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TELEMEDICINE INFRASTRUCTURE FOR POST COVID-19 UNIVERSAL HEALTH.

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Abstract

*Health, Sustainable Development Goal No 3 and Big 4 Agenda item has been the most devasted by COVID-19. Health is the fundamental contributor to economic growth and wellbeing of Populations. Kenya has recorded **41,939** confirmed cases and 787 deaths. Engineering Post COVID – 19 is ineffective without engineering sustainable and affordable access to Medicare. Post COVID-19 has proved development of Telemedicine and Tele-Healthcare as key for remote Medicare. The models protect medical personnel to infections through interactions or contact. Engineering Post COVID-19 therefore comprise building a National Health Communication Infrastructure (NHCI) by transforming all electricity supply lines to hospital and health facilities to high capacity broadband links using fiber optic technology. These will be used for advanced remote nursing, consultancy, Internet access, data warehousing, Artificial Intelligence, and Internet of things infrastructure.*

Key COVID-19, SDG, Fiber Optic, Electricity Grid, 3993Words

1.0 Introduction

According to (WHO Coronavirus Disease (COVID-19) Dashboard, 2020), over **38** Million people are infected with COVID-19 with more than **1** million deaths. Kenya has recorded **41,939** confirmed cases and **787** deaths. COVID-19 is a highly contagious disease that has endangered all populations. According to (*Over **10 000** health workers in Africa infected with COVID-19, n.d.*), **10,000** health workers infested with COVID-19 in Africa. It is estimated that **10%** of all cases of COVID-19 infection are among health workers.

Exposure or direct contact with infected patients who are asymptomatic identified as one of the leading causes of COVID-19 infections among health workers. This occurs when patients visit the facility for other Medicare needs. Other factors are inadequate personal protective equipment, weak infection prevention and control measures, inadequate briefing of health workers prior to dispensation of Medicare and fatigue due to workload.

According to World Health Organization (WHO) assessment of clinics and hospitals, only **16%** of approximately **30,000** facilities surveyed scored above **75%** for prevention of infections within health facilities. A paltry **7.8%** i.e. **2,213** of health facilities had isolation capacities and **1/3** had capabilities triage. Largely, most hospitals lack the desired infrastructure for implementation of infection prevention and overcrowding.

According to the Ministry of Health (MoH) Kenya, *projections of general practitioners, Clinical*

*Officers and Nurses **2013-2030***, Kenya needs **136,905** active health workers by the year 2030. Implementation of urgent interventions is key to protect Health workers from COVID-19 and ensure realization of the MOH 2030 staff projections.

Adoption of telemedicine/telehealth minimizes need for physical interaction between health workers and populations thereby greatly reducing risk of infection. Further incidences of burnout, fatigue and failure to adhere to procedures due to high work volume in emergencies becomes less.

Consideration for a model to develop a National Health Communication Infrastructure based on deployment of fiber optic technology in electricity supply infrastructure to connect all health facilities is now. The model will provide high capacity dark fibers for point to point and point to multipoint connections, faster rollout times; least cost of ownership (TCO) model for future proof broadband infrastructure, environmentally compliant broadband deployment option, highly secure, and flexible.

2.0 TELEMEDICINE

Telemedicine is the use of ICT to provide clinical services whenever health workers and patients are in separate locations. It is a means by which health workers extend practice of medicine outside the facility to distant locations.

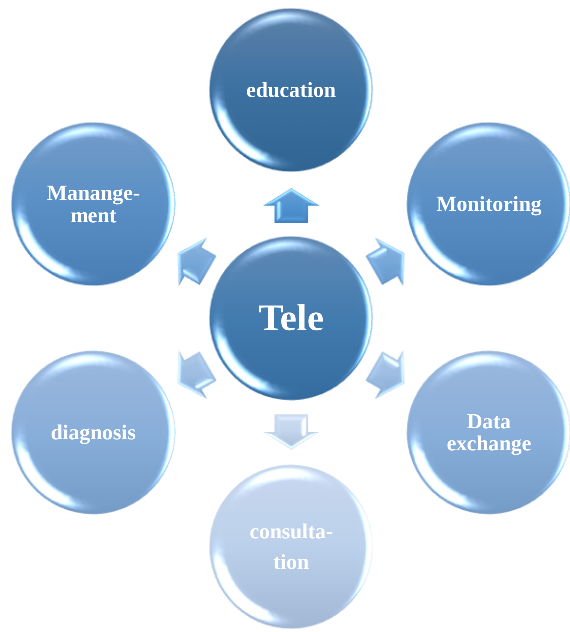
2.1 TYPES OF SERVICES

Telemedicine/Telehealth needed for the following situations

- **Specialist referral services** – Diagnosis support to a general practitioner by an expert or specialist. The specialist views the patient's data or images using ICT tools comprising video conferencing, still images and consultation /interrogation.
- **Direct patient care** – Remote diagnosis, treatment and or prescription done with a health professional based on a patient's medical data, audio, and video recordings. The patient may be at home, remote clinic, or remote clinic etc.
- **Remote patient monitoring** – Data collection done remotely using devices such as telemetry to collect important health data i.e. blood pressure, weight, etc.
- **Medical education and mentoring** – comprise medical support by a professional to another professional performing a medical procedure.
- **Consumer medical and health information** – online platforms on Internet used for access to specialized medical procedures and peer to peer support.

2.2 SERVICES OFFERED BY TELEMEDICINE

Figure 1: Service Model for Telemedicine



Source: Author, 2020

2.3 TYPICAL TELEMEDICINE OUTCOMES

Telemedicine is used in post communication of the following outcomes

Table 1 Requirements for Telemedicine Application

	USE	MEANS	RESULTS
1	Radiology	Tele radiology	Images, X-rays etc.
2	Pathology	Tele pathology	Microscopic images
3	Dermatology	Tele dermatology	Skin images
4	Psychiatry	Telepsychiatry	Telephony and video

Source, Author 2020

3.0 TELEHEALTH

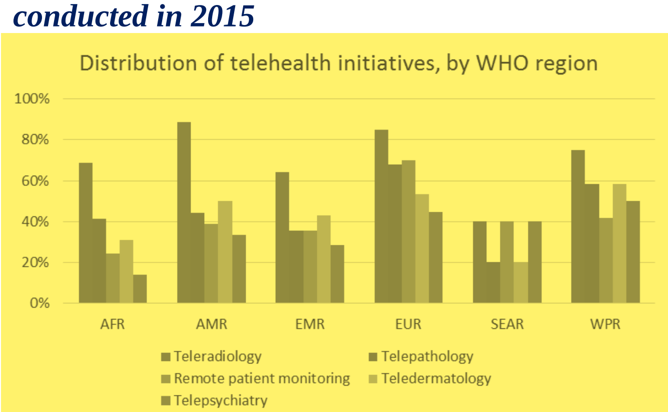
Telehealth model operates where the health worker and the patient are at a distance. Services offered are diagnosis, treatment, research, consumer outreach, nursing call centers, education, and exchange of information.

Telehealth enhances access to affordable Medicare hence realization of the universal health coverage objectives mainly in the rural areas and among elderly populations.

3.1 A CASE STUDY

According to WHO sponsored global health survey of 2015, over 50% of surveyed countries confirmed existence of telehealth in their eHealth policy. Teleradiology was confirmed the most widely used telehealth solution. Others were Teledermatology, telepathology, telepsychiatry and remote patient monitoring. Below is graph 1.

Graph1: Percentage of countries reporting an evaluation of a government-sponsored telehealth program, from the third global health survey conducted in 2015



Source: WHO

4.0 ACCESS TO ELECTRICITY

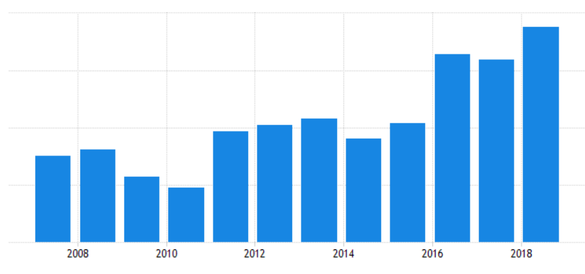
According to the World Bank, access to electricity in Kenya grew to a high of 75% in 2018. This implies significant infrastructure rollout and coverage countrywide. Access to electricity for health care facilities increased by **1.5%** annually in Kenya between 2004 and 2010 to a high of 98% access see table 2 below. Kenya electricity access to the population grew to approximately 74% at 2018 see graph 2 on electricity access in Kenya.

Table 2: Trends in Electricity Access in Health Care Facilities, by Facility Type, Kenya, and Rwanda

	All Facilities		Hospitals Only		Other Facilities Besides Hospitals	
Country and Year	Percentage	Annual Percentage Change	Percentage	Annual Percentage Change	Percentage	Annual Percentage Change
Kenya						
2004	65	1.5	98	0	63	1.5
2010	74		98		72	
Rwanda						
2001	58	4	92	1	52	5
2007	82		98		81	

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4168575/

Graph 2: Access to Electricity in Kenya as a Percentage (%) of the Population



Source: World bank tradingeconomics.com

According to the data above, the central power grid covers over 90% of health facilities in Kenya. To re-use this grid infrastructure by deploying fiber optic cable provides an unrivalled opportunity for realization of a private high-speed broadband infrastructure interconnecting all grid connected health facilities.

5.0 HEALTH SECTOR INDICATORS

According to *table 3* below, Kenya had a total of **7795** health facilities in **2017** of which **16** were national hospitals. Government owned health facilities were **3956**.

Dispensaries held the largest composition at **45.8%** while maternity and nursing homes held the least composition at **2.5%** *see table 4.*

Table 3: Distribution of Health Facilities by ownership and Level of Care

Key Health Infrastructure	Community	Primary Care facilities					County hospitals	National hospitals	Total
		Dispensaries	Health Centres	Medical Clinics	Maternity homes	Nursing homes			
Government		2954	682	35	1	0	268	16	3956
Faith Based		561	166	61	3	11	79		881
NGO's		200	24	73	4	5			306
Private		196	60	2,098	32	150	116		2652
Total		3911	932	2267	40	166	463	16	7795

Source: KHSSP 2013-2017

Table 4: Distribution of health Facilities

Type	Number of facilities	Percent
Hospital	507	5.5
Health Centre	1,012	10.9
Maternity and Nursing Home	232	2.5
Medical Clinic	2,943	31.8
Dispensary	4,239	45.8
Other	316	3.4
Total	**9249**	**100**

Source: Master Facility List/Health Information System (MFL/HIS)

According to the Economic Survey 2013 see table 5 below, dentistry had the least number of workers at 985 while registered nurses were the leading in composition with approximately **35,148** workers.

Table 5: Registered Health Personnel of Essential Cadre

Registered Health Personnel	2008	2009	2010	2011	2012
Doctors	6623	6800	7129	7549	8092
Dentists	974	859	898	930	985
Pharmacists	2860	2921	3097	2432	2532
Pharmaceutical Technologists	1815	1950	2233	4436	5236
BSC Nursing	657	863	988	1173	1532
Registered Nurses	14073	26988	29678	31719	35148
Enrolled Nurses	31915	34032	34282	24375	26621
Clinical Officers	5035	7816	8598	9793	11185
Public Health Officers	6960	7192	7429	7584	8069
Public Health Technicians	5969	5969	5969	5969	5969
Total	**76881**	**95390**	**100301**	**95960**	**105369**

Source: Economic Survey, 2013

According to the MOH projections in *table 5* below, projections for growth in health workers is bound to grow to **315,557** workers by **2030.** To prevent further loss of medical workers in the line of duty during epidemics urgent adoption of "RIGHT" technology is necessary. There is every plea to ensure not only safe distancing but also limitation of contact within health facility premises between frontline health workers and patients with highly contagious diseases like COVID-19, Ebola and SARS etc.

Table 5: Projections of general practitioners, Clinical Officers and Nurses 2013-2030

Cadre		2013	2015	2020	2025	2030
General Practitioners	Active	3,443	4,148	6,051	8,117	10,310
	Norm	7,551	7,939	9,038	10,275	11,682
	Gap	4,108	3,801	2,987	2,159	1,372
Clinical Officers	Active	7,043	9,656	16,021	22,658	29,438
	Norm	15,447	16,261	18,488	21,019	23,898
	Gap	8,404	6,696	2,466	-1,638	-5,541
Nurses	Active	34,381	38,911	54,564	73,666	97,157
	Norm	75,407	79,379	90,249	102,607	116,658
	Gap	41,026	40,468	35,685	28,941	19,501

Source: MOH, USAID and Funzo Kenya, September 24, 2013

6.0 THE CONCEPT

The need to provide an ALWAYS ON broadband connectivity to every health facility is more priority now with COVID-19 epidemic than ever before. Telemedicine and telehealth service providers are present in most health sectors, yet the impact is still low. The high cost of infrastructure ownership and bandwidth is a major limitation to widespread adoption of telemedicine and telehealth.

Hospitals, clinics, and dispensary have had to lease or procure broadband services at prevailing market prices. The high prices and ever-increasing demand for more bandwidth has limited adoption of new ICT technologies in health services. This limitation can only be overcome through facilitation of broadband connectivity through a single National Health Communication Infrastructure (NHCI).

This broadband infrastructure must be high capacity technology with low total cost of ownership. The infrastructure must allow open access and "ALWAYS ON" model 27/4 to ensure hospitals and health workers benefit from widespread adoption of telemedicine and telehealth. The solution is transformation of the supply grid to provide access to electricity and broadband connectivity. The concept provides for deployment of fiber optic cable infrastructure onto existing and new electricity grid to provide access to high speed broadband/Internet infrastructure. All grid connected health facilities are expected to have access to high speed broadband network via the electricity supply grid. The aerial fiber optic infrastructure runs to interconnect all designate health facilities. Transmission, distribution, and last mile segments of the grid are integrated with fiber optic cable. This model provides open access network where available dark fibers are assigned to specific services. The electricity utility provider assigns some dark fiber cores for distribution automation of the power grid to enhance quality of services and availability. Surplus dark fiber(s) are assigned/leased for use under the *proposed National Health Communication Infrastructure*. Under this concept, Level 6 Referral Hospitals, Level 5, Level 4, Level 3, Level 2, and Level 1 are interconnected into one network.

7.0 A CASE FOR KENYA POWER CO.PLC

The company, licensed distributor of electricity owns and operates an extensive grid comprising transmission, distribution and last mile as detailed in table 6 and 7 below.

Table 6: Growth of Transmission, Distribution and Last mile Network in Kenya Power and Lighting Co. Plc

VOLTAGE	2013/14	2014/15	2015/16	2016/17	2017/18
400 kV	-	-	-	96.8	1244.4
220 kV	1,248	1,352	1,452	1,555	1,686
132 kV	2,797	2,824	3,087	3,208	3,322
66 kV	928	952	977	1,000	1,168
33 kV	20,778	21,370	27,497	30,846	34,508
11 kV	30,860	32,823	35,383	37,234	38,968
Total HV and MV	**56,611**	**59,322**	**68,396**	**73,940**	**80,897**
415/240V or 433/250V	-	-	110,778	139,642	152,803
TOTAL	**56,611**	**59,322**	**179,174**	**213,582**	**233,700**
% INCREASE P.A.	**14.0%**	**4.8%**	**15.3%**	**19.2%**	**9.4%**

Source: www.kplc.co.ke - Annual Report and Financial Statement Period 2017/2018

Table 7: Transformers in Service installed capacity

Transmission Substations					
132/220 and 220/132kV	835	1,266	1,266	1,266	1,350
220/66kV	450	450	720	720	1,111
220/33 kV	46	69	69	69	69
132/66kV	360	420	420	600	600
132/33kV	916	939	1,229	1,721	1,721
132/11kV	-	-	-	-	15
TOTAL	**2,607**	**3,144**	**3,704**	**4,376**	**4,866**
Distribution Substations					
66/11kV	1,838	2,139	2,345	2,465	2,670
66/33kV	138	138	138	138	161
40/11kV	-	-	-	-	-
33/11kV	1,200	1,295	1,365	1,453	1,541
TOTAL	**3,176**	**3,572**	**3,848**	**4,056**	**4,372**
Distribution Transformers					
11/0.415kV and 33/0.415kV	**6,317**	**6,384**	**7,088**	**7,276**	**7,606**

Source: www.kplc.co.ke - Annual Report and Financial Statement Period 2017/2018

KPLC Co. Plc has deployed over an estimated 4700 km of dark fiber optic infrastructure on the power grid. Dark fibers are used internally for supervisory control and data acquisition network (SCADA), billing and data networks. Surplus fiber optic capacity is however leased for revenue generation.

Table 8 below show the different technologies in the power grid.

Table 8: Optical Technology in Power Grid

	Power-Grid Segment	Voltage Level (V)	Fiber optic Technology
1	Transmission	132 kV & above	Optical Ground Wire -OPGW
2	Distribution	66kV, 33kV, 11kV	All Dielectric Self Support - ADSS
3	Last mile	415V & 240V	ADSS

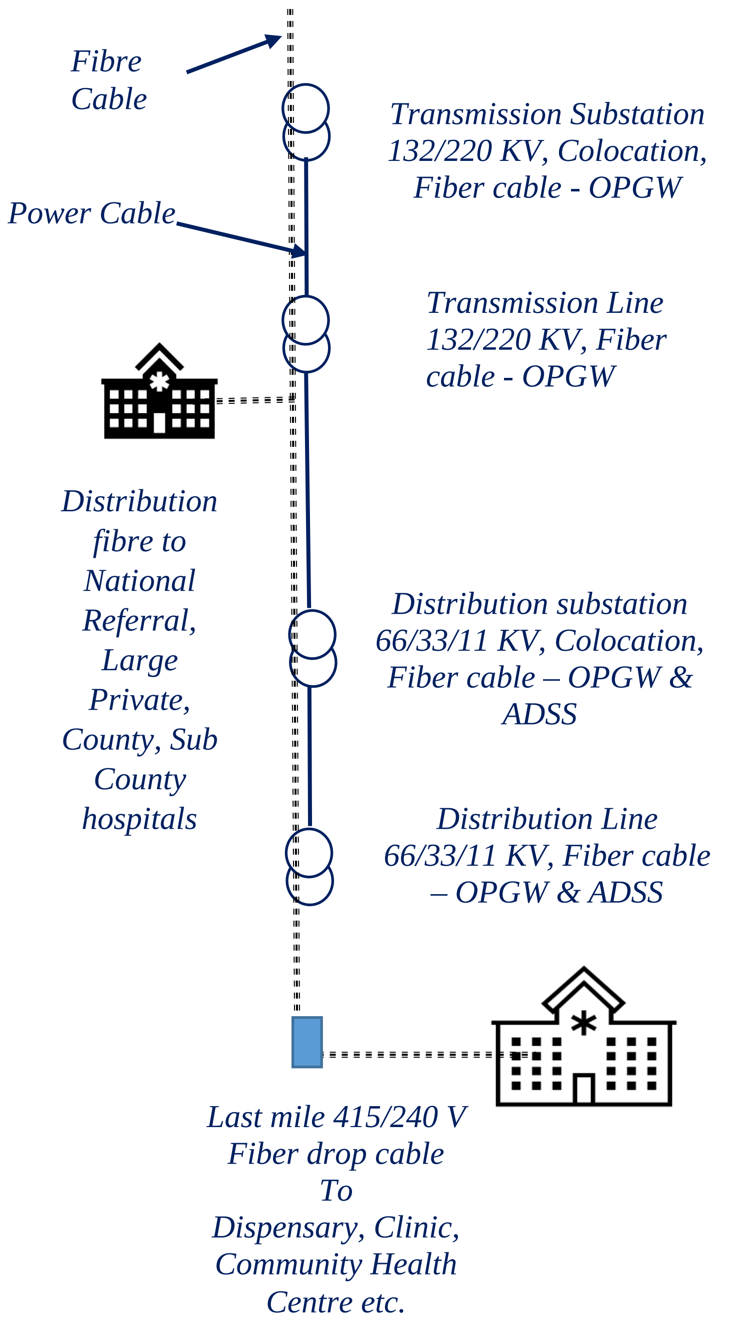
Source: Author 2020

With a countrywide grid connectivity, refer table 6 and 7 above, KPLC. Co. Plc dark fiber network can be extended to reach all grid connected health facilities countrywide. Aerial deployments are cost effective (*3 times cheaper than underground option*), faster, and environmentally friendly. The model offers least TCO model and provides an open access where dark fibers are available for dedicated applications end to end.

All grid connected health facilities, just like other customers of electricity are supplied by specific distribution transformer. *See below figure 2.*

Aerial deployment of fiber optic cables run end to end from transmission substations to distribution substations, transformers, and fiber access terminals FAT/Access Terminal Boxes-ATB in the premises under emerging fiber to the home FTTH technologies.

. ***Figure 2: Proposed Fiber Optic Connectivity for Universal National Health Communication Infrastructure – Passive Layer***



Source: Author 2020

There are intermediary points for jointing and access. The utility power station control facilities provide space for colocation of terminal equipment. These may be access terminal boxes (ATB), optical distribution frames (ODF), patch panels or aerial jointing /splice boxes.

Scalable broadband links are implementable depending on capacity of the terminal equipment. All targeted hospitals, medical and research institutions within a direct distance of 80 Km or less interconnect directly without additional amplification separately.

Health facilities over 100Km spans require separate amplification or boost. Fiber strand counts of 12, 24, 48, 96, 144, 244 etc. available. Assigning services can dedicated per core strand /pair end to end. Fiber connects and integrates all other wireline and wireless technologies inter-site. This enables either.

- *Fiber to fiber connections within the hospital's functions /areas.*
- *Fiber to enhanced Digital subscriber DSL technologies on copper.*
- *Fiber to Wireless Fidelity Wi-Fi technologies*
- *Fiber to WiMAX*
- *Fiber to mobile GSM (3G, 4G, 5G) etc.*

within health facility premises.

7.1 STANDARDS AND INTERFACES

Fiber optic technology has various standards. **IEC 60793** and **IEC 60794** fiber optic cable standards define specifications and types of cables **G 652** and **G652D** used in both **OPGW** and **ADSS** applications.

Telemedicine and Telehealth services (Teledermatology, Telepathology, Telepsychiatry, Teleradiology), generate different traffic formats ranging from audio, graphic, video, pictorials etc.

7.2 BIG DATA, ANALYTICS (AI) AND IoT

Medicare is known as the most confidential in data generation, security, and analytics. This is because the data requires high security and integrity measures as it determines health of the people.

The success of modern medical care and research is largely dependent on in-depth application of data analytics and or artificial intelligence (AI). Big data forms the basis for the collection of data. Data security, credibility and privacy is therefore principal in the strategy for telemedicine or telehealth. Fiber optic technology is the only technology with such high intrusion protection at the physical layer due to electromagnetic immunity.

This concept provides for implementation of IoT or Internet of medical things (IoMT) ready infrastructure. IoT /IoMT devices connect with reliable and high capacity fiber optic technology that supports integration of all other wireless and wireline technologies.

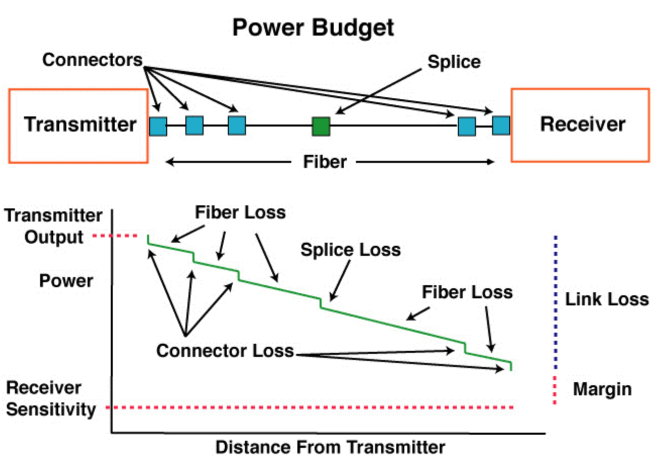
8.0 DESIGN CONSIDERATIONS

The point-to-point links designed to ensure optimal operation. Assuming a point to point link between any two (2) hospitals, the terminal equipment must be capable to overcome the link loss budget.

Calculation

Atypical loss profile for a dark fiber link is shown in figure below.

Figure 3 Loss Profile for a Fiber Optic Link



Source: (The FOA Reference for Fiber Optics - Fiber Optic Network Design, n.d.)

Transmit Equipment Power (dB) – Link Loss Budget > Receiver Sensitivity (dBm)

Cable Plant Link Loss Budget Analysis

Refer table 9,10,11,12,13, and 14 for end to end design steps.

Step 1. Calculate fiber loss at the operating wavelengths (850nm,1310nm,155onm)

Table 9: Fiber Loss

	Item	
1	Fiber cable length (km)	K
2	Fiber type	*Single/Multimode*
3	Wavelength	W
4	Fiber Attenuation	A
	Total Fiber Loss (dB)	= (K*A)

Source: Author,2020

Step 2. Connector Loss

Table 10: Connector Loss

	Item	
1	Connector Loss (dB)	K
2	Fiber type	*Single/Multimode*
3	Wavelength	W
4	Fiber Attenuation	A
	Total Fiber Loss (dB)	= (K*A)

Source: Author,2020

Step 3. Splice Loss

There two (2) types of splices namely fusion and mechanical. Splices on multimode fibers have an average loss of 0.3 dB (*EIA/TIA 568 standard*) and fusion splices on single mode are 0.05 dB.

Table 11: Calculation of Splice Loss

	Item	
1	Splice loss (dB)	X
2	No of Splices	Y
3	Total Splice loss (dB)	(X*Y)

Source: Author, 2020

Step 4. Total Cable Plant Loss

Table 12: Calculation of Total Cable Plant Loss

	Item	
1	Wavelength (nm)	V
2	Total Fiber loss (dB)	W
3	Total Connector Loss (dB)	X
4	Total Splice Loss (dB)	Y
4	Other (dB)	Z
	TOTAL	***W+X+Y+Z***

Source: Author, 2020

Step 5 Equipment Loss Budget

This is the difference between the receiver (Rx) sensitivity and the output of the source (transmitter Tx) into the fiber

Table 13: Active Component

	Item	
1	Operating Wavelength (nm)	V
2	Fiber Type	
3	Receiver Sensitivity *(dBm@ required BER)*	W
4	Average Transmitter Output (dBm)	X
5	Dynamic Range (dB)	X-W
6	*Recommended Excess Margin (dB)*	

Source: Author, 2020

Step 6. Loss Margin Calculation

It is expected that the link loss margin be greater than 3 dB as a general principle. This compensates for eventual link degradation and splicing.

Table 14: Link Loss Margin

	Item	
1	Splice loss (dB)	X
2	No of Splices	Y
3	Total Splice loss (dB)	(X*Y)

Source: Author, 2020

Link Loss Budget (dB) *= {(Average Loss (dB) per Km * Link Distance (kM) + Splice loss * No. of. Splices (dB) + Connector Loss(dB) * No. of Connectors + safety margin} ………………….….1*

9.0 RECOMMENDATION

1. For the success of Universal Health obligation and SDG 3, post COVID-19 period there must be realization of remote healthcare support. Crowding, asymptomatic cases, direct contact/interaction etc. has compounded and exposed frontline health workers and mounting casualties are evidence enough. Extension of utility fiber optic on electricity grid to offer broadband connectivity to all grid connected health facilities is clear. Adopt Telemedicine and telehealth across all the six (6) levels of healthcare structure in Kenya. This fiber network can provide redundant capacity where there are existing alternatives.
2. Development of policy guidelines to ensure all facilities that are grid connected enjoy full unlimited "Always ON" model 24/7 connectivity to realize proper safeguard to frontline health workers against pandemics like the COVID-19.
3. Ministry of Health MoH and partners to engage with the utility companies to advance and facilitate Proof of Concept – PoC for dark fiber extensions and lit services level implementation to provide reassurance of all facets of the concept.
4. Phased implementation of the proposed National Health Communication Infrastructure "*Passive Layer*". It is desirable to start with *Layer 6*, *Layer 5* and *layer 4* connectivity where congestion, crowding and need for telemedicine and telehealth is highest. Ref Appendix 1 for a proposed passive architecture.
5. Formation of Kenya Telemedicine Association KETA for advancing the understanding, interaction and development of telemedicine and telehealth in Kenya.

10. CONCLUSION

Over 10,000 healthcare infected with COVID-19 in Africa. According to Pan American Health Organization **570,000** health workers infected in America and **2,500** dead. These are catastrophic impacts where safe distance, wearing protective gears is commendable but require further intervention in health facility management for frontline workers.

Congestion and or overcrowding in health facilities compounded by asymptomatic cases have exposed healthcare personnel more. A sure way of the limiting this is urgent implementation of the fiber to healthcare institutions using existing utility grid connections. This provides an open access optical network where any service provider to provide affordable services can utilize the dark fibers. The cost in US dollar / Megabit for the competitive market are high for dedicated requirements of telemedicine and telehealth. *Refer appendix 2 for prevailing market rates.* The cost for 1Gbps would be very high. Current mobile broadband is effective and adequate for short intervals of communication. It is bandwidth limited and costly for higher capacities needed for ALWAYS ON, 24/7 model needed for telemedicine and telehealth respectively.

This passive layer network shall provide the much-needed connectivity between higher-level national referral, large private, county, and sub-county hospitals, dispensaries, clinics, and community health facilities into one network. This shall provide connectivity for telemedicine and telehealth services and serve as an Internet of Things (IoT) ready infrastructure. The same shall extend connectivity to data centers for warehousing and analytics.

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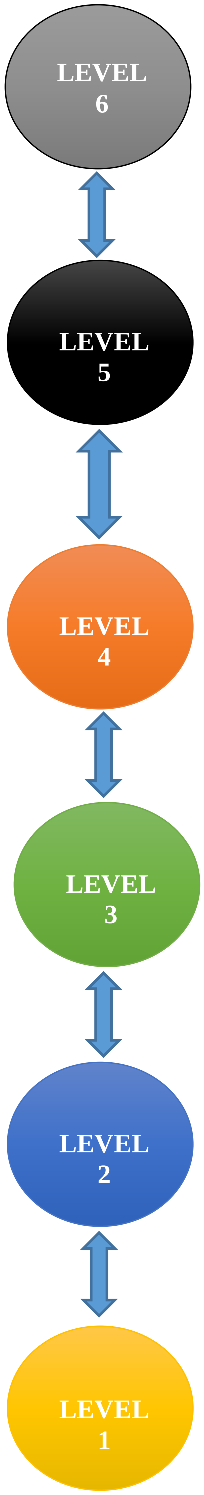
Appendix 2: Proposed Layer 1 Passive Network for National Health Communication Infrastructure NHCI



NATIONAL REFERRAL & LARGE PRIVATE, i.e. *KNH, MTRH, MATHARE*
Min Link Speeds > or = 1Gbps (1,000 Mbps), Team of Minimum Health Workers over 500 per facility. Application: Telehealth and Telemedicine *- Hospital Management, Internet-Web browsing, email communication etc., Access to Electronic Health Records (EHR), high-quality video consultations, Closed Circuit Television surveillance (CCTV), Real-time image transfer, Remote monitoring, HD video consultations, Integration of other wireless and wireline technologies within facility i.e. WiMAX, DSL, Wi-Fi Fiber, GSM etc.*

COUNTY REFERRAL & LARGE PRIVATE – *Nairobi, Aga-Khan, MP-Shah, Kakamega Etc.*
Min Link Speeds > or = 1Gbps (1,000 Mbps), Est Team of health workers between > 25. Application: Telehealth and Telemedicine *-Hospital management, email communication, web browsing etc., Access to Electronic Health Records (EHR), high-quality video consultations, Real-time image transfer, Remote monitoring, HD video consultations, CCTV surveillance, Integration of other wireless and wireline technologies i.e. WiMAX, DSL, Wi-Fi Fiber, GSM etc.*

SUB-COUNTY HOSPITALS AND MEDIUM-SIZED PRIVATE HOSPITALS; *Min Link Speeds > or = 100Mbps, Est team of health workers between 10-50*
Application: Telehealth and Telemedicine*-Hospital Management, email communication, web browsing etc., Access to Electronic Health Records (EHR), high-quality video consultations, Real-time image transfer, Remote monitoring, HD video consultations, CCTV Surveillance, Integration of other wireless and wireline technologies i.e. WiMAX, DSL, Wi-Fi Fiber, GSM etc.*

HEALTH CENTRES AND MATERNITY AND NURSING HOMES.
Min Link Speeds 25 - 100Mbps., Est team of health workers between 2-25. Application: Telehealth and Telemedicine*, email communication, web browsing etc., Access to electronic health records (EHR), high-quality video consultations, Real-time image transfer, Remote monitoring, HD video consultations, Integration of other wireless and wireline technologies i.e. WiMAX, DSL, Wi-Fi Fiber, GSM etc.*

DISPENSARIES AND CLINICS.
Min Link Speeds 10 - 25Mbps., Est team of health workers between 1-10
Application: Telehealth and Telemedicine*, Email communication, Internet / web browsing, Access to electronic health records (EHR), Supports practice management functions, Instantaneous use of EHR and high-quality video consultations, CCTV Surveillance, Non real-time image downloads, Remote Monitoring*

COMMUNITY SERVICES.
Min Link Speeds 4 – 10 Mbps., Est team of health workers between 1 – 10
Application: Telehealth and Telemedicine: *Supports practice management functions, email, Internet/web browsing, Concurrent use of Electronic Health Record (EHR), high-quality video consultations, non-real-time image downloads, Remote monitoring, CCTV surveillance etc.*

Source: Author,2020

Appendix 2: Typical Bandwidth Prices in the Telecom Market

1. Company 1.

Name	Download	Upload	Type	Price	Payments
Fiber	50 Mbit/s	512 kbit/s	Fiber to the home	$96,61	monthly
Fiber	20 Mbit/s	512 kbit/s	Fiber to the home	$53,15	monthly
Fiber	10 Mbit/s	512 kbit/s	Fiber to the home	$44,16	monthly
Fiber	1 Mbit/s	512 kbit/s	Fiber to the home	$28,98	monthly

Source: https://isp.today/en/o/Zuku-Fiber

2. Company 2

Name	*Download*	*Upload*	*Type*	*Price USD*
Fiber	*1-50 Mbit/s*	*512 kbit/s*	Fiber to the home	*$28,98 to 96,61*
Faiba Residential	*5-20 Mbit/s*	*5-20 Mbit/s*	Fiber to the home	*$48,33 to 193,33*
Faiba Business	*3-12 Mbit/s*	*3-12 Mbit/s*	Fiber to the home	*$96,66 to 289,97*

Source: https://isp.today/en/list-of-all-services/KENYA,toic-11

3. Company 3

Name	Download	Upload	Type	Price	Payments	FAP
Monthly Data Bundles	4.8 Mbit/s	1.1 Mbit/s	Mobile broadband	$2,42	monthly	350 MB
Monthly Data Bundles	4.8 Mbit/s	1.1 Mbit/s	Mobile broadband	$4,83	monthly	1 GB
Monthly Data Bundles	4.8 Mbit/s	1.1 Mbit/s	Mobile broadband	$9,66	monthly	3 GB
Monthly Data Bundles	4.8 Mbit/s	1.1 Mbit/s	Mobile broadband	$19,32	monthly	7,5 GB
Monthly Data Bundles	4.8 Mbit/s	1.1 Mbit/s	Mobile broadband	$28,99	monthly	12 GB

Source: https://isp.today/en/o/Monthly-Data-Bundles