]:

- It ensures steady availability of ARV and other resources by defining when products should be ordered to avoid stockouts.
- It provides accurate information on the quantities of resources to be ordered to avoid overstocking and stockout.
- It shows how to maintain adequate resources that meets the required demand, while considering other factors that could hinder the operations of the programs.

ICT contribute to prevent new infections by improving the dissemination of evidence-based knowledge and facilitate linkages between people who wish to get tested and local health services. They reduce HIV-related discrimination by complementing HIV awareness campaigns and help avoid preventable AIDS-related deaths through the strengthening of patient-health provider relationships. It also helps in providing a stable and continuous delivery of resources.

A value chain framework was used as an approach to analyse the importance of employing the ICT tools and techniques with the new and existing HIV/AIDS intervention programmes in South Africa, and this is further elaborated in the section below.

III. RESEARCH METHODOLOGY

The research methodology used for the research study is a combination of the qualitative and quantitative research method. The qualitative approach was chosen due to the goal and objective of the research study, which is to explore the role of ICT in the management of HIV/AIDS epidemic, the main aim of using the qualitative approach is to gain a deep understanding of the research problem. The quantitative approach was chosen to objectively measure the outcome of the research study.

The interview process includes 20 HIV/AIDS management organizations selected across South Africa and according to their role in the HIV/AIDS value chain in figure 1 above, and 5 ICT and health technology experts. The HIV management organizations were consulted to know the rate of utilisation, benefits accrued, challenges experienced, and the response rate of the employment of ICT tools and techniques, while the ICT and Health technology management experts were consulted to get suggestions on the possible ICT tools that could be used. The aim of splitting the interview into two categories is to make comparison and conclusions on the rate of utilisation of the ICT tools within the HIV management organizations and the suggested ICT tools by the ICT and health technology management experts.

IV. RESULTS

As indicated in the research methodology section, the interview participants were chosen from various HIV intervention programmes all across South Africa, and were from two categories:

- Category A covers the HIV management organizations and caregivers. This gives us a view of the status quo of the intervention programmes in South Africa.
- Category B covers experts in the ICT and Health technology management field. This gives us a view of the potential improvements and future development for using ICTs to support HIV/AIDS intervention programmes.

A. Category A: response from the HIV management experts

According to table 3 below, it is shown that most of the HIV management organizations in South Africa run more than one activity on the value chain framework of HIV/AIDS service delivery and care.

The research interview discovered that 12 out of the 20 participating organizations employs the ICT tools in enhancing their intervention programmes, while 8 do not utilise any ICT tools.

ICT Tools: According to figure 4 given above, 6 organizations indicated that their organization uses bulk SMS services, another 6 indicated that their organization uses social media networks such as Facebook, Twitter, Whatsapp, and MXIT, 4 of the organization indicated that they use e-mail, 4 indicated that they use telephone and Skype call services, while the remaining 3 employs the use of other data capturing tools such as Datafax, TherapyEdge, SAS, Excel, and Microsoft Access application.

The frequency of ICT utilisation varies within the interviewed organizations, 4 out of the 12 organizations that use ICT tools indicated that a combination of the various ICT tools such as Social media, SMS, and telephone calls are used by their organization, while the others solely use a particular type of the ICT tools listed in the illustration.

TABLE 3: ALIGNMENT OF THE INTERVIEWED ORGANIZATIONS TO THE HIV/AIDS VALUE CHAIN

	Phases of value chain								
	Prevention and screening	Diagnosis and staging	Medical management	Intervening measures	Disease management	Managing complications	Advocacy	Counselling	Science of HIV
1	1	1		1	1	1			
2	1	1						1	
3		1	1	1					
4	1		1		1	1		1	
5					1	1			
6		1			1	1		1	
7	1			1				1	
8		1			1	1		1	
9	1	1					1	1	1
10	1	1						1	
11	1		1	1					
12			1				1	1	1
13	1	1		1	1		1		1
14	1	1					1	1	
15	1		1	1			1		1
16					1	1		1	
17	1	1			1	1		1	
18	1								
19	1	1	1	1	1	1			
20	1	1			1	1			

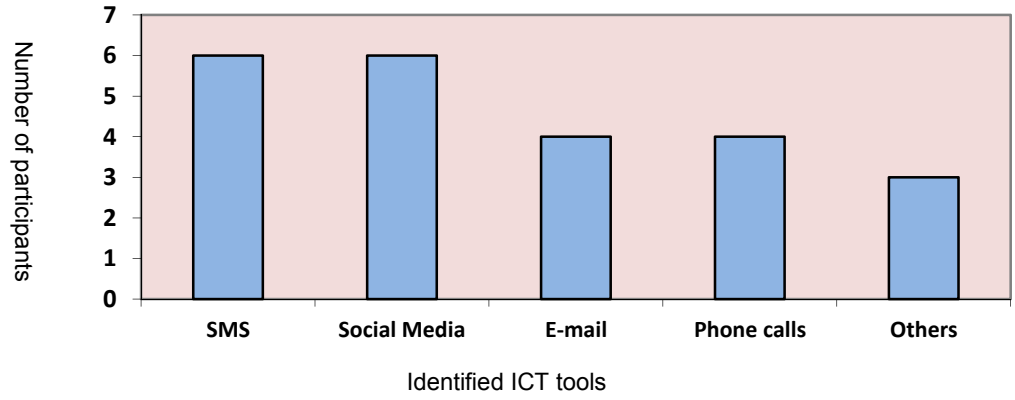

Figure 4: Summary of ICT tools used by surveyed programmes {N = 20}

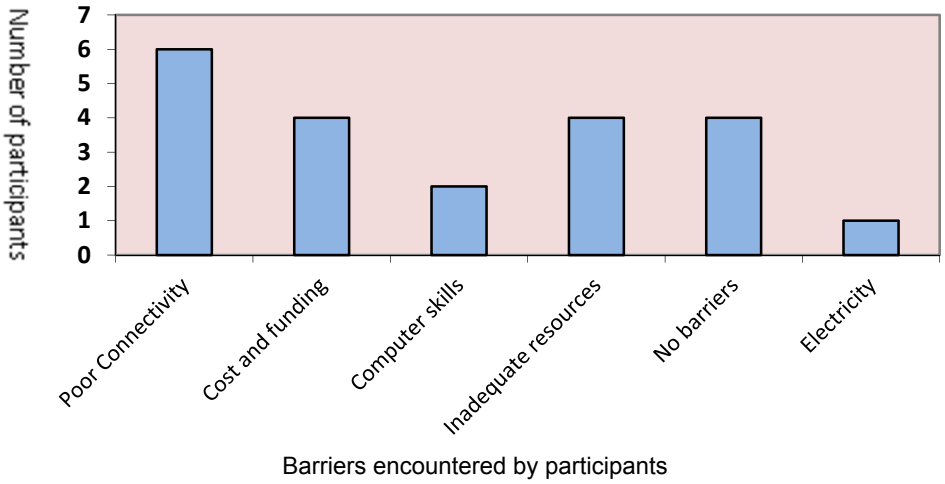

Figure 5: Summary of the barriers encountered by surveyed programmes {N = 20}

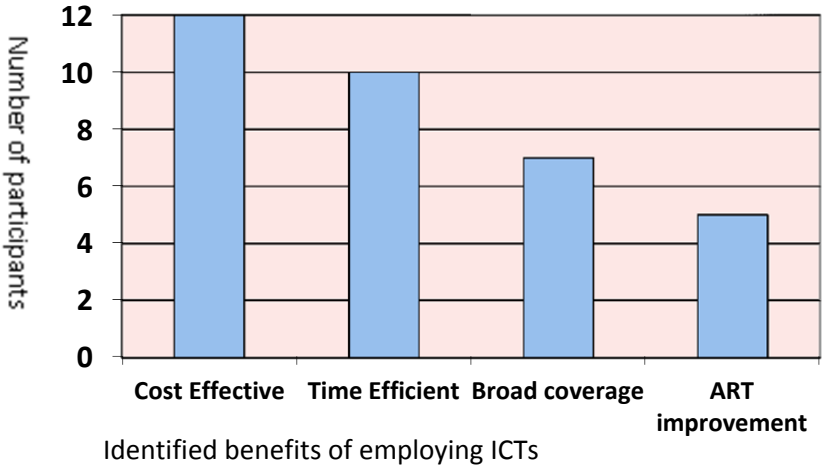

Figure 6: Summary of the identified benefits by surveyed programmes {N = 20}

Barriers: According to figure 5 above, the interviews revealed that the participating organizations face challenges such as poor network connectivity due to the rural location of their organization, insufficient funding, unavailability of skilled ICT personnel, and inaccessibility or unavailability of required ICT tools or equipment. The major barrier identified by the interviewed organizations revolved around the acquisition and implementation cost, and network connectivity. This reflects on the existence of a digital divide between the urban areas and the rural areas.

Benefits: The interview participants highlighted a range of benefits of employing ICT tools within their organization's intervention programmes. According to figure 6 above, all participants indicated that the employment of the ICT tools within their organization is a highly cost effective means of disseminating resourceful information about the preventative measures to be taken and resources to the PLWHA, and the community at large. 10 participants indicated that the deployment of the ICT tools is time efficient in spreading information about their organization and their programmes, the adverse effect of the epidemic, and preventative measures. 7 participants indicated that the deployment of the ICT tools provide access to a wider range and coverage of the prevention and intervention programmes been offered to their community and the country as a whole. While 5 indicated that the employment of the ICT tools helps in monitoring and controlling the ART adherence rate of the PLWHA, thereby enhancing the quality of care given to the community.

Response rate: The interview process identified that 7 out of the 12 organizations indicated that employing ICTs on their various intervention programmes did improve the quality of service delivery, and the utilisation has been impactful in the community they serve. A participant indicated an increase in their social media network which gives them a broader coverage, some indicated it has been effective in their ART programmes by providing a good adherence measures for the PLWHA. 3 organizations indicated a low response rate as compared to the cost of implementing the ICT tools, while the remaining 2 organizations indicated that the response rate within their organization cannot be quantified or they do not know the value of the utilization.

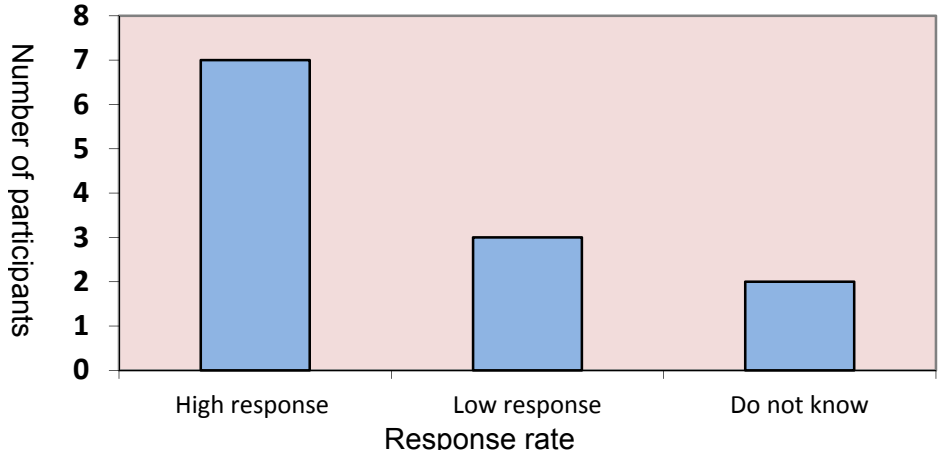

Figure 7: Summary of the response by surveyed programmes {N = 20}

TABLE 4: POTENTIAL ICT TOOLS IDENTIFIED BY THE ICT AND HEALTH TECHNOLOGY SPECIALISTS

Suggested ICT tool	Potential usage
m-Health (SMS-based technologies, HIV/AIDS awareness cellphone applications)	• To encourage VCT, clinic appointment reminders, health education, medication reminders and support groups • To educate the populace about the epidemic and to encourage participation in HIV test and to promote adherence to HIV treatment programs • To facilitate a feasible and larger scale dissemination of awareness and prevention information to the citizens, and to also encourage adherence to the ART programme
Shared Electronic health records	• To prevent duplication of tests thereby reducing costs, and to also facilitate better quality and comprehensive care for the PLWHA.
Pharmaceutical database record	• To monitor the distribution of the ARV drugs to the
National HIV/AIDS database management system	• To track all individual cases on both positive/negative individuals
Electronic billboards	• To enhance rapid spread of helpful and vital information to the community on the national HIV/AIDS issue
Social networking platforms and Internet services	• To promote cheap and broad awareness of the epidemic, promoting effective reduction strategies, providing additional information and support to PLWHA that connects them to primary care service, and providing required information to the populace

B, Category B: Response from the ICT and Health technology experts

The table below illustrates the potential ICT tools that could be used to enhance the new and existing HIV/AIDS intervention programmes in South Africa as indicated by specialists both in the ICT field and healthcare technology management field.

Benefits: The benefits identified by the respondents are dedicated capacity that enhances web content, adherence to ART therapy, adequate and a unified information database, reach of coverage, global connectedness, cohesion in the community, easy access to useful information and facilities, effective drug dispensing and distribution, and effective awareness about the epidemic is easily conferred to the general public due to the availability and easy access to these tools.

The envisioned benefits of developing a National HIV/AIDS database management system is that it creates a reporting platform on the epidemic's footprint nationally, regionally and in other smaller proximity, and it also provides an opportunity for Individuals to challenge prescribed medication by tracking medicinal usage.

The benefits of mHealth technology includes: it encourages voluntary counselling and testing (VCT), it serves as clinic appointment and medication reminders, health education, and it also helps in linking PLWHA with relevant support groups, while the benefits of EHR: prevents duplication of tests and therefore reduces costs, facilitates better comprehensive care for the patient.

ICT integration: The ways in which ICT can be integrated into the intervention programmes includes: strengthening the awareness and knowledge about the potential importance of utilizing ICT tools within the organization, government involvement in making the ICT tools and resources available to the HIV/AIDS management organizations, and improvement to the network connectivity bandwidth.

Barriers for implementing ICT: The basic obstacles indicated by the participants are: ensuring privacy and confidentiality of patient information, gaining a proper informed consent from patients prior to the implementation of ICT tools, adhering to current law and clinical and ethical guidelines will address some of these issues, financial implications of utilizing the required ICT tools i.e. cost of technology acquisition. lack or inadequate ICT supporting infrastructure i.e. uneven infrastructural development and network coverage within the country, lack of knowledge and skills in the usage of basic ICT tools, and general issues when older generations are left behind due to lack of knowledge.

Barriers to existing HIV/AIDS intervention programmes: The barriers identified by the participants are: lack of information or inadequate access to information. Users questioning reliability of information gathered e.g. sample size, demographic spread. AIDS fatigue, this occurs due to the lack of innovative approach to the diffusion of useful and impactful information, and the reoccurring nature of the messages, and massive cultural barriers i.e. traditional norms.

V. CONCLUSIONS AND RECOMMENDATIONS

The interview process identified the state of ICT utilization within the HIV management organizations, and the potential ICT tools that could be used in response to the epidemic in South Africa and globally. During the interview process, it was evident that there was a huge gap in the ICT

tools currently used within the HIV management organizations compared to the Potential ICT tools that could be used in response to the HIV/AIDS epidemic in South Africa. The research interview also discovered that there was a conformance between the identified benefits of deploying the ICT tools with the envisioned benefits of the deployment of the ICT tool alongside the intervention programs in the South Africa. The benefits includes: cost effectiveness benefits, to the time efficiency benefits, to the ease of communication, accessibility to vast and adequate information, rapid and continuous awareness, promotion of great adherence to the health management plans, feasible publicity, broader community coverage

The research interview process also discovered that there was a conformance between the barriers to the utilization of ICT tools between the two categories covered in the interview process i.e. the HIV management organizations and the suggested barriers by the ICT, Healthcare Technology management experts. The major constraints identified by the categories revolve around the massive cost implications of the implementation, inadequate ICT infrastructures and resources, and lack of required knowledge.

The interview process also discovered that there was a conformance between the envisioned benefits of the utilization of the ICT tools from the perspective of the HIV management organizations and the ICT and health technology experts.

A. Conclusions

Figure 8: identified areas for improvement

During the research study and the interview process, some areas that need further development and improvement were identified:

Technologies: As depicted in figure 4, various ICT tools were identified during the research study that could be used in conjunction with the existing HIV/AIDS intervention programmes in South Africa. The massive growth rate currently being experienced in South Africa's ICT sector, as indicated by the Global Competitiveness Report [58], should be effectively harnessed in developing a nationwide ICT based intervention programme that enhances the conventional and existing HIV/AIDS intervention programmes in South Africa.

When comparing the ICT tools used by the HIV management organizations with the potential ICT tools suggested by the ICT and healthcare technology management experts in figure 5, the interview process discovered that the mobile applications for HIV/AIDS, pharmaceutical information systems, and national HIV/AIDS database solely dedicated to monitoring, controlling and managing the epidemic are yet to be employed in South Africa. The potential benefit of employing and deploying the technologies mentioned above is to facilitate a better means of managing, controlling, and reducing the prevalence rate, incidence rate, and the mortality rate of the epidemic in South Africa.

Removing technological barriers: A range of barriers to the implementation of ICT based intervention programmes were identified during the research study. The barriers identified are: ensuring privacy and confidentiality of patient information, adhering to current law and clinical and ethical guidelines, financial implications, inadequate ICT supporting infrastructure, insufficient access to ICT professionals, and gaining informed consent from patients prior to the implementation of ICT tools.

Capacity Development: The importance of developing a adequate technological capacity or capability in South Africa's response to the HIV/AIDS epidemic is to provide a cost effective nationwide intervention programme, that helps in disseminating right information to the citizens irrespective of their location, effective distribution of resources through SCM, ARTIS, and inventory management, to better monitor and control the epidemic both on a regional level and national level, and the wider coverage potentials of the deployment of the technological capabilities. According to the above stated benefits, the need for the national level development and deployment of the technological capabilities is paramount to the facilitation of an effective HIV/AIDS intervention programmes in the country.

Integration into the current infrastructure: In order for novel ICT tools indicated by the ICT professionals to be effectively harnessed in response to the epidemic, there needs to be a strategic plan in place for the integration of the new proposed systems into the current and existing infrastructural components of South Africa.

Stakeholders and effectiveness in reaching them: The stakeholders in the system need to be consulted and it needs to be ensured that their value positions are addressed in order to incentivise the systems and market for a thriving e-Health community.

B. Recommendations

Based on the identification of the possible means that ICTs could be implemented within the treatment, prevention, awareness, and care of the HIV/AIDS intervention programmes the following are the recommendations that can be identified for the existing prevention and intervention programmes seeking to improve the quality of care and services being provided to the community. The recommendations given below aim to also incorporate the challenges identified by the National Department of health (NDoH) in the 2012 – 2016 eHealth strategy [16].

Policy framework should consider the following issues as discussed below:

- It is suggested that before the ICT tools and technologies can be effectively used in strengthening the services provided by the HIV/AIDS management organizations, adequate access to infrastructural facilities plays a big role. This means that there needs to be development of technological capabilities both on a regional (provincial) and national level.
- The effective utilisation of the ICT tools within the intervention programmes requires highly skilled professionals and knowledge transfer from the skilled personnel to the caregivers.
- The development of national policies and programs that supports the sustainable development and dissemination of evidence-based consumer e-health tools to diverse individuals and communities should be promoted.
- In order for ICT tools to be effectively utilised within existing intervention programmes, there needs to be adequate access to funding and incentives for the creation of an e-Health market. This entails appropriate funding and incentives to in public policy to enable the sustainable development and implementation of tools with demonstrated effectiveness.
- There needs to be a push for strategic alliances and partnership between e-Health stakeholders to facilitate consumer access and usage of e-Health tools.
- The ICT technologies to be employed needs to be highly secured, in order to protect privacy and confidentiality of patients information.
- Before any pursuit of implementing the ICT tools and technologies within the organizations, there is a great need to ensure complete support and buy-in from the government and other stakeholders. Identifying and engaging the right groups in order to ensure that their value propositions are addressed, the programmes are implemented effectively and that expert skills are pulled into the design and roll out organizations funding the programmes.
- The diverse perspectives of consumers should be included and considered in the design of the e-Health tools.
- Finally, an effective ICT governance structure is needed to assume responsibility for establishing and ensuring compliance with the consistent application of nation-wide standards, policies and processes. The aim of the ICT governance structure is to list the technical standards required to ensure compatibility on a regional, national and international level. The strategy enables the acquisition and development of a cost effective, affordable and easily accessible technology that are in conformance with the stated standards.

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