Heart Attack Concern Kenya
P.O. Box 66286, Nairobi, 00800, KENYA
Tel: +254-79011199
www.heartattackconcern.org

Baseline Survey Report

Project: KENYA COUNTY PREPAREDNESS INITIATIVE: STEMI CARE

Agreement: Contribution Agreement (Philips Foundation)

Technical Team:

Caroline Mutai, Abdirizak Mohamed, Caleb Nyongesa Wanjala, Dr. Hassan Ahmed, Dr. Hazel Mburu, Dr. Ken Kipkulei, Dr. Hasham Varwani Mohamed

Project Manager:

Teddy Orachah

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

ACS : Acute Coronary Syndrome

ACLS : Advanced Cardiac Life Support

AMI : Acute Myocardial Infarct

BLS : Basic Life Support

ECG : Electrocardiogram

ICU : Intensive Care Unit

GIS : Geographic Information System

KEPH : Kenya Essential Package for Health

PPCI : Primary Percutaneous Coronary Intervention

SA : Spatial Accessibility

STEMI :ST- Segment Elevation Myocardial Infarct

ACKNOWLEDGEMENTS

Project Directors: Dr. Mohamed Jeilan, Dr. Hassan Adan

Principal Authors: Caroline Mutai, Teddy Orachah

Contributors: Dr. Caroline Gitonga

Design and Layout: Caroline Mutai

Data and GIS analysis: Caroline Mutai

1. Introduction and Background

A heart attack is associated with serious health complications and if no action is taken often leads to death. It is estimated that 50% of patients suffering from heart attacks die before arrival to hospital and Kenya experiencing a steep rise in disease burden from cardiovascular diseases (CVDs). A study conducted at the Kenyatta National Referral Hospital reported an in-hospital death rate of 21% due to heart attacks.

Heart attack care in Kenya faces major challenges. These challenges are compounded by lack of adequate interventions at primary care facilities and poor prevention measures, lack of early detection, poor treatment methods including misdiagnosis and ineffective referral process. These challenges are more visible in underserved communities, where socioeconomic barriers and inequalities in accessing treatment are more common.

Successful management of a heart attack in the early phase is time sensitive and requires correct recognition of symptoms, prompt diagnosis by ECG and urgent institution of treatment aimed at restoring blood flow in the blocked artery. Rapid transfer to a hospital capable of providing treatment and early management of complications is a key determinant of survival.

Heart Attack Concern Kenya (HACK) is implementing a Project funded by the Philips Foundation with the aim of improving heart attack care preparedness in county hospitals in 3 counties in Kenya. HACK was founded in 2017, as a not-for-profit organization in Kenya, with the aim of improving access to timely and quality treatment for patients suffering a heart attack. With the skills and knowledge of the team at HACK, who are healthcare key opinion leaders within Africa, HACK aims to use evidence to lobby county, national and regional governments to improve policy and investments in cardiac care. Through funding and support from Phillips Foundation, HACK envisions to create a model for end–to–end cardiac care system, within the counties of Garissa, Embu and Kiambu. These counties have been shown to have a high number of patients who are at risk of cardiovascular disease (high cases of patients with hypertension and diabetes mellitus). The aim of the Project is to use the learnings from the 3 counties to inform and lobby the Kenyan government to invest in a nationwide cardiac care model.

This report presents results from a baseline study conducted 6 health facilities in the 3 counties, to assess the preparedness for diagnosis and management of STEMI and inform the planning and implementation of the Project.

1.1. Project Description

Heart Attack Concern Kenya (HACK) is implementing the preparedness initiative to create a model for quality delivery of STEMI care in the county hospitals. The Project is set out to ensure county level health care workers are equipped with proper skills to diagnose and manage STEMI and with the help of the County governments we are able to mobilize and implement the project.

The HACK project aims to improve preparedness for recognition, diagnosis and prompt and appropriate treatment for heart attack patients through:

- Development of STEMI guidelines, training of health workers and mentorship
- Equipping of facilities with ECGs and training
- Strengthening heart attack referral systems
- Educating the public on recognition of heart attack symptoms and appropriate care
- M&E for learning and policy advocacy

1.1.1. Project theory of change

HACK hypothesizes that if heart attack care gaps are established based on needs assessment, and if hospitals are equipped with ECGs, and if healthcare workers and cardiologists are trained on acute heart attacks and referral networks strengthened, then preparedness and response to acute myocardial infarction at county hospitals is improved.

If public awareness campaigns are conducted on heart attack and cardiovascular disease and access to service centres and treatment options, and if response preparedness is implemented in health facilities, then acute myocardial infarction (AMI) identification and reporting shall be increased in Kenya.

If a hospital AMI preparedness pilot is successfully implemented, and if evidence of an effective preparedness model is generated and shared with key stakeholders, and if knowledge and learning are scaled, then decisions are influenced at policy making level.

If preparedness and response to acute myocardial infarction at County hospitals is improved, and AMI reporting rate is increased in Kenya and if decisions are influenced at policy making level, then AMI and the patient outcomes shall be reduced in Kenya.

This is assuming that physical safety of frontline healthcare workers shall not be jeopardized due to extremist or political activity, resurgence of COVID-19 shall not result in county travel bans, government shut down and cessation of all new projects, healthcare workers in union shall not go on strike, preventing selected staff from attending training or providing care at hospitals, COVID-19 health protocols shall not prevent large group trainings, that there shall be no delayed arrival of ECG at Level 4 & 5 hospitals due to bureaucracy, postponing launch of Heart Attack Centres, that release of funding from MoH to Counties shall not be delayed, preventing procurement of essential goods and equipment and blocking establishment of referral network, that hospital management shall input Key performance indicators (KPI) data on a monthly basis, that Kiambu County shall expedite the launch of Preparedness Survey, that focal points at hospitals shall not fabricate information on surveys, the HCWs will use the protocols and the knowledge gained from the trainings to improve quality of care and patient outcomes, that the IEC will lead to behavior change prompt care seeking and referral and lead to better outcomes, that the generated data and evidence will be used to inform policy.

1.1.2. Choice of Intervention

This baseline survey conducted before the implementation of the project gave us an in-depth understanding of the gaps in STEMI management. With the results of the survey, we would be able to tailor make interventions and create a model that would suit the setup in the county hospitals.

This baseline survey will also provide insights into some of the challenges the program might face during implementation and effective mitigation strategies would be drawn from the survey.

1.2. Literature review

1.2.1. Coronary Artery Disease

The last few decades have witnessed a considerable transition in the epidemiology of disease in low- and middle-income countries. Increasing urbanization and changing lifestyles have triggered an exponential rise in the frequency of coronary artery disease (CAD) risk factors in black Africans (MOH, 2015).

An acute myocardial infarct (AMI) is the most serious presentation of coronary artery disease (CAD) and is associated with serious morbidity and high mortality. It is estimated that half of all patients suffering from an AMI die before arrival to hospital. An ST elevation myocardial infarction (STEMI) occurs when there is an abrupt and complete occlusion of a coronary artery by cholesterol plaques and superimposed thrombus. This starves the heart muscle cells of nutrients and oxygen, leading to cell death and an array of complications.

Successful management of an AMI in the early phase is time sensitive and requires recognition of symptoms, prompt diagnosis by ECG and urgent institution of treatment aimed at restoring blood flow in the blocked artery. Rapid transfer to a hospital capable of providing this treatment and early management of complications such as cardiac arrest are key determinants of success.

In 2005, coronary artery disease caused approximately 361,000 deaths in the African region, and current projections suggest that this number will nearly double by 2030 (Mathers CD and Loncar D, 2006). Importantly, in people aged under 60 years, CAD has emerged the leading cause of death in men and the second leading cause of death in women in the African region. Considering that CAD was previously regarded as a rare disease in sub- Saharan Africa, these observations highlight the emerging burden of chronic non-communicable diseases (NCDs) that is now superimposed on the huge burden of infectious diseases, malnutrition, and social conflict that constitute Africa’s health challenges today (Mathers CD and Loncar D, 2006).

Traditionally, healthcare systems in sub-Saharan Africa (SSA) were designed to manage communicable and infectious diseases and are not optimally equipped to deal with the rising prevalence of NCDs

(Shavadia J, 2012). According to epidemiological data from the past decade, Kenya has experienced a steep rise in disease burden from cardiovascular diseases. These now account for 6.1 to 8% of all mortality while autopsy studies suggest that 13% of all-cause specific deaths among adults is due to CVD (World Health Organization, 2018). Heart attack management in Kenya faces major challenges that include limited capacity of health facilities to manage heart attacks due to lack of relevant equipment, commodities, medicines and adequately trained health workers that can recognize and manage heart attacks. There is also low level of awareness at the community level on the recognition of heart attack symptoms and other accessibility barriers such as affordability, distance, poor referral systems among others. Lack of political goodwill to invest in heart attack programmes, has also crippled the health system in preparedness and therefore an increase in mortality from non -communicable disease. Globalization, urbanization and lifestyle changes have exposed most individuals to non-communicable diseases in the rural and urban settings. This is compounded by lack of adequate intervention at primary care facilities, poor prevention, early detection, treatment and referral process. These challenges are particularly felt at the county level, where socio-economic barriers and inequalities in accessing treatment are more common.

A heart attack is associated with serious health complications and death. It is estimated that 50% of patients suffering from heart attacks die before arrival to hospital. Kenya has experienced a steep rise in disease burden from cardiovascular diseases (CVDs). A study conducted at the Kenyatta National Referral Hospital reported an in-hospital death rate of 21% due to heart attacks.

Successful management of a heart attack in the early phase is time sensitive and requires recognition of symptoms, prompt diagnosis by ECG and urgent institution of treatment aimed at restoring blood flow in the blocked artery. Rapid transfer to a hospital capable of providing this treatment and early management of complications such as heart failure or adverse effects such as death are key determinants of success. With timely and correct intervention, the recovery rate and functionality post heart attacks is generally good.

2. STUDY METHODS

2.1. Study objectives

The HACK Kenya County Preparedness survey's main objective was to carry out a situational analysis of select County hospitals to understand some of the challenge's Counties face in STEMI diagnosis and management.

The following were the specific objectives:

1. To determine the skill set in STEMI diagnosis and management of the healthcare workers in the County hospitals
2. To determine the level of preparedness of the County hospitals in STEMI management

2.2. Study design

The study was carried out as a cross sectional survey of the selected County hospitals in Embu, Kiambu and Garissa. This gave an in depth understanding of the gaps in the hospitals in terms of management of STEMI patients.

2.2.1. Data Collection

This survey was carried out by the project coordinators in each of the Counties and had a face-to-face interview with the Project focal point person, usually a County physician. The data were collected using a structured interviewer administered questionnaire which was later entered into the digital Kobo tool box. The questionnaire was in English. The questionnaire comprised of questions relating to skills in STEMI diagnosis and management of the health care workers, the availability of ECG machines in the emergency department, availability of thrombolytics, the rate of dissemination of cardiac enzyme results, the mode of patient transfer in case of emergencies, the existence of a STEMI and Cardiac protocol and heart attack referral networks.

To assess the level of STEMI management preparedness at the hospital level, a tool was created to benchmark the preparedness levels based on the assessment of constrains to STEMI management ranging from having STEMI protocols in place to having a referral system that works.

All the data collected was downloaded inform of a Micro Soft Excel for analysis.

Data of interest include:

1. Availability of essential medicines
2. Skill set of healthcare workers
3. Referral networks in place
4. Cardiac monitoring units and critical care
5. Emergency response and patient transfer
6. Perceived barriers.

2.3. Data analysis

Data analysis was done using MS excel and results interpreted and summarized. Preparedness was assessed using a preparedness criterion that assessed the availability of care protocols, availability of equipment and commodities for heart attack management and referral processes. The criteria scored each element on levels 1-5 as shown in Table 1.

Geographic Information System analysis was done using ArcMap and accessibility of health facility was done using AccessMod (Version 5).

Table 1: The elements for facility level preparedness for Acute Coronary Care that were assessed during the survey and their scoring level

	1	2	3	4	5	6	7	8	9	10	11	12
Level	**Chest pain Protocol**	**ECG Availability**	**ECG Interpretation**	**Troponin Testing**	**Aspirin Loading (300mg)**	**Anti-platelet therapy loading**	**Lysis Protocol**	**Thrombolysis**	**Monitoring**	**Resuscitation protocols**	**Defibrillator**	**Referral System**
5	In Situ and staff well versed	Within 10 minutes	Dedicated system to ensure interpretation within 10 minutes of performance. Referral processes and on-site interpretation included	Result within 60 minutes	Can be given at on arrival and within 10 minutes	Can be given at on arrival and within 10 minutes	In situ and staff we'll versed	Available at entry point. Can be given within 20 minutes of ECG	ECG and hemodynamics monitoring in ER and ICU/HDU level with spare available	Appropriate staff mandated to complete ACLS course. At least two per shift	Functioning and in ER and HDU	In situ and staff well versed
4		Within 30 minutes	No dedicated system. ECGs can be reported via informal network within 30 minutes	Result within 120 minutes	Available and can be given within 30 minutes	Available and can be given within 30 minutes		Available at entry point. Can be given within 60 minutes of ECG	ECG and hemodynamics monitoring in ER and ICU/HDU level. No spare available			Staff not well versed
3	In place. Staff not well versed	Within 90 minutes	Within 90 minutes	Result within six hours	Available and can be given within 90 minutes	Available and can be given within 90 minutes	In place. Most staff not well versed	Not available at entry point or cannot be given in 60 minutes	ECG and hemodynamics monitoring in either ER or ICU/HDU but not in both level	Less than 30% staff on shift able to do this	One in hospital	Informal processes exist but not formalized
2		Within 3 hours	Within 3 hours informally	Result within 12 hours	Available within 3 hours	Available within 3 hours		Available within 3 hours	Only one of the above available, but not both, within the ER or HDU level areas			Process depends on person to person referral
1	Not in place	Greater than 3 hours	Greater than 3 hours	Greater than 12 hours to get the result	Not available	Not available	Not in place	Takes more than three hours to access	Not in place	Not in place	Not in place	No process demonstrated

2.4. Ethical Consideration

Ethical approval was obtained from the AMREF Ethical and Research Committee and the research permit was obtained from the National Commission for Science, Technology & Innovation (NACOSTI). Permission to conduct the study was obtained from the County departments of health in the three counties. A memorandum of understanding to undertake the Project including the surveys was signed by HACK and the County governments in the three counties.

Confidentiality was maintained by the project team and patient names; contacts and other personal details were not collected at any point.

Information collected was stored safely in a password protected computer and was kept confidential and was accessible to the research team only.

3. STUDY FINDINGS

The survey was carried out in the 6 Project health facilities in Garissa, Embu and Kiambu Counties in December 2020. Garissa County is located in North Eastern region of Kenya comprising six sub-counties. It has a total population of 841,353 people with a total number of 126 health facilities. Embu County is in the former Eastern province of Kenya. Embu County serves a wider population in the Mt. Kenya region with a rising burden of cardiovascular disease. Embu county has a population of 608,599 people, of this 304,208 are male and 304,367 are female as per the 2019 national census data. Embu County has a population growth rate of 1.4% per annum. The county has 173 healthcare facilities comprising of private, non-governmental, faith based and public. Kiambu County is located in the central region of Kenya. The County covers a total area of 254.5km2 and has a total population of 2,417,735 as per the 2019 national census. The county has both private and public health facilities providing services to its population.

The study facilities included one county referral hospital (level 5) and a selected sub-county hospital (level 4) in each county. In Garissa County, the Garissa Provincial General Hospital (GPGH) and Iftin Sub-county Hospital were included in the survey. Garissa PGH is a level five hospital located in Garissa town and has a 4-bed ICU and continuous monitoring of critical patients can be done in the ICU and HDU. Iftin level 4 hospital is a 24-bed hospital serving the Iftin sub-County in Garissa. In Embu County, Embu Level 5 hospital and Siakago level 4 hospital were included in the Project and the survey. Embu level 5 is a 618-bed hospital located in Embu town. The hospital has an ICU and HDU. Siakago (Mbeere) level 4 in Mbeere district with 42 bed facility with no ICU and HDU. It can have a turnover of 500 patients daily. In Kiambu County, Kiambu level 5 and Kihara level 5 facilities were included in the study. Kiambu level 5 is a 361-bed facility with a turnover of more than 2000 patients daily. The hospital has a recently established ICU. Kihara level 4 is an 84-bed facility located in Gachie Kiambu. The level 5 hospitals are better staffed with specialists, doctors, nurses and other cadres of staff.

3.1. STEMI preparedness

The facilities were assessed on the availability of facilities for diagnosis, treatment, management and referral of STEMI using the criteria in Table 1. Table 2 presents the findings of the STEMI preparedness assessment in the 6 hospitals.

3.2. STEMI diagnosis

None of the hospitals had chest pain protocols to guide health workers in the diagnosis and management of chest pain, Table 2. On availability of ECG and interpretation of the results, none of the hospitals had the capability of performing an ECG within minutes as recommended and interpreting the findings.

Table 2: The level of heart attack management preparedness in the 6 County hospitals assessed in the HACK project baseline assessment.

County	Hospital	Level of heart attack preparedness based on the 12 elements criteria											
		Chest pain Protocol	ECG Availability	ECG Interpretation	Troponin Testing	Aspirin Loading (300mg)	Anti-platelet therapy loading	Lysis Protocol	Thrombo-lysis	Monitoring	Resuscitation protocols	Defibrillator	Referral System
Garissa	Garissa level 5	Not in place	Within 90 minutes	Within 3 hours informally	Result within 120 minutes	Available and can be given within 90 minutes	Available and can be given within 90 minutes	Not in place	Available within 3 hours	ECG and hemodynamics monitoring in either ER or ICU/HDU but not in both level	Not in place	One in hospital	Informal processes exist but not formalized
Garissa	Iftin level 4	Not in place	Greater than 3 hours	Within 3 hours informally	Result within 12 hours	Not available	Not available	Not in place	Takes more than 3hrs to access	Only one of the above available, but not both, within the ER or HDU level areas	Not in place	Not in place	No process demonstrated
Embu	Embu level 5	Not in place	Within 90 minutes	Greater than 3 hours	Result within six hours	Available and can be given within 90 minutes	Not available	Not in place	Takes more than 3hrs to access	ECG and hemodynamics monitoring in either ER or ICU/HDU but not in both level	Not in place	One in hospital	Informal processes exist but not formalized
Embu	Siakago level 4	Not in place	Greater than 3 hours	Greater than 3 hours	Result within 12 hours	Available within 3 hours	Not available	Not in place	Takes more than 3hrs to access	Only one of the above available, but not both, within the ER or HDU level areas	Not in place	Not in place	Informal processes exist but not formalized
Kiambu	Kiambu level 5	Not in place	Within 3 hours	Within 3 hours informally	Result within six hours	Available and can be given within 30 minutes	Not available	Not in place	Takes more than three hours to access	Only one of the above available, but not both, within the ER or HDU level areas	Not in place	One in hospital	Process depends on person to person referral

County	Hospital	Level of heart attack preparedness based on the 12 elements criteria											
		Chest pain Protocol	**ECG Availability**	**ECG Interpretation**	**Troponin Testing**	**Aspirin Loading (300mg)**	**Anti-platelet therapy loading**	**Lysis Protocol**	**Thrombo-lysis**	**Monitoring**	**Resuscitation protocols**	**Defibrillator**	**Referral System**
Kiambu	Kihara level 4	Not in place	Within 30 minutes	Reported via informal network within 30 minutes	Result within six hours	Available within 3 hours	Not available	Not in place	Takes more than 3hrs to access	Available within 3 hours Only one of the above available, but not both, within the ER or HDU level areas	Not in place	One in hospital	Process depends on person to person referral

Kihara level 4 hospitals had access to an ECG within 30 minutes and the results could be interpreted through informal channels within 30 minutes. Garissa and Embu level 5 hospitals had access to an ECG within 90 minutes while the rest of the facilities access to an ECG was within 3 hours, in Kiambu level 5, or greater than 3 hours in the other 2 facilities.

None of the hospital had facilities for cardiac troponin testing within 60 minutes of receiving a patient with chest pain. Only Garissa Level 5 hospital had the capability to provide Troponin testing within 120 minutes, the rest of the hospitals provided testing within 6 hours to 12 hours. Cardiac Troponin levels are essential in the definitive diagnosis of myocardial infarction.

3.3. STEMI management and treatment

Preparedness for STEMI management was assessed checking the availability of loading aspirin, antiplatelet therapy, thrombolysis, monitoring and resuscitation. Only Kiambu level 5 hospital could provide 300mg loading aspirin within 30 minutes while loading aspirin was not available in Iftin level 4 hospital. The rest of the hospitals could provide loading aspirin with 90 minutes to 3 hours, Table 2. Loading anti-platelet therapy was only available in Garissa level 5 hospital. None of the other hospitals could provide anti-platelet therapy.

None of the hospitals had a lysis protocol in place. Garissa level 5 facility had the capability of providing thrombolysis within 3 hours while it took more than 3 hours in the rest of the hospitals. In all the facilities ECG and hemodynamics monitoring was available in either emergency department or the ICU/HDU.

Resuscitation protocols were unavailable in all the hospitals. Garissa, Embu and Kiambu level 5 hospitals had a defibrillator within the hospital. None of the level 4 facilities had a defibrillator.

3.4. Referral

No formal referral systems existed in any of the hospitals for referral of suspected STEMI patients. Informal referral processes were reported in all the facilities expect Iftin level 4 where there was no referral process at all.

4. DISCUSSION AND CONCLUSION

The baseline assessment was aimed at providing information on the level of preparedness for STEMI management in the 6 hospitals before the implementation of the Project. The results provide evidence that the County hospitals, both level 4 and 5, are not able to diagnose and manage myocardial infarctions. STEMI management needs a systems approach and as seen in the Counties these are not available. Basic heart attack equipment's such as ECG, defibrillators and monitors are lacking in the emergency units and if available, then they are not functional and or the medical health practitioners are not equipped with the right skills to use them. Further, lack of access to thrombolytics is a clear indicator of the likelihood of adverse outcomes.

The skill set of the County personnel to diagnose and manage STEMI was very low. Majority of the health workers lacked basic skills to perform and interpret ECGs. Transport systems such as lack of an ambulance service with a defibrillator and 12-lead ECG was quite low and the referral system in the Counties were non-existent. Catheterization facilities in Kenya are few and most are found in the urban areas making accessibility difficult and services are quite expensive for majority of Kenyans (see GIS analysis). Therefore, thrombolytic therapy should be readily available in the counties. This will stabilize patients as they plan to transfer the patients to PCI capable centers. Preparedness for comprehensive care from prevention, early diagnosis to treatment and complication management of ACS at the County hospitals is sub-optimal due to critical gaps in health facilities in these counties. These gaps highlight need for strengthening of County health care systems for scaling up of interventions for prevention and management of chronic diseases to achieve the goal of universal health coverage. The results will be used to design a package of interventions for the county heart attack preparedness Project.

5. References

Ministry of Health, Kenya. (2015) Kenya STEPwise survey for non-communicable diseases risk factors 2015 report. https://www.health.go.ke/wp-content/uploads/2016/04/Steps-Report-NCD-2015.pdf. Accessed, October 2021.

Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 2006 Nov;3(11):e442. doi: 10.1371/journal.pmed.0030442. PMID: 17132052; PMCID: PMC1664601.c

Shavadia J, Yonga G, Otieno H. A prospective review of acute coronary syndromes in an urban hospital in sub-Saharan Africa. Cardiovasc J Afr. 2012 Jul;23(6):318-21. doi: 10.5830/CVJA-2012-002. PMID: 22836154; PMCID: PMC3734739.

World Health Organization. (2018). Technical package for cardiovascular disease management in primary health care: healthy-lifestyle counselling. World Health Organization. https://apps.who.int/iris/handle/10665/260422. License: CC BY-NC-SA 3.0 IGO. Accessed, October 2021.

SUPPLEMENTARY: GIS ANALYSIS

1. SPATIAL ANALYSIS FOR HEALTHCARE ACCESSIBILITY

Accessibility is a measurement of how easily and how many opportunities are accessible at different locations. It is not just about the travel time (mobility) provided by transport systems but also the distribution of opportunities or destinations and individual's socio-economic characteristics (Hansen, 1959) Accessibility of healthcare services by population varies across space due to uneven distribution of healthcare services and consumers and also a geographical factors such as location of health facilities.

Accessibility of healthcare facilities can be both spatial and non-spatial or potential versus realized accessibility (Khan, 1992). Potential accessibility is defined as when a needy population coexists in space and time with a willing and able healthcare delivery system. Realized care, sometimes referred to as actualized care, follows when all barriers to provision are overcome.

Spatial accessibility (SA) looks at the barriers that must be overcome to reach a service area while non-spatial accessibility focuses on the socio- economic aspect of the population such as age, gender, financial status (income) and ethnicity. Barriers have been grouped into five categories; accessibility, affordability, availability, accommodation and acceptability (Roy Penchansky, D.B.A; J.William Thomas, n.d.)

In developed countries, SA has been used to determine the accessibility of healthcare services. In the United States, SA has been used since the 1970 and has been able to inform policy and planning. Distance was viewed as one of the barriers to access of healthcare services (Hunter et al., 1986) Literature on SA has clearly shown that social inequity in spatial distribution of health care providers including primary care providers but little is known about the effects of SA in healthcare delivery.

A study done in China, looked at the hierarchical facility accessibility to determine the location of facilities using the two-step floating catchment area hierarchical method 2SFCA (H2SFCA) and revealed that the supply of healthcare resources at primary facilities is far from sufficient and in order to improve spatial accessibility to hierarchical healthcare facilities, some actions needed to be taken at each level (Tao et al., 2020)

Similarly, Fortney and Colleagues showed that travel distance affected the probability of utilization of mental health and alcoholic treatment services (Fortney et al., 1999) and increase of travel distance affects the health seeking behavior of a population at a particular area. This was evidently illustrated by Athas et al (Athas et al., 2000) in his article on utilization of breast cancer treatment.

In low- and middle-income countries, SA and the use of GIS to determine access is still at its infancy stage but strides have been made to use GIS for accessibility of primary health centers. In Niger, a study by N. Oliphant et al demonstrated the accessibility of health posts by community health volunteers by modeling travel times to community health posts and results showed an increase in accessibility from 0% to 17% between 2000 and 2013 (Oliphant et al., 2021). Similar studies have been carried in Uganda to determine access to healthcare which revealed a widespread disparities in accessibility between regions, using the policy relevant threshold of ensuring people live within 1 h of the nearest health facility (Ouma et al., 2021) and also as a tool to determine the stunting rates of children under 5 years in Ghana. The prevalence maps showed that environmental factors contributed to stunting among these children (Aheto & Dagne, 2021).

In Kenya, SA has been used to model the accessibility of urban areas using boda-boda and found that 84% of the population can access an urban centers within 1 hour (Macharia, Mumo, et al., 2021) as well mapping the child survival patterns in the last 22 years and the results revealed lives lost were due to high declining parity (Macharia, Joseph, et al., 2021)

GIS in public health has had a tremendous growth because of the availability of various technological information services and software. Therefore, SA has been used to clearly answer health problems in different geographical areas by modeling scenarios using the barriers populations face in order to access health care and these results in western countries has been used to inform policy and measures be placed in order to reduce the effects of these barriers.

1.1. Introduction

Healthcare planning and provision is a critical matter to the well-being of a population. Accessibility of health care facilities differs in terms of health care needs and accessibility by the population. In this regard planning involves mostly the accessibility and distribution of health facilities in the Country.

The levels of care of healthcare facilities and its distribution also plays a vital role in the distribution of healthcare personnel and equipment's and the population demand for the different facilities.

Geographic Information System (GIS) has formed the basis in decision making in most developed countries and has played a vital role in decision-making and economic planning.

Spatial analysis requires an integrated use of information from a multitude of sources both at local and at national government. In most developing Countries, the use of GIS has been hampered by the lack of accurate, detailed, and spatial demographic data use and has not been able to use it to determine the accessibility and distribution of health facilities across the countries.

In Kenya, GIS is still at its infancy stage in healthcare systems in understanding the distribution of disease, health facility accessibility and distribution. Therefore, we are going to use GIS to understand the distribution and accessibility of Cath lab facilities and Cardiologists in Kenya. Spatial analysis will involve the use of a AccessMod 5 tool to determine time to revascularization therapy and the geographic barriers involved in the accessibility of facilities for patients suffering from ACS and STEMI. This will provide information on the referral system between health facilities in the Counties.

We will also have a county accessibility map indicating the access of counties to the Cath lab facilities within 2hrs in Kenya. This will give an overview of the counties where patients are at risk of developing adverse cardiac outcomes due to the inaccessibility of the Cath lab facilities. To determine the impact of equipping facilities to be STEMI prepared, a map was created to show the difference in counties at risk and the accessibility.

1.2. Geographic accessibility

Geographic accessibility refers to the ease of individuals accessing health facilities from one facility to the next. This can be determined by population distribution, transport infrastructure and the distribution of health facilities. Geographic accessibility can be measured in three different ways, provider versus people, distance, and travel time to facilities. Spatial analysis tools that can best outline geographic accessibility are Kernel density, network analysis, cost-distance analysis, gravity models and Euclidean analysis.

For the purposes of determining the least cost time and modeling our data as per the travel time, we are going to use the cost distance spatial analysis to determine the accessibility of Cath lab facilities and the population at risk within the revascularization therapy time, which is 120 minutes.

1.3. Cost distance analysis

Health seeking behavior among populations is dependent on several factors such as financial ability, economic status, and geographic location of facilities. To determine accessibility of health facilities by individuals, we calculated the least cost path a person would take to reach a Cath lab facility. Cost in this case has been defined as time. Geographic barriers such as water bodies, forests and rivers were considered in the analysis. For this modeling study, we used data of Kenya's Cath lab facilities from Regional Center for Mapping of Resources for Development (RCMRD) and roads to determine the least cost distance a patient would take to seek revascularization therapy for the management of STEMI in Kenya.

Travel scenarios used in this modeling were: 1) Walking, ii) bicycle, iii) motorcycle, iv) vehicle transport. These travel scenarios were based on the land surface and the type of roads in Kenya. Mean travel time was based on the type of travel scenario and ranged between 1 and two hours with up to 110km/hr. in distance.

1.4. Methodology

We used the health facility shapefile from RCMRD and included Cath lab facilities and those facilities that have access to a cardiologist. For hospitals with incorrect coordinates, we geocoded facilities using ArcMap and world map. We obtained the total population from the world population geoportal for 2020. As for the travel distance, we gathered the road network data from RCMRD and open street map using arc map (version 10.6). Using the road network, facilities, and the population, we created a travel impedance, which was later used to create a cost distance set of rules based on the location of the Cath lab facilities using the AccessMod (version 5). This enabled us to compute the proportion of population at risk of developing adverse cardiac outcomes due to lack of access to revascularization therapy. We obtained the county map using the population map and this gave an outline of the counties able to access Cath lab facilities before and after upgrade.

1.5. Results

Accesibility of healthcare facilities

We used three scenarios to model the accessibility of Cath Lab facilities in Kenya. The first scenario we used a walking distance with a speed of 5km/hr keeping in mind the barriers set while accessing health facilities. We also modeled our accessibility by using the motorized model and results showed the accessibility to the Cath Lab facilities in the urban areas be accessed by cars at a speed of 80km/hr. This can be attributed to the fact that the road networks in these counties are better and healthcare services can be accessed easily.

The results showed the Cath-Lab facilities accessibility is more than 2hrs for majority of the Counties and very few Counties that were near the facilities could access them within 30 minutes and 60 minutes respectively. These are the facilities within a road network and in an urban area.

Figure 1: Accessibility of Cath-Lab facilities within 2hrs

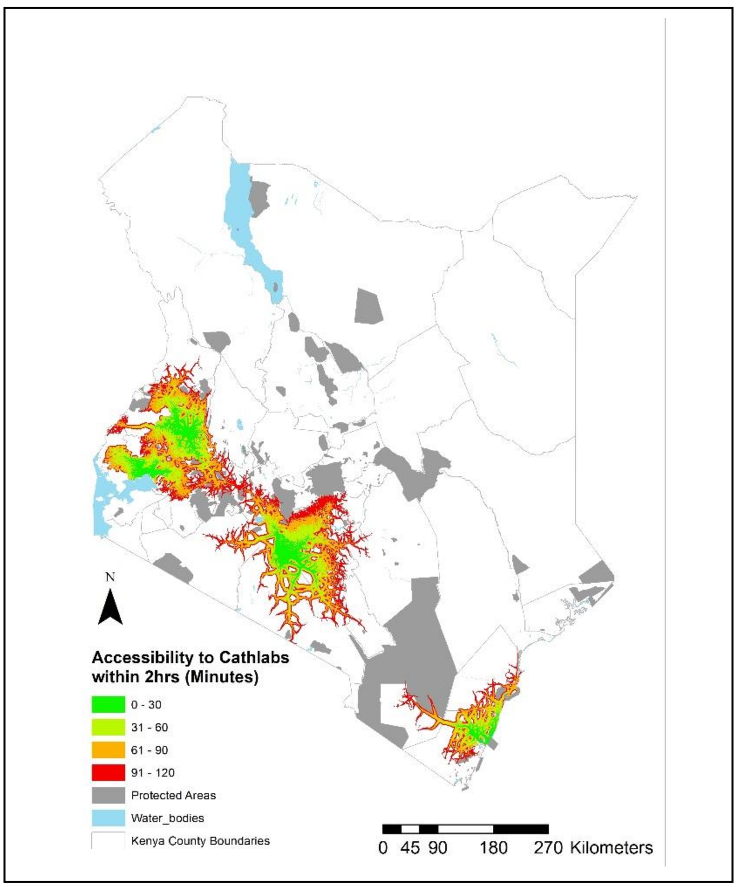
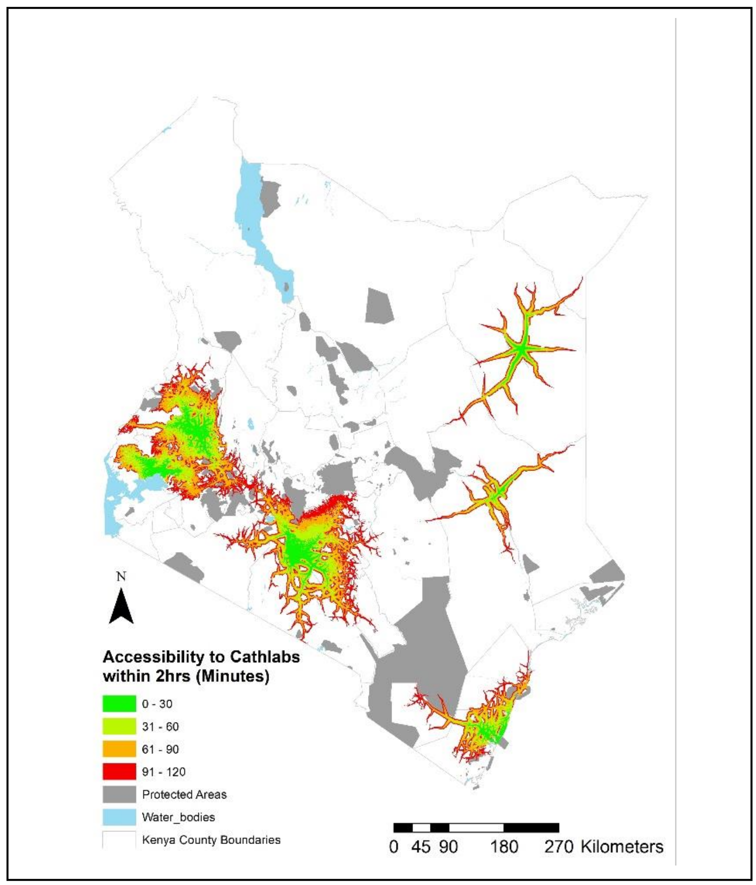


Figure 2: Accessibility of Cath-Lab Facilities with upgrade of Level 5



Majority of North Eastern part of the country can only access the Cath Lab facilities in more than 2hrs, increasing the likelihood of developing adverse cardiac outcomes. The recommend time to a Cath-Lab facility is within 120 minutes. A second analysis was done to determine the accessibility if the level 5 hospital would be equipped to be STEMI prepared. The results showed that the upgrade of the facilities would greatly improve the accessibility of counties and the facilities and this would see a reduction in mortality and an improvement in outcomes.

Figure 3: Accessibility of Counties before upgrade

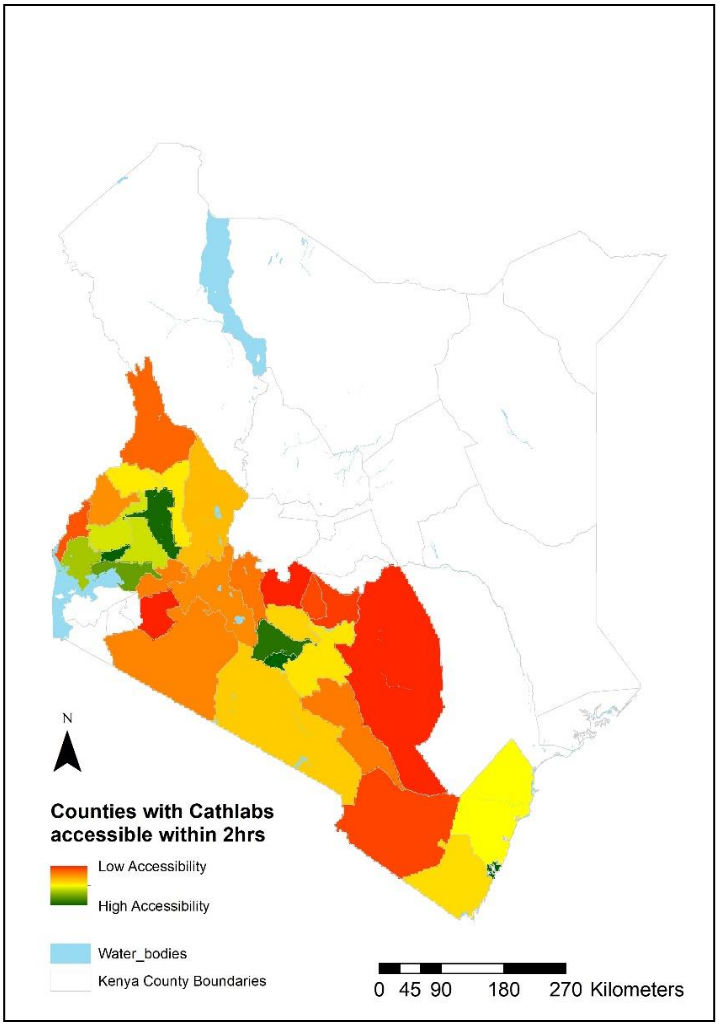
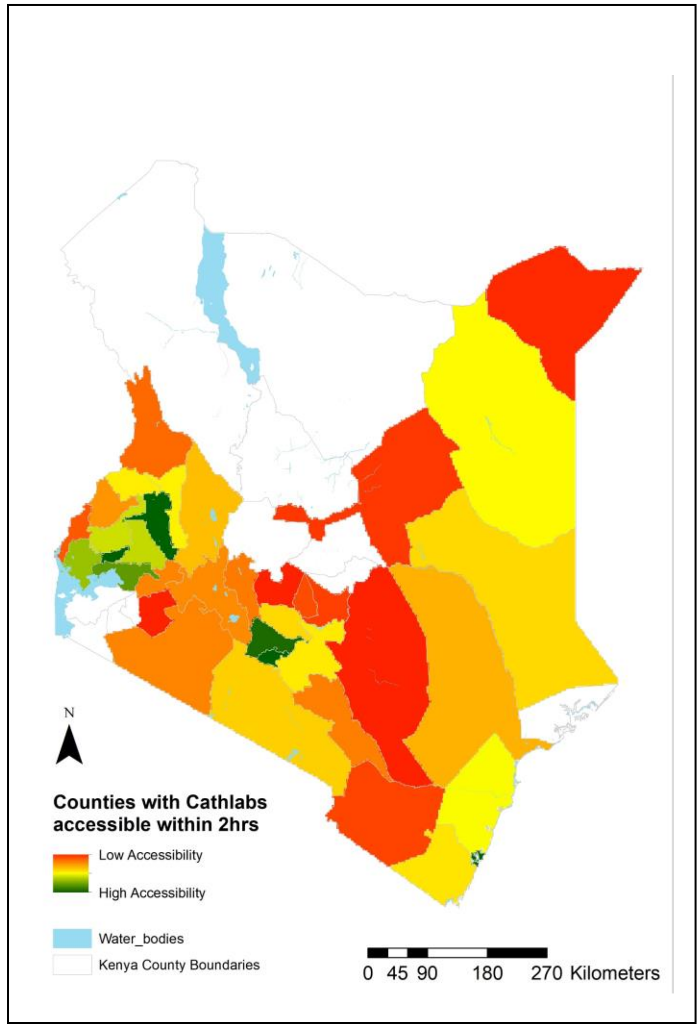


Figure 4: Accessibility of Counties after upgrade



A county accessibility map was obtained to determine the total number of counties at risk of developing adverse cardiac outcomes and as per the above map, a total of the population in North Eastern are not able to access the Cath lab facilities within the recommended time of 2hrs. After the upgrade of the level 4 hospital in Wajir and Garissa Level 5 hospital the accessibility of Counties improved with a total of 38 counties with accessibility and 9 Counties still not able to access revascularization therapy.

The results revealed 15 counties could not access Cath lab facilities and revascularization therapy and after the upgrade the numbers dropped to 9 Counties who couldn't access the Cath lab facilities.

No.	COUNTY	Accessibility before Upgrade	Accessibility after upgrade
1	Baringo	Yes	
2	Bomet	Yes	
3	Bungoma	Yes	
4	Busia	Yes	
5	Elgeyo-Marakwet	Yes	
6	Embu	Yes	
7	Garissa	No	New Included
8	Isiolo	No	New Included
9	Kajiado	Yes	
10	Kakamega	Yes	
11	Kericho	Yes	
12	Kiambu	Yes	
13	Kilifi	Yes	
14	Kirinyaga	Yes	
15	Kisumu	Yes	
16	Kitui	Yes	
17	Kwale	Yes	
18	Machakos	Yes	
19	Makueni	Yes	
20	Mandera	No	New Included
21	Mombasa	Yes	
22	Murang'a	Yes	
23	Nairobi	Yes	
24	Nakuru	Yes	
25	Nandi	Yes	
26	Narok	Yes	
27	Nyamira	Yes	
28	Nyandarua	Yes	
29	Nyeri	Yes	
30	Siaya	Yes	
31	Taita Taveta	Yes	
32	Tana River	No	New Included
33	Trans Nzoia	Yes	
34	Uasin Gishu	Yes	
35	Vihiga	Yes	
36	Wajir	No	New Included

37	West Pokot	Yes	

A population map was obtained to determine the total percentage of individuals at risk of developing adverse cardiac outcomes. As per the above map, 53619823 individuals were included in the analysis. The results revealed that 24957935 individuals could be able to access a cardiologist and facilities, which translates to 46.54% of individuals. The North Eastern part of Kenya are not able to access the Cath lab facilities within the recommended time of 2hrs. After the upgrade of the level 4 hospital in Wajir and Garissa Level 5 hospital the accessibility of the population increased to 49.3% with accessibility and this will reduce the number of adverse outcomes.

Figure 5: Population Accessibility before Upgrade

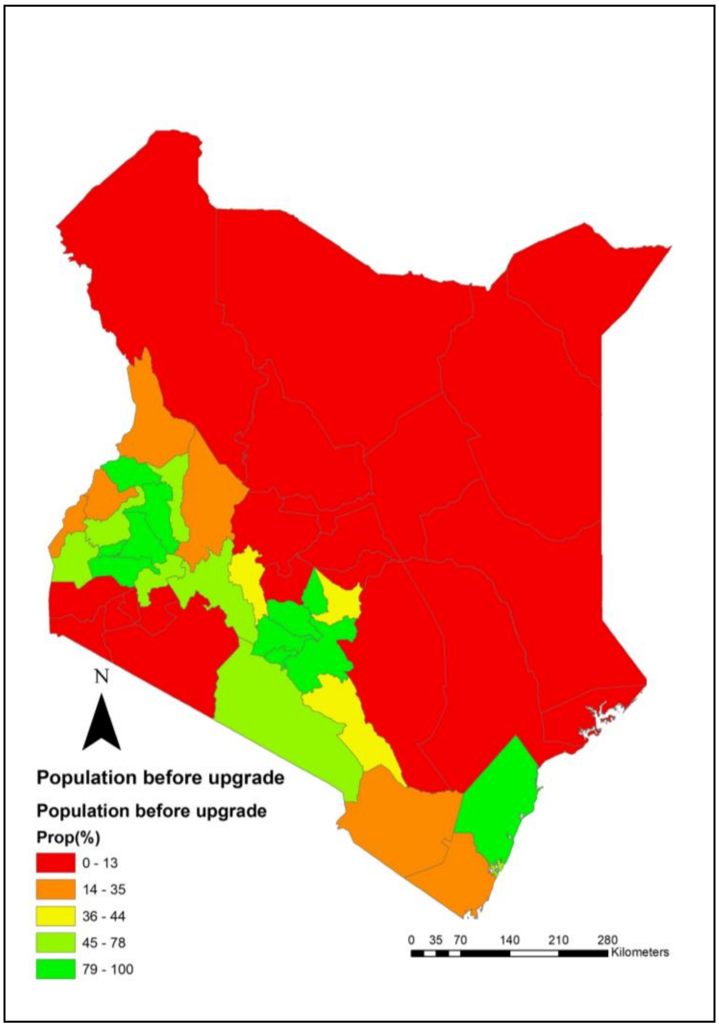
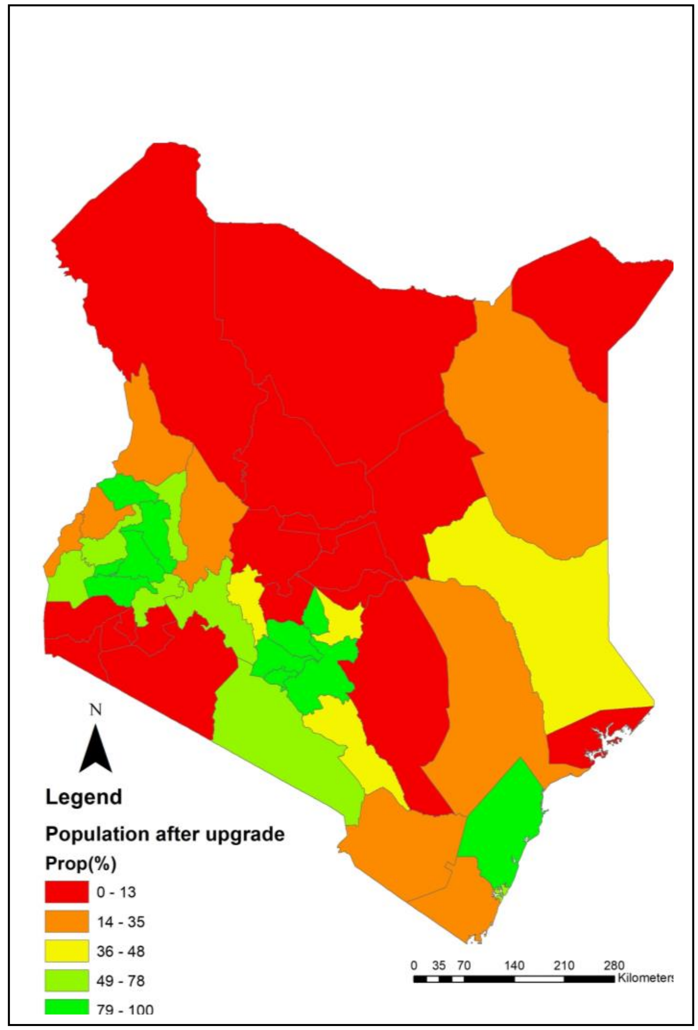


Figure 6: Population Accessibility after Upgrade



The below table shows the population increased before and after the upgrade of facilities to be STEMI prepared.

NAME	Total	Cath-lab	Prop (%)	Cath-lab upgraded	Prop (%)	Increase
Bungoma	1759286	502703	29	502703	29	0
Busia	940447	314280	33	314280	33	0
Nyandarua	700504	308411	44	308411	44	0
Mandera	2587522	0	0	97019	4	4
Embu	634109	279899	44	279899	44	0
Kitui	1237516	29378	2	30225	2	0
Nyamira	724361	233	0	233	0	0
Marsabit	354764	0	0	0	0	0
Kiambu	1882916	1858099	99	1858099	99	0
Laikipia	560668	0	0	0	0	0
Migori	1132744	0	0	0	0	0
Isiolo	176997	0	0	4433	3	3
Uasin Gishu	1304465	1279263	98	1279263	98	0
Bomet	1062172	14457	1	14457	1	0
Murang'a	1106499	1003514	91	1003514	91	0
Kajiado	989422	605305	61	605305	61	0
Meru	1651705	0	0	0	0	0
Machakos	1342117	1107149	82	1107149	82	0
Lamu	120330	0	0	0	0	0
Kakamega	2145849	1497588	70	1497588	70	0
Turkana	1208590	0	0	0	0	0
Tana River	376776	1079	0	82758	22	22
Kilifi	1467143	1232405	84	1232405	84	0
Taita Taveta	384037	96544	25	96544	25	0
Narok	1245380	160300	13	160300	13	0
Kisii	1418515	0	0	0	0	0
Wajir	1712079	0	0	565934	33	33
Makueni	1067829	473910	44	473910	44	0
Kericho	1082744	741580	68	741580	68	0
Nakuru	2320012	1525409	66	1525409	66	0
Nairobi	4660454	4637659	100	4637659	100	0
Elgeyo Marakwet	538245	403610	75	403610	75	0
Garissa	1536287	0	0	733741	48	48
Vihiga	706032	696068	99	696068	99	0
Baringo	793586	160487	20	160487	20	0
Samburu	319323	0	0	0	0	0
Nyeri	810356	55053	7	55053	7	0
Mombasa	1205664	945353	78	945353	78	0
Nandi	1099227	1065521	97	1065521	97	0
Kirinyaga	614838	552903	90	552903	90	0
Tharaka Nithi	450652	6236	1	6236	1	0
Kwale	842968	294312	35	294312	35	0
Trans Nzoia	1178118	1139801	97	1139801	97	0
West Pokot	735171	197218	27	197218	27	0
Siaya	1037581	691983	67	691983	67	0
Homa Bay	1187845	3269	0	3269	0	0
Kisumu	1205979	1076952	89	1076952	89	0
Total	**53,619,823**	**24,957,935**		**26,441,587**		
		46.54609651%		**49.31308129%**		

1.6. Conclusion

This analysis was done to assess the accessibility of the Cath lab facilities In Kenya. STEMI preparedness is time sensitive and requires patients to be attended to in a timely fashion. The reperfusion therapy is usually within 120 minutes and this will minimize any adverse effects on the patients. The GIS analysis using the cost distance analysis to assess accessibility to a cardiologist and more so revascularization therapy revealed that majority of the counties cannot access the facilities within 2hrs of onset of symptoms suggestive of STEMI. With the upgrade of the Level 4 and level 5, the population accessibility increased by 2.8% indicating if systemic challenges can be solved in this County hospitals and focus be on improving their level of STEMI preparedness, then there is a likely hood of decreasing the mortality rate due to STEMI. This will also improve the quality of life and economic status of these counties. Therefore, the county governments in each county needs to work collaboratively with other institutions to ensure the service delivery is improved.

2. References

Aheto, J. M. K., & Dagne, G. A. (2021). Geostatistical analysis, web-based mapping, and environmental determinants of under-5 stunting: evidence from the 2014 Ghana Demographic and Health Survey. *The Lancet Planetary Health*, *5*(6), e347–e355. https://doi.org/10.1016/S2542-5196(21)00080-2

Athas, W. F., Adams-Cameron, M., Hunt, W. C., Amir-Fazli, A., & Key, C. R. (2000). Travel distance to radiation therapy and receipt of radiotherapy following breast-conserving surgery. *Journal of the National Cancer Institute*, *92*(3), 269–271. https://doi.org/10.1093/jnci/92.3.269

Fortney, J., Rost, K., Zhang, M., & Warren, J. (1999). The Impact of Geographic Accessibility on the Intensity and Quality of Depression Treatment. *Medical Care*, *37*(9). https://journals.lww.com/lww-medicalcare/Fulltext/1999/09000/The_Impact_of_Geographic_Accessibility_on_the.5.aspx

Hansen, W. G. (1959). How Accessibility Shapes Land Use. *Journal of the American Planning Association*, *25*(2), 73–76. https://doi.org/10.1080/01944365908978307

Hunter, J. M., Shannon, G. W., & Sambrook, S. L. (1986). Rings of madness: Service areas of 19th century asylums in North America. *Social Science and Medicine*, *23*(10), 1033–1050. https://doi.org/10.1016/0277-9536(86)90262-5

Khan, A. A. (1992). An integrated approach to measuring potential spatial access to health care services. *Socio-Economic Planning Sciences*, *26*(4), 275–287. https://doi.org/10.1016/0038-0121(92)90004-O

Macharia, P. M., Joseph, N. K., Snow, R. W., Sartorius, B., & Okiro, E. A. (2021). The impact of child health interventions and risk factors on child survival in Kenya, 1993–2014: a Bayesian spatio-temporal analysis with counterfactual scenarios. *BMC Medicine*, *19*(1), 1–15. https://doi.org/10.1186/s12916-021-01974-x

Macharia, P. M., Mumo, E., & Okiro, E. A. (2021). Modelling geographical accessibility to urban centres in Kenya in 2019. *PLoS ONE*, *16*(5 May), 1–24. https://doi.org/10.1371/journal.pone.0251624

Oliphant, N. P., Ray, N., Bensaid, K., Ouedraogo, A., Gali, A. Y., Habi, O., Maazou, I., Panciera, R., Muñiz, M., Sy, Z., Manda, S., Jackson, D., & Doherty, T. (2021). Optimising geographical accessibility to primary health care: A geospatial analysis of community health posts and community health workers in Niger. *BMJ Global Health*, *6*(6), 1–11. https://doi.org/10.1136/bmjgh-2021-005238

Ouma, P., Macharia, P. M., Okiro, E., & Alegana, V. (2021). *Methods of Measuring Spatial Accessibility to Health Care in Uganda*. 77–90. https://doi.org/10.1007/978-3-030-63471-1_6

Roy Penchansky, D.B.A; J.William Thomas, P. . (n.d.). *Concepts of Access*.

Tao, Z., Cheng, Y., & Liu, J. (2020). Hierarchical two-step floating catchment area (2SFCA) method: Measuring the spatial accessibility to hierarchical healthcare facilities in Shenzhen, China. *International Journal for Equity in Health*, *19*(1), 1–16. https://doi.org/10.1186/s12939-020-01280-7