The Use of GIS in Mapping, Analysis and Evaluation of HIV/AIDS Occurrence Patterns

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Key words: HIV/AIDS, GIS, Database, Results.

ABSTRACT

AIDS in full stands for Acquired Immune deficiency Syndrome. It is a disease that is caused by a virus known as Human Immunodeficiency virus (HIV). This virus attacks a person's immune system (white blood cells). This weakens the immune system and makes the person vulnerable to opportunistic diseases e.g. tuberculosis. HIV was first diagnosed more than twenty years ago and up to now there is no known cure for the disease.

The rate at which HIV is spreading in sub-Sahara Africa is so high that the future generation is threatened with extinction. Thousands of people are dying daily of AIDS while tens of thousands are being infected. Different techniques have been used in campaign awareness programmes. These include; the media (Television, Radio, newspapers), books, schools, churches, the administration, parents/relatives, workshops etc. However there has been little attempt to understand the society in which behavioural changes are made. HIV/AIDS has been explained in categories – that it is fuelled by poverty, migration, unemployment and illiteracy. However, AIDS has not been analysed.

The most common mode of transmission of HIV is through sexual relations. Other modes of transmission include transfusion of infected blood to a healthy person. This mostly occurs in hospitals where blood is not thoroughly screened. HIV can also be transmitted from an infected mother to child during birth when necessary precautions are not taken. The epidemic primarily affects young, working age, sexually active adults- people between the ages of 15 and 50. Both women and men become infected in similar numbers, but women tend to become infected at a younger age than men, reflecting the biological and social vulnerability of teenage women.

The basic preventive methods that have been stressed upon in fighting AIDS include; abstinence, being in a monogamous relationship, being faithful to one's partner and the use of condoms. However due to cultural, social, economic, political and other secondary influences, these campaign programs have not been effective up to the desired level. There is therefore a need to explore other strategies that can be incorporated alongside the laid down strategies or any other strategy so that the effectiveness of these methods can be evaluated before implementation.

Partly in response to the realisation that AIDS is a global disaster and the call for commitment to the partnership against AIDS and also in recognition of the severity of the epidemic, this paper has been written with the intention to bring forth a new and dynamic

way in which the epidemic can be viewed and managed. It is known that due to the uniqueness of the backgrounds of people, different campaign methods have had different effects in different regions.

One of the most challenging and unexplored issues is the ability to determine the spread patterns, the ability to predict future spread patterns and the ability to evaluate the effectiveness of the methods that are used in curbing future spread patterns of HIV/AIDS.
The purpose of this paper is therefore aimed at introducing the technique of Geographic Information Systems (GIS) in activities that are undertaken by organisations with special emphasis on programmes that are put in place in the fighting of HIV/AIDS.

The world is divided in different continents and countries. Various organisations have carried out different programmes in these regions and a GIS is automatically an important tool for integrating these programmes and carrying out comprehensive analysis of the programme impacts. A GIS would present an integrated output that is effective in worldwide planning of intervention strategies.

The spread of the scourge across the world varies from one geographic region to another and this has been attributed to the cultural, social and economic variations in the respective regions. Different interventionary programs have been put in place in the respective regions to combat the spread of the scourge and as a result, different geographical regions have registered different feedbacks to these interventionary programmes.

In this respect, this paper will address its goal by identifying the significant effects of HIV through a scientific investigation and to demonstrate the usefulness of GIS techniques in analysing and mapping its spatial distribution patterns.

A project designed along these lines should fulfil particular fundamental objectives. This should be demonstrated by the project's ability to;

- Instantly show the occurrence of HIV/AIDS patterns in form of a map (digital/ hard copy) showing high risk and low risk areas.
- Instantly determine the geographic location of areas of highest demand for intervention programmes.
- Build questions and be able to obtain instant answers e.g.
- what is the pattern of occurrence of HIV/AIDS?.
- Easy and effective data manipulation

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1. CURRENT IMPACTS OF HIV/AIDS

The current status of the HIV/AIDS epidemic globally is characterised by a high rate of HIV infection and a growing number of illnesses and deaths among the world's citizens. While in the past HIV infection may have been an abstraction, the impact from more than 40 million global cases of AIDS has brought the reality of the epidemic fully to the forefront across the world- for families, businesses, religious groups and the global leadership. There is a growing consciousness that the 40 million people estimated to be currently infected with HIV will eventually die of AIDS or AIDS-related illness, that millions of others will become infected in the coming years, and that a set of inter-related social, economic and social cries for communities and the world will increase, unless swift and appropriate action is pursued immediately.

1.1 Economic Impacts

HIV/AIDS has had serious impacts on National economies and the global economy. The economic impacts can be grouped into five basic categories:

- Reduction in investment and savings due to higher health care expenditures.
- Decline in labour productivity due to worker absenteeism.
- Decline in labour productivity due to the loss of experienced workers.
- Changes in labour market supply and demand.
- Changing demand for government services.

1.2 Social Impacts

While the epidemiological impact of HIV/AIDS is significant, the corresponding impact on the social welfare of the family is even more devastating. Decades of improvements in social welfare are being undermined by the uninhibited progress of the epidemic. The imbalance in household structure, with women and children forming the majority of rural dwellers is worsening. Children are increasingly being pulled into the informal economy to supplement income lost when parents become sick with AIDS or related illness. Economic, legal and social inequalities have placed women in a more vulnerable position in preventing HIV transmission, while at the same time making them more responsible and less able to respond to family illnesses and losses due to AIDS. Families and communities are feeling the greatest burden of AIDS and need assistance as they try to cope with its impact.

The impact of HIV/AIDS on the family has resulted in a high number of orphans. Some of the children have been absorbed by the extended family and cared for by siblings. Still others have found a home on the streets.

2. GIS

2.1 Definition

GIS in full stands for Geographic Information Systems. These are computer-based systems that are used to store and manipulate all kinds of spatially referenced land related data. A GIS is designed to collect, store, analyse and retrieve data in a structured form.

2.2 How a GIS Works

A GIS can use information from many different sources, in many different forms. The primary requirement for the source data is that the locations for the variables are known. A location may be annotated by x, y and z co-ordinates of longitude, latitude and elevation or by such systems as zip codes or highway mile makers. Any variable that can be located spatially can be fed into a GIS.

The basic consideration in analysis of the data is the geographic location. A GIS can therefore provide managers with graphical, digital and statistical information as well as maps, which are essential in decision making and dissemination of information.

Data representing the real world can be stored and processed so that it can be presented later in simplified forms to suit specified needs. When the manipulation and presentation of data relates to geographical location, our understanding of the real world is enhanced.

As an information system, GIS is designed to produce information in support of decision making. It may be manual or computerised. The malfunctioning capabilities of a GIS make it widely applicable to any problem involving georeferenced data.

2.3 What is Special about GIS

Given that there are systems that can handle spatial data, database management and data analysis, the major driving force for the adoption of GIS for use in mapping, analysis and evaluation of HIV occurrence patterns can be viewed in terms of the following advantages over other conventional methods.

- **Information retrieval**

With a GIS one can 'point' at a location, object or area on the screen and retrieve HIV information about it from off-screen files. One can query a GIS about the status of the area with relation to other areas. This kind of analytical function allows one to draw conclusions about the area. It also increases the speed of working and reduces the costs.

- **Topological modelling**.

A GIS can recognise and analyse the spatial relationships among mapped phenomena. Conditions of adjacency (what is next to what), containment (which Organisations are found in which area) and proximity (how close certain facilities are) can be determined with a GIS.

– **Networks**

If all health facilities in an area were co-ordinated or related by roads, then a GIS can determine the distance and time one can take to reach a particular health facility from his home. A GIS can simulate the shortest routes to reach certain facilities.

– **Overlay**

Using maps of population and maps of infection, a GIS can produce a new map layer or overlay that ranks the regions according to infection rate.

– **Data output**

A critical component of a GIS is its ability to produce graphics on the screen or on paper that convey the results of analysis to people who make decisions about resources. Graphical, digital and statistical information as well as maps can be generated thereby allowing the viewer to visualise and understand the results of analysis or simulations of special events.

3. DATABASE DESIGN AND CREATION

3.1 Equipment and Materials Needed

A GIS that is designed to handle data relating to HIV or other diseases should have the following equipment and material;

1 Hardware

a) Host computer – For data and software storage; data processing and manipulation; overall system control
b) Digitiser – For data digitisation in the vector format.
c) Digital plotter – For output of hardcopy graphics.
d) Printer – Report and table output.
e) Tape/CD drive – offline data import; back up; external storage.
f) Modem – intercomputer communication; Internet access.
g) UPS – regulation of power supply

2 Software.

Software is a set of instructions (programmes) that a computer can carry out. GIS software has different modules. When purchasing GIS software, one should be able to understand these modules and know the specifics that are required. There are many GIS software that that can handle data relating to HIV. Among these include; Arcview, Arcinfo, Idrisi, Ilwis etc.

3 Data

Data refers to the material from which information should be processed. These data can be grouped into different categories depending on available statistics e.g.

– Number of people infected with HIV per area (District, province, state, country e.t.c.)
– Number of people who have developed AIDS
– Number of people who have died as a result of AIDS

The data can be grouped into different classes e.g. by sex (male, female), Age (children/adults)

3.2 Methodology

An overview of the method that can be used is illustrated in the figure below

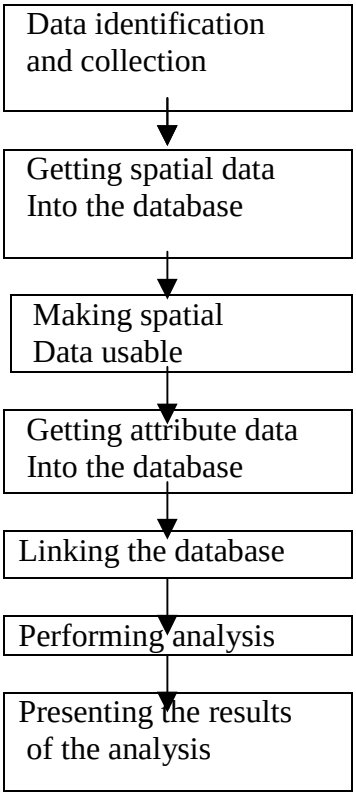

Figure3.1: Overview of the Methodology

3.3 GIS Data Capture and Editing

This refers to the identification, collection, digitisation and correction of errors for the data necessary in the building of a GIS database.
Two types of data are used. They include:

Spatial data:
Spatial data refers to the land related data i.e. boundaries, roads, river etc.

Non spatial / attribute data
Attribute data refers to the non land related data i.e. HIV/AIDS statistics, population statistics, NGO information.

To achieve the best of GIS data, the database is designed and stored in such a way that it can be easily and repeatedly be accessed by different users, and that it can satisfy most of the needs of the users.

Since the data handled is large and diverse i.e. from different sources, the database is organised in a series of tables so that it can be shared. Each table is called a relation and it consists of a number of rows and columns. Once the database has been created, then it can be managed by a DBMS (Database Management Systems).

A database has many users, each of who may have a different perspective (view) of the data. The DBMS by being able to abstract just the data needed by each user is able to provide these different user views, without presenting the whole database to each user.

Another method of creating a database is by the approach of hybrid GIS. By this approach, two separate databases, one dedicated to spatial data and the other dedicated to non-spatial data are used in a single GIS, integrating software modules are used to provide a uniform interface to both databases.

4. DATA ANALYSIS

The analysis of HIV database comprises of tools and operations that use the spatial and non-spatial data to answer questions about the real world. For analysis, GIS data is vertically organised into layers or themes. For large coverages HIV data may be horizontally organised into files.

4.1 Categories of Analysis Functions

There are three broad categories.

1. Database query
2. Derivative mapping
3. Modelling.

4.1.1. Database Query Functions

These basically involve basic retrieval of what is already in the database. These may be;

- With constraint e.g. show areas with percentage infection of HIV above 10.
- Without constraint e.g. show the spatial locations of health facilities.

4.1.2. Derivative Mapping

This involves the combination of selected components of the database to yield new layers that may also become additions to database

Common Derivative mapping functions include;

- Overlay: it involves finding those locations from several layers of data where a specified set of conditions exists or do not exist.

- Proximity analysis: it involves generation of buffers. A buffer is a zone of specified width drawn around map elements.
- Polygon search: it involves determining whether a given point or line lies within a given polygon.
- Network analysis: A network is a system of connected linear features through which resources flow e.g. road network

4.1.3. Modelling

Example is modelling of an unknown relationship between variables in order to use it to predict other variables

5. DATA PRESENTATION

HIV/AIDS data can be presented in different forms depending on the capabilities of the software that is used. The forms in which the data can be presented include:

- Digital maps
- Bar graphs
- Pie charts
- Line graphs

4 CONCLUSIONS AND RECOMMENDATIONS

This paper has addressed the challenge of exploring other strategies that can be used alongside the laid down strategies in fighting the epidemic. As has been seen, this can be achieved using GIS techniques through integrated analysis. The digital map can be produced which have the benefit of easier revision and spatial analysis, besides a clear representation of geographically referenced information. GIS techniques are therefore highly suitable for analysis of HIV occurrence patterns and planning of punctual preventive measures to mitigate it.

As it has been put forward in this paper, the use of GIS in mapping, analysis and evaluation of HIV/AIDS occurrence patterns has greater potential of being the first step towards achieving an integrated analysis of HIV world wide

Enough resources should be projected towards this technique and make it a reality. An expert system can be developed which among other things will be able to:

- Make decisions about HIV basing on its knowledge base
- Be able to give instructions from fore facts
- Reason and explain its procedures.

A broader database that will be able to incorporate Africa and the whole world can also be created.

Since HIV is a global disaster, the database created should be shared and be made available to different organisations and individuals across the world through the Internet. This should include designing of software that can enable people who are not specialists in GIS or who do not understand the GIS software to be able to access this information easily on the web

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BIOGRAPHICAL NOTES

Armstrong Kamadi Indusa was born on 18th march 1976 at chavakali in western province of Kenya. He attained primary education between 1982 and 1990 and secondary education from 1991 to 1994.

In 1996, Kamadi entered the University of Nairobi where he pursued a Bachelor of Science degree in surveying. During the period in the university, Kamadi actively participated in programmes aimed at sensitising the youths and students of the risks of HIV/AIDS. He did a project on the use of GIS in mapping analysis and evaluation of HIV occurrence patterns in Kenya. This project has been handed over to the National AIDS and STDs control programme (NASCOP), an NGO in Kenya that is concerned with statistical research and analysis of HIV. NASCOP is currently contemplating to introduce the use of GIS in its projects.

Kamadi has also worked at the Regional Centre for Mapping for Development (RCFMD) where he was mostly concerned with designing of GIS databases.