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Where is GIS Technology Applied in the Public Health Discipline: A Literature Review

Beatrice Winnie Nyemera,
Division of geo-information serivices, Uganda
Bureau of Statistics, Statistics House,
Kampala, Uganda.

Peng Jia assistant professor
Faculty of Geo-Information Science and Earth Observation
University of Twente, Enschede,
The Netherlands

Abstract:- The purpose of this study was to identify the use of GIS (Geographical Information System) technology in supporting information required for public health evidence-based planning and decision-making. The review discusses examples of different areas GIS technology have been applied in public health. A search of scientific databases and online resources was undertaken to describe the uses of GIS technology in public health research. Our study contributes to research examining the uses of GIS in public health in two ways: It gives an understanding of how GIS can be adapted and applied to public health decision-making in developing countries, and it identifies both barriers limiting GIS use in Africa and measures that can be used to successfully apply GIS in its public health sector. Additionally, our literature review adds knowledge on how GIS technology are understood by decision-makers, health professionals in evidence-based planning and decision-making processes. Conclusively, there are many African studies in the literature that have benefited from using (in which the use of) GIS technology in guiding to (helped) solve health problems.

Keywords:- *Geographical Information Systems; Public Health Sector; Uses; Africa.*

I. INTRODUCTION

The use of modernized tools such as Geographical Information System (GIS) technology and data collection is rapidly evolving as a basis platform to successfully merge, mass, scrutinize and disseminate the various datasets to solve difficulties or troubles in community well-being. GIS technology generates openings for society or community professionals', administrators to improve design, scrutiny and make evidence-based conclusions. Healthiness data collection progressed from the time of Dr. Snow's cholera data collection of epidemic occurrences establishing that a particular water pump was the source of contamination in London, England, in 1854 the mid-19th century, (Shaw, 2012) to the modern interactive web display of information shared and exchanged world web systems across the globe.

Knowing that public tends to access health services within their local geographical community locations and data used and generated by health organizations has a geospatial dimension, the application of GIS technology for society amenities development, delivery and policymaking (PM) is appropriate to the medical professionals in day-to-day management (Shaw, 2012). Keen to note is that, even though GIS technology is extensively applied in health activities to demarcate occurrence and dominance of infections, health professionals and researchers need to ascertain and comprehend GIS technology application accessibility health facility, use and its need (Clarke, McLafferty & Tempalski, 1996; Joyce, 2009; Nykiforuk & Flaman, 2011; Shaw, 2012). When GIS technology has been utilized to its capability,

GIS technology empower decision making, enlighten and inform health authorities and the society, offer ways to envision and scrutinize health outcomes data, change practices, monitor and analyze changes and public health resources (Kandwal, Garg & Garg, 2009; Shaw, 2012). According to research by various authors, GIS technology has various benefits which include:

- GIS technology can help generate disease maps showing its distribution, disease extent, population affected in a particular area
- Can help identify and locate resourceful sites to develop health centers which can be easily accessed by nearby populations
- Can create buffer zones and this information can be combined with disease incidence data to determine how many cases fall within the buffer zone
- Permits active merge amongst databases and allows interactive mapping where data updating can be done by several people at different sources. The data updates are automatically shown on the web active maps. Active maps available on the web helps the interested patients in locating the nearby facility for treatment.
- Can inspire information sharing of data partnership and exchange at all levels (Joyce, 2009). For example to develop a map of motor vehicle injuries and fatalities in a community, a local public health department could develop data partnerships with the department of transportation (for information about traffic flow and accidents), local ambulance services(for information about injuries requiring transportation by ambulance to hospital emergency rooms) and medical examiner's office (for information about fatalities).
- In comparison with using tables or charts, maps developed using GIS technology can be effective tool for communicating messages clearly even to those who are not familiar with technology. This can be of help to decision makers to visualize and understand a public health problem in relation to available resources and effectively target resources to the communities at risk or

need. This technology can enable detailed maps to be generated with relative speed and ease. Information like this when mapped together can create a powerful tool for decision making, planning, monitoring and management of epidemic diseases. This can provide public health professionals with the ability to provide quick responses to the outbreak.

However, although GIS has several advantages, a GIS' primary advantage is its analytical process operation where various datasets from different sources of origin with differing formats are joined together to form one symbol. For example, Wall and Devine (2000) highlight that, proximity analysis processes can be engaged in wellbeing infection investigation which is assembling and tracing of data on infection occurrence, prevalence and distribution; health access and public wellbeing profiling which is the compilation and data collection of facts about wellbeing of a inhabitants (Cromley & McLafferty, 2002; Guptill, 2001; Nykiforuk & Flaman, 2011).

Joyce (2009) highlight that, although GIS technology is good in supporting evidenced-based planning and equitable resource allocation, guidance in interactive web mapping across the globe, they are not enough solution to solve health problems. This is because technology outputs are sometimes misunderstood explaining slow adoption, thus indicating little /not enough awareness on technical organizational strategies. Despite evidence of benefits of GIS technology applications in society, its application in community wellbeing is underutilized (Shaw, 2012). Basing on this, it is advisable to carry empirical study on GIS technology applications to understand the perception of how health professionals value GIS in supporting decision making at national level especially with respect to health facility access, planning and utilization to avoid wastage and duplication of limited scare assets.

This study present description literature procedure, to provide how GIS technology is applied community wellbeing activities, review of current applications of GIS use in health services, to provide a brief insight of hindrances of GIS use and to conclusion.

II. LITERATURE PROCEDURE

To identify relevant literature about the uses of GIS technology, we conducted a literature review. As GIS technology is an interdisciplinary topic, many articles are published in a variety of journals. According to (Hrastinski (2008), Webster and Watson, (2002) a search for scientific information can be broad basing on the topic/title other than limiting the search to specific areas such as one research methodology, one set of journals, geographic region or years. The literature review was conducted through literature search in the following databases; Web of Science (electronic version of the social sciences citation index), Geobase, Science Direct, Scopus, PsycINFO, ACM Digital Library, JSTOR, IEE Xplore Digital Library, Springer Link, CAB Abstracts, Inspec, e-journals, URISA Journal and Google Scholar for academic conference papers and hand searching of reference lists and texts were undertaken.

In our search, only articles reported in English journals and addressed GIS applications for public health mapping were considered. Abstracts, introductions, conclusions of the selected articles and book chapters dealing with GIS definition, GIS technology use for decision-making and other GIS applications were reviewed.

III. GEOGRAPHICAL INFORMATION SYSTEMS

GIS is a computer-aided database management and mapping technology that organizes and stores large amounts of multi-purpose information. Its' a computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. GIS adds the dimension of geographic analysis to information technology by providing an interface between the data and a map. It performs spatial analyses by developing and applying spatial models. This makes it easy to present information to key decision-makers quickly, efficiently and effectively.

GIS has capabilities ideally suited for use in infectious disease surveillance and control, particularly for the many vector-borne neglected diseases that are often found in poor populations in remote rural areas. They are also highly relevant to meet the demands of outbreak investigation and response, where prompt location of cases, rapid communication of information, and quick mapping of the epidemic's dynamics are vital. Though, for many years, the use of GIS in public health was limited due to expensive cost of hardware and the great complexity of GIS software that made it extremely time-consuming and costly to extract information relevant to the practical demands of disease prevention and control. Over the past few years, hardware prices have fallen; simple new devices are now available. The Public Health Mapping and GIS program, based within WHO Communicable Diseases, has been developed with the goal of providing greater access to simple, low-cost geographic information and related data management and mapping systems to public health administrators at all levels of the health system. So GIS is now readily available and usable in public health (Shaw, 2012) but "who are the users and in what ways do they use GIS in public health?" need great attention.

IV. USERS AND THE WAYS OF USING GIS IN PUBLIC HEALTH

Considering at the evolution of GIS, there are various users which can range from different personalities, societies, scholastic and study establishments, indigenous people, at all levels. GIS can be used by public health specialists, decision makers, professionals, statisticians, regional and district medical specialists for different purposes (Kandwal, et al., 2009). In the sector, thus, these people can use GIS to address DM which goes from addressing simple questions to complex questions. They apply it for DM to provide solutions inquiries (where is…?), situation (what is at….?), direction-finding, design demonstrating (what geospatial patterns exist?), trend modeling (what has changed since…?), and scenario or modeling building (what-if) are addressed (O'Looney, 2000). They can also use GIS for identifying population affected by landslides, drought, mudslides and produce maps of those events of the affected regions (Nykiforuk & Flaman, 2008).

DM today applies global positioning systems which can that aids in defining geographical location of facilities, demography, service availability, disaster preparedness etc. The use of the systems supports in emergency referral system, emergency prevention, response recovery (Silva, Eglese, & Pidd, 2003).

GIS is developed with various functions that enables decision makers to carry analysis to DM process; to integrate, to make, to apply various geospatial analysis of health outcomes and present results in high impact maps can be presented. These maps can communicate relationship, tell inequalities in service deliveries (Mullner, Chung, Croke, & Mensah, 2004; Tanser & le Sueur, 2002). Maps generated by using GIS can help identify gaps and inefficiency, get feedback from stakeholders and serves as a starting point to collect new data at different levels of aggregation.

There are also various ways GIS uses such as map and find. Each of GIS uses identified by Shaw is further elaborated as follows;

Map Where Things Are is the use of GIS to identify where an individual feature is, such as the location of disease outbreak, an emergency room or to look at the distribution of features on a map to visualize the emergency of patterns. The well-known use of GIS in public health, is that of Dr. John Snow in London, England, in 1854 when he carried mapping of incidences of cholera outbreak demonstrating a specific water pump as the cause of infection (Kandwal, et al., 2009; Shaw, 2012). This study shows us the importance of geospatial dynamics in understanding diseases and the use of maps to describe and analyze diseases to inform health decision making.

Find what's nearby is used to map what is occurring within a set distance of a feature. For instance, if we see increased mortality in a specific locality we can look at what might be causing the problem such as a practice of murder by medical malice doctors like Dr. Shipman (Baker, 2004; Richard Baker & Hurwitz, 2009; Kaplan, 2000). Nowadays, World Health Organization (WHO) provides real time disease alerts that are mapped at http://www.healthmap.org. Interactive web maps are used for equitable planning and distribution of resources (Shaw, 2012).

Find out what is inside using GIS can enable us look at what is happening inside a health facility or area; for instance we can map the movement of staff, equipment and patients as they move around within the facility to assist with the tracking of infection. In Andean, Bolivia, a study applied GIS and found that there were variations in accessibility of primary health care due to socioeconomic barriers, hash climate and long travel distances to access health services. Such information can be of help to decision makers to determine an area to build a new facility which is closer for more households to access(Perry & Gesler, 2000).

Map change using GIS can enable us to map the change in a locality to anticipate future conditions, decide on a course of action, or to evaluate the results of an action. For instance Shaw (2012) provided an example where GIS can be used to study how emergency patterns change from day to day to aid decision and help decide where ambulances should be stationed.

Map quantities identify places of most and least of something to meet specified criteria and take action. Such mapping can indicate countries with the highest percentage of HIV/AIDS prevalence or children of overweight. Knowing areas with the greatest problem with HIV/AIDS can be of help to health decision makers to aid in planning services. For instance, GIS was used in India (Kandwal, et al., 2009), Nigeria (Djukpen, 2012), Toronto (Fulcher & Kaukinen, 2005; McLafferty, 2003), Zambia (Moise & Kalipeni, 2012) to map and represent HIV prevalence rates to understand the geospatial spread of HIV with respect to time and space. GIS in these countries was also used to calculate the distance of the prevention health facility center from the highly infected regions and to map the number of HIV services in a given area in order to understand access to prevention and health care. Such geospatial analysis can aid decision making and increase efficiency of preventive programs.

Map densities of areas which may vary greatly in size but have smaller numbers of people against smaller geographical areas that have large numbers of people to see the true density of the feature we are looking at. It should be noted that although health maps can always show concentrations of disease around major urban settings. It does not indicate that urban settings have a causal link with that disease but because of rural-urban migration in search of access to specialized services (Shaw, 2012). In India GIS plus GPS were used to determine the vector borne diseases density areas (Rai, Nathawat, Mishra, Singh, & Onagh, 2011). Maps were produced to show location of infected person and the distribution of the disease. We begin by identifying how GIS is being used in public health facility mapping.

V. GIS APPLICATION IN PUBLIC HEALTH MAPPING

Health facility mapping is data collection of geographic coordinate points that represent the earth position of that particular feature, toxic spills and other calamities using GIS technology. The health facility mapping is important as it can determine how many of a specific facility currently exist in an area, find the best locations for new ones; determine disease surveillance; service availability: which facility offers this type of service (HIV/AIDS treatment, counseling etc.); population health access and determine how many to open. Though there are researches already done, due to WHO out-cry of resistance and stagnation of some killer diseases such as HIV/AIDS we feel inevitable to carry this study to propose strategies for prevention of GIS technology use which necessities it to be carried out.

Study carried by Nykiforuk and Flaman (2011) found that GIS application for health access is accessible and useful global health tool reported worldwide, but necessities further research addressing critical issues. The literature on wellbeing access helps health medical specialists and the society at large effectively make use of research data to solve health issues (Nykiforuk & Flaman, 2008; Nykiforuk & Flaman, 2011).

Thus, to solve health problems, requires public health facility specialists to plan and monitor activities, which it can be necessary to do at all levels. As every health problem needs a response and policy decision that reflects a realistic measure of the situation at every level; local, regional, national or international. The problem should be done with precaution a mindset of disease transmission dynamics, availability and accessibility to existing health, social services and environmental features(Nykiforuk & Flaman, 2011).

GIS is appropriate for ascertaining disease trends and interrelations of different formats, it enables spend scare resources adequately(Nykiforuk & Flaman, 2011).

Clarke, et al., (1996) in their review study, addressed the disciplinary crossover between GIS, public health and epidemiology. They provided an overview of GIS functionality in terms of data storage, capture, retrieval and display. Clarke, et al., (1996) identified GIS applications in health such as the surveillance and monitoring of water borne diseases, environmental health, modeling exposure to electro-magnetic fields, predicting child pedestrian injuries, the analysis of disease policy and planning, and making the prospect use of GIS health arena.

Further, McLafferty (2003) provides areas with specific categories where GIS can be used in public health mapping: 1) analyzing necessity for healthcare development in a particular area; 2) evaluating accessibility to health services, i) measuring access, ii) evaluating inequalities in access; 3) geographic variation in utilization; and 4) GIS and health care delivery, i) locating health services, ii) spatial decision support systems and iii) GIS and disasters. McLafferty (2003) in her review of GIS and public notes that GIS acceptance by medical specialists and authorities can depend on access to unified geospatial data on wellbeing amenities use and results, and geospatial data that is shared between human service systems in this fast shifting healthcare discipline.

On the hand, Grave (2008) integrated review in assessing healthcare access and analyzing geographical health outcomes, mapped AIDS prevalence, correlated sciodemographic variable and teen pregnancy, etc. She found GIS can be used as the level of determining health inequalities. Grave in her review discovered that The Institute of Medicine and the department of Health and human services in Washington, DC recommends further researches in public health to develop strategies to improve access to healthcare services and support improvement of health comes

Furthermore, Kandwal, et al (2009) identifies GIS applications in public health such as: 1) determining geographical distribution and variation of diseases; 2) analysis of geospatial and temporal trends; 3) identifying gaps in immunizations; 4) mapping populations at risk and statifying risk factors 5) documenting health care needs of a community and assessing resource allocations; 6) forecasting epidemics; 7) planning and targeting interventions; 8) monitoring diseases and interventions over time;9) managing patient care environments, materials, supplies and human resources; 10) monitoring the utilization of health centres; 11) route health workers, equipment and supplies to service locations; 12) publishing health information using maps. The study concluded that GIS technology can be of help to geospatial data infrastructure to have up-to-date data and information which guides to solve HIV/AIDS issues, guide monitoring and evaluation, and planning using evidence-based data. They further noted, GIS can be an effective tool in public health, health research and education.

Additionally, Nykiforuk and Flaman (2011) identifies four themes with specific categories in public heath where GIS facility mapping can be applied in decision making: disease surveillance, risk analysis to map environmental risk disease prone areas, health access and planning and community health profiling. Their study reveal that GIS technology can be a pivotal and effective support tool to answer a diversity of program, policy and planning issues in health promotion and public health. Hence GIS can be used to monitor and assess the health of the people geographically linked with global positioning system (GPS) to collect data to make tangible decisions. For example location position of households who can access health services of a certain facility; of environmental risk disease prone areas (Nykiforuk & Flaman, 2011) and of areas of equal resource allocation(Ishfaq & Lodhi, 2012).

Shaw (2012) carried a study to determine the current state of GIS use in the health public. Shaw (2012) highlight that although there is evidence growth of GIS technology use in public health, it is maturing and growing slowly in contrast with GIS use in other disciplines such as urban and regional planning, environmental assessments, utilities, transportation and logistics who are regarding it as essential component. Shaw concludes that despite having established GIS massive benefits and matured enough as a technology that researchers can use readily and easily, researchers should embrace it although for fifteen years GIS is still underutilized in public health. Like McLafferty and Nykiforuk; Shaw identified six areas in public health applications: 1) disease surveillance; 2) risk analysis; 3) health access and planning; 4) community health profiling; 5) built environment and neighborhoods; and 6) crisis management

A. Disease Surveillance

Disease surveillance key part study element is disease incident reporting. Its role is to predict, observe and minimize the harm caused by the outbreak, epidemic, pandemic situations and increase knowledge about which factors contribute to such circumstances.

Disease surveillance is an epidemiological practice which tracks and collects data on incidence, prevalence and distribution of disease to ascertain advancement (Nykiforuk & Flaman, 2011; Shaw, 2012; Wall & Devine, 2000). Whereas, epidemiology is defined as the spread and patterns of health happenings, health characterizes and their causes in well-defined population (Vanmeulebrouk et al., 2008). Epidemiology is considered a foundation in investigation and supports ascertaining threat elements for disease, deterrent drug and society strategies growth. Hence, the effective purpose falls in the development of geospatial prototypes of infection occurrence, threat, and to ascertain possible extent of contagious diseases (Moffett, Shackelford, & Sarkar, 2007).

Nykiforuk (2011) categorize two interconnected components of disease surveillance as; disease mapping and disease modeling. Disease mapping is applied to know the geographical extent and distribution of disease in the previous or current (Myers, Rogers, Cox, Flahault, & Hay, 2000; Nykiforuk & Flaman, 2011; Robinson, 2000). With the rapid evolution of GIS technology, disease epidemics can currently be monitored with worldwide internet communication more fast than through using traditional reporting methods like manual record book keeping (Dugas et al., 2012; Shaw, 2012).

In the application of disease surveillance, GIS technology is used commonly in disease mapping and disease modelling. Disease mapping is the production and tracking of death (mortality) and illness (morbidity) patterns associated to a particular disease or set of diseases. The importance of mapping and GIS technology is becoming better known to public health professionals to help in linking disease control to prevention efforts, which can aid decision makers in developing better immunization programs (Cromley & McLafferty, 2002). Disease maps can distinguish the low, high risk areas and highlight physical or socio-cultural factors that contribute to the causation of disease (Rytkönen, 2004). According to Rytkönen (2004), disease mapping goals include: Identify areas and population at high risk in order to increase prevention, provide a map of disease risk for a region for better risk preparedness, and describe the geospatial variation in disease incidence.

Additionally, literature ascertains numerous examples of the diseases been surveilled using GIS technology namely; Lozano-Fuentes et al. (2008) carried out a study where an information system for city infrastructures was developed with integrated Google Earth and GIS software (healthmapper) in Chetumal and Merida, Mexico to be used: for strengthening public health capacity, and displaying of public health data directly on an image of the physical environment; for the visualization of geospatial patterns of risk for exposure to malaria parasites in Africa and globally (Hay, Guerra, Tatem, Noor, & Snow, 2004; Hay et al., 2010); for global mapping of the distribution of dengue fever outbreak and population at high risk (Hales, de Wet, Maindonald, & Woodward, 2002), and in Chachoengsao Province, Thailand, (Kittayapong, Yoksan, Chansang, Chansang, & Bhumiratana, 2008), Taiwan (Wen et al., 2010); mapping of Sleeping sickness in Africa (Cecchi et al., 2009); HIV/AIDS in Texas, USA (Oppong, Tiwari, Ruckthongsook, Huddleston, & Arbona, 2012), Malawi (Feldacker, Emch, & Ennett, 2010), South Africa (Vanmeulebrouk, Rivett, Ricketts, & Loudon, 2008), Netherlands (Haar, Cobelens, Kalisvaart, van Gerven, & van der Have, 2007); Communicable diseases in Europe (Desjeux, 2003); in France (Flahault et al., 2006); Injury prevalence (Edelman, 2007), and to reveal patterns of injury and services (Schuurman, Hameed, Fiedler, Bell, & Simons, 2008).

Disease modeling is an of element of disease mapping and is applied to predict forthcoming disease distribution or epidemic outbreaks and to ascertain those factors that may raise or inhibit disease transmission (Myers, et al., 2000; Nykiforuk & Flaman, 2011; Robinson, 2000). The literature identifies six areas GIS technology is applied in public health perspective. According to Myers, et al., (2000), Nykiforuk & Flaman (2011), Robinson (2000), areas of disease modelling include: to 1) predict the future spread of disease, 2) identify factors that may foster or inhibit disease transmission, 3) pinpoint high-risk areas for disease prevention or intervention, 4) target control efforts, 5) identify gaps and 6) increase stimulus for data collection in these areas.

Specific examples of GIS disease modeling include studies carried out to examine whether GIS and remote sensing provided valuable information to assess and monitor malaria early warning systems. The studies that were done to investigate the system potentiality in disease surveillance and weather monitoring for effective early warning include in Temotu province, Solomon Islands (Kelly et al., 2010), Israel (Kitron et al., 1994), USA (Pinzon, Wilson, & Tucker, 2005), and in South Africa, (Martin, Curtis, Fraser, & Sharp, 2002).

Others include: Plague distribution pattern in sub-Saharan African (Neerinckx, Peterson, Gulinck, Deckers, & Leirs, 2008); Cholera health risk prediction in South Africa (Fleming, Merwe, & McFerren, 2007), and in Lusaka, Zambia (Sasaki, Suzuki, Fujino, Kimura, & Cheelo, 2009);Guinea worm disease in Africa (Cairncross, Muller, & Zagaria, 2002); Mapping neglected human African trypanosomiasis (sleeping sickness) (Hotez & Kamath, 2009; Simarro et al., 2010);Schistosomiasis in Africa (Brooker, Kabatereine, Gyapong, Stothard, & Utzinger, 2009);Tuberculosis transmission and incidences in USA (Moonan et al., 2004), Cape Town, South Africa (Munch et al., 2003), Almora district, India (Tiwari, Adhikari, Tewari, & Kandpal, 2006), in Portugal (Nunes, 2007).

B. Health Facility Access, Utilization and Planning

GIS access applications are associated precisely to market segmentation analysis and network analysis for health services and delivery (Nykiforuk &Flaman, 2011). Thus, access is denoted as a construct that describes a populace's capacity to use health services when required (Cromley & McLafferty, 2002; Nykiforuk & Flaman, 2011). Based on that, Cromley and McLafferty (2002), and Nykiforuk and Flaman (2011) state that health ease of use associates to geographical position-site of the health amenities, capability to travel between them or linkage of facilities in a place.

On the other hand, the GIS technology application of network analysis is applied to establish patient catchment zones or ascertain the section of the populace in a particular zone with possible access to facilities around a demarcated network (Nykiforuk & Flaman 2011). Market utilization applications is applied to ascertain and describe recognized access to services within a network or catchment zone to characterize patterns of health service use. Literature highlight the technology is correlated with each separately solving a diversity difficulties.

On that note, GIS technology application of network analysis is associated to geographical position of and ease use to health amenities with the purpose of solving queries of path, distance and nearness(Nykiforuk & Flaman, 2008). These are useful analyses in the evidence-based design of health planning of organized encounter of necessities of the society. The literature show GIS technology for health is being applied in projects to explore, design and assess the system depicting key indicators of distance from and access to health care (Kivell & Mason, 1999; Kohli et al., 1995); to analyze access for specific sub populations (Love & Lindquist, 1995; Tanser, LeSueur, Solarsh, & Wilkinson, 2000) and to understand overviews of health care coverage and degree of regionalization (Florin, Gesler, Savitz, & Fondren, 1994).

GIS technology reply queries of provision of amenities that is a main influencing element to deprived health in developing countries (Phillips, Kinman, Schnitzer, Lindbloom, & Ewigman, 2000; Tanser & le Sueur, 2002). Public health utilization applications using GIS technology is applied in ascertaining access to necessities and in focusing resources at a local level. Literature show that information gathered on amenities utilization is important in comprehending accessibility, evaluating quantity of patients accessing services, and in describing health facility catchment zones at a national level. This catchment inhabitants, when demarcated precisely, assists in scrutinizing the access gaps, service necessities, and clarification of disease occurrence (Alegana et al., 2012).

Examples of studies done include; evidence-based approach to decision making (de Souza, 2009);access to health care services for low socioeconomic populations (Amin, Shah, & Becker, 2010); identifying the availability of prenatal clinic services for low-income mothers(McLafferty & Grady, 2004); assessing health care utilization (Higgs, 2009; Lopez-Cevallos & Chi, 2010; Phillips, Morrison, Andersen, & Aday, 1998), Zambia (Gabrysch, Cousens, Cox, & Campbell, 2011); general physical access to primary health care and quality of services studies(Higgs, 2004; Noor, Zurovac, Hay, Ochola, & Snow, 2003;Perry & Gesler, 2000); modeling ambulance response times (Peleg & Pliskin, 2004); trauma management (Schuurman, et al., 2008);injury research (Edelman, 2007); sledding injuries (Juang, Feliz, Miller, & Gaines, 2010).

C. Strategic Health Planning of Services

GIS technology applications can be embraced for using to design health facility accessibility and utilization, and to study service need. In order for these applications to be integrated into the strategic decision making process, they should incorporate task-appropriate statistical and modeling techniques such as geospatial interaction models (allowing proposed health facility service centers to be added interactively to assess their impact) and location-allocation models in order to forecast and evaluate the implication of modifying the configuration of existing services and play a proactive role in the healthcare planning services.

GIS technology can be applied in strategic health planning context where thematic information presented in maps can assist in cross-sectional decision making (Higgs, Smith, & Gould, 2005). It can be applied to approximate the best optimal geographical place for a new health facility, to reduce distances possible sick people travel taking into justification of present facilities, hourly disparities in jams (Tanser, 2006b).

Studies on planning health facilities include tracking and control of infectious disease outbreak (McKee, et al., 2000); design population based interventions (Caley, 2004); assessing the applicability of GIS in a health and social care setting for planning services (Foley, 2002); nursing workforce distribution planning(Courtney, 2005).

Additionally, GIS technology can be applied to strategize administration management, enhance activities, and developments avoidance (Peng et al., 2010). This can be done by delineating regions with considerably high rates, and to forecast which regions might be at future risk and which may benefit most from future local inhabitants selection (Boulos, 2004; Higgs & Gould, 2001; Martin et al., 2002; Sudhof et al., 2013). Hence, it's a vital instrument to be applied to ascertain spreading of socio-economic elements (Higgs & Gould, 2001).

D. Community Health Profiling

Nykiforuk & Flaman (2011) stated that community health profiling is demarcating and collecting of information regarding general health welfare of inhabitants within a geographical area , by the use of socio-demographic factors (socio-economic status); health behavior; disease mortality and morbidity name it. This collected information is then joined with the attribute geographical position of community infrastructure, namely religious institutions, education facilities, health facilities, roads, public utilities and grocery stores information then permits inquiry of universal associations among results (Nykiforuk & Flaman, 2008).

According to Pine and Diaz (2000), community health profiling is utilized as a foundation relating features geographically. Thus, technology is utilized for perceiving association amongst people and aids to guarantee the health necessities of societies (Plescia, Koontz, & Laurent, 2001).

Nykiforuk and Flaman (2011), Pine and Diaz (2000), Plescia, et al., (2001) suggest that community profiles could be used on limited basis to i) develop hypothesis and act as a catalyst for obtaining more information about individual patients, families, or neighborhoods; ii) observe general relationships between the environment and health outcomes; iii) track changes in the health of a community over time; iv) make suggestions for follow up analysis and research.

Profiles increase data access by local health users and planners, and permits engagement of diverse stakeholders in a partnership, offers reference point statistics and ascertain possible society difficulties (Latkin, Glass, & Duncan, 1998; Pine & Diaz, 2000).The practitioners then use information acquired from profile to ascertain possible disease exposures in society, forecast circulation, follow-up variations in society, and design prevention programs to disadvantaged communities (Latkin, Glass, & Duncan, 1998; Pine & Diaz, 2000).

Examples of studies done include; examining the process and to gauge how GIS is integrated with other software in problem solving during community health assessment data analysis (Scotch, Parmanto, Gadd, & Sharma, 2006); assessing community primary care needs (Dulin et al., 2010); development of health information community networks for exchanging geographically based information on community health status (Duhl, 2000);community based participatory approach to improving heath in a Hispanic population (Dulin, Tapp, Smith, Urquieta de Hernandez, & Furuseth, 2011);visualizing the infrastructure of US healthcare for reducing health disparities (Cromley & Cromley, 2009; Fulcher & Kaukinen, 2004); Socio-demographic data sources for monitoring locality health profiles and geographical planning of healthcare(Samarasundera, Martin, Saxena, & Majeed, 2010).

However, data-merging in community profiling must be carried-out with great care, taking into account of ethics of confidentiality and individual privacy. Regularly, geospatial data can be merged in an approach community users recognize persons. Hence to note, important to safeguard person's particulars by generating map layouts that safeguard envisioned persons it represents (Nykiforuk & Flaman, 2011).

E. Built Environment and Neighborhoods

A neighborhood is a physically generalized community inside a bigger city, town or suburb (Cutchin, Eschbach, Mair, Ju, & Goodwin, 2011;Shaw, 2012). Examples of studies; measures of environmental barriers (Hammel et al., 2008), the food environment (Charreire et al., 2010; Matthews, Moudon, & Daniel, 2009); residential location, vehicle ownership and travel (Senbil, Kitamura, & Mohamad, 2009); needs for school transport (Wong, Faulkner, & Buliung, 2011) and walkability (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Butler, Ambs, Reedy, & Bowles, 2011; Gray, Zimmerman, & Rimmer, 2012; Leslie et al., 2007) may be different in neighborhoods that have the same built environment. Built environment are human-created erections that may enable or deter a person's capability to be physically active. Built environment consist of urban design, land use, transportation systems (Handy, Boarnet, Ewing, & Killingsworth, 2002).

Of recent, built environment capacity in enlightening geographical modelling of obesity has been adequately honored in public health and epidemiology literature (Feng, Glass, Curriero, Stewart, & Schwartz, 2010;Papas et al., 2007). Obesogenic that are rated unfavorable inspire harmful consumption (Booth, Pinkston, & Poston, 2005;Thornton, Pearce, & Kavanagh, 2011). To note, literature indicate that characteristics of the built environment brought and created impacts and actions, socio-demographic population staying in those geographical areas (Grafova, Freedman, Kumar, & Rogowski, 2008; Kim, 2008). Also, street connectivity, transport infrastructure and the location and quality of community resources such as parks and schools are part of built environment that influences obesity through the promotion of physical activity (Owen, Humpel, Leslie, Bauman, & Sallis, 2004; Saelens, Sallis, & Frank, 2003).

F. Health Education

Health Education activity in health arena is GIS-enabled web-based locations used as outreach for public recording a place of inhabitants that have the utmost necessity of better-quality health information (Boulos, 2004). Examples of health education include a childhood lead poisoning prevention program(Hanchette, 1999);

mapping of motor vehicle injuries and fatalities in a community; and using data collected by marketing firms about consumer spending patterns and lifestyle segmentation profiles to identify the best target populations for prevention interventions e.g. anti-smoking programs, select the best media channels and during day time to communicate a particular message to a given population (Richards, Croner, Rushton, Brown, & Fowler, 1999); in primary healthcare research and development (Hasmadi & Imas, 2010; Samarasundera et al., 2012)

G. *Crisis Management*

Crisis management is an area in public health benefiting from capabilities of GIS technology in calculating travel time isochrones to determine the effective response time zones for provision of emergency care services (Boulos, 2004). Although not used extensively in public health, GIS technology is utilized in combination with a sensor web, citizen sensing and social web technologies to monitor public and environmental crises (Kamel Boulos et al., 2011). It can still be used to manage and plan disasters and humanitarian emergencies (Kaiser, Spiegel, Henderson, & Gerber, 2003; Mathew, 2005; Pate, 2008; Shaw, 2012). Of recent, public health practitioners are currently using GIS to produce enhanced capacity for emergency response, effective and efficient government operations, increased transparency of public decision making and better addressing of social inequalities. Examples include management and planning for disasters and humanitarian emergencies (Mathew, 2005).

H. *Risk Analysis*

GIS technology application for risk analysis is normally merged together with environment exposures. The risk analysis application is comprised of components like risk assessment, management, communication, monitoring or evaluation of management strategies (Nykiforuk & Flaman, 2011). Risk analysis application can allow monitoring public health officials to focus limited resources on those hazards that pose the greatest risk to public health. Kaiser et al., (2003) states that risk assessment element is known as the systematic grounded procedure for assessing hazards and approximating further highlight that aid using support, element offer responding numerous medication policies?

Risk analysis responsibilities scrutinize dangerous contamination or lack of access to healthcare.

Examples of GIS technology use of risk analysis include hazardous waste transport (Contini, Bellezza, Christou, & Kirchsteiger, 2000); mapping of exposure and disease risk assessment (Jarup, 2004; Nuckols, Ward, & Jarup, 2004; Rinaldi, et al., 2004); flood management (Taylor et al., 2011); pesticide exposure(Maroni, Fanetti, & Metruccio, 2006); air pollution (Beelen et al., 2008; Levy, Clougherty, Baxter, Houseman, & Paciorek, 2010; Vienneau, de Hoogh, & Briggs, 2009);soil-borne infections (Jex et al., 2011); ecosystem decline (Twumasi & Merem, 2007); arsenic poisoning from ground water(Hassan, 2005; Khan, Owens, Bruce, & Naidu, 2009).

VI. KEY ISSUES TO NOTE

Despite the wide range of benefits that can be gained by utilizing GIS with a combination of related technologies for public health, it is vital to be aware of the key issues associated with limiting its use in public health. The most important ones are briefly discussed below.

Data limitation access is a problem that has been faced by GIS users for decades in public health (in developing countries) these days (Bauer & Puotinen, 2002; Boulos, 2004; Joyce, 2009; McLafferty, 2003; Nykiforuk & Flaman, 2011; Shaw, 2012;Sipe & Dale, 2003).

According to Armstrong and Ruggles, (2005), Higgs, et al., (2005), Joyce (2009), and Shaw (2012) *Privacy and confidentiality of individuals* hinders GIS use that limits data access about health status and outcomes especially at an individual level or small areas together should be taken seriously because it applies on sometimes individual properties (Richards,1993).

Financial implications of hardware and software is also one of the hindrance for GIS technology use (Bauer & Puotinen, 2002; Boulos, 2004; Fox, 1991; Mullner, et al., 2004; Sipe & Dale, 2003; Yeh, 1991). The cost of using GIS requires adequate financial capability for buying and development of the infrastructure that enables it functioning. However, as Tanser & le Sueur (2002) state, GIS difficulties are few now compared to past decade as computer equipment are inexpensive.

Frequently mentioned in literature as hindrance for GIS technology adoption is also shortage of knowledgeable skilled personnel with competences of applying GIS technology for health activities (Boulos, 2004; Edralin, 1991; Fox, 1991; Mullner, et al., 2004; Sipe & Dale, 2003; Tanser & le Sueur, 2002; Yeh, 1991). Thus, GIS courses for health specialists be delivered precisely to advantage of patients.

Lack of software extensions/functions that perform geospatial analysis is also a constrain in public health (Fonseca Nobre, Luiz Braga, Pinheiro, & dos Santos Lopes, 1997; Yeh, 1991). Hawkers mostly sell it without extensions individually and very expensive to afford due to limited budget constraints.

Further recognized is misinterpretation of results or misuse of information which is attached to lack of knowledge and technical expertise in GIS (Mullner et al 2004; Sipe & Dale, 2003; Tanser & Le Sueur, 2002). Based on this information, however easy it is to identify institutions of learning for GIS technology for rudimentary understanding of GIS, it is normally not easy for interested persons to discover those institutes of GIS for understanding public health. Key to note, map information has become a source of public health information, however, maps if not interpreted properly can lie or mislead planning and decision-making.

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The absence of a service level agreement for accessing and sharing digital data (data policy); geospatial data availability; quality and standards (formats); poor understanding and lack of awareness of collaborative GIS, and limited awareness of the benefits of GIS (Boulos, 2004; Joyce, 2009) are some of the issues that should be noted.

VII. CONCLUSION

Whereas obstacles have been identified that deter the adoption of use of GIS technology in public health, a number of authors have made some particular recommendations that may help address GIS use in public health. Some are summarized below:

Tanser and Le Sueur (2002) proposed that as all disciplines information have and use the component geographical data for analysis, planning and decision making, developing spatial data infrastructure which encompasses geospatial policies would improve sharing of data. On the other-hand, this this would increase GIS technology adoption, use and access. Thus, overcoming data limitation access and reduces expenses for data collection, Privacy and confidentiality of individuals, Financial implications of hardware and software, Lack of software extensions/functions, Misinterpretation of results or misuse, Lack of qualified staff and Decision makers do not understand GIS applications. In this review, we noticed that, public health professionals should be aware of both benefits and hindrances of GIS technology adoption. However, the public disease analysis, evidenced-based information is the way to go.

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