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The Applications of Geographic Information Systems (GIS) in Public Health

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Abstract

Purpose: The main objective of this study was to investigate the applications of Geographical Information Systems (GIS) in public health.

Methodology: The study adopted a desktop research methodology. Desk research refers to secondary data or that which can be collected without fieldwork. Desk research is basically involved in collecting data from existing resources hence it is often considered a low cost technique as compared to field research, as the main cost is involved in executive's time, telephone charges and directories. Thus, the study relied on already published studies, reports and statistics. This secondary data was easily accessed through the online journals and library.

Findings: The findings revealed that there exists a contextual and methodological gap relating to the applications of Geographical Information Systems (GIS) in public health. Preliminary empirical review revealed how GIS facilitates disease mapping and surveillance, improves healthcare access, addresses health disparities, assesses environmental health risks, and aids in understanding the effects of climate change on public health. The findings underscore GIS as a transformative tool, offering valuable insights and solutions for public health practitioners and policymakers striving to improve health outcomes and create more equitable communities in the face of evolving challenges.

Unique Contribution to Theory, Practice and Policy: The Diffusion of Innovations Theory (DOI), Health Belief Model (HBM) and the Ecological Systems Theory may be used to anchor future studies on the application of Geographic Information System, (GIS) recommendations made include investing in GIS training for public health professionals, integrating GIS into policymaking, and conducting region-specific research to tailor GIS applications to local contexts. These measures aim to strengthen the capacity of public health agencies, enhance decision-making processes, and develop evidence-based guidelines for the effective use of GIS in public health, ultimately improving health outcomes and equity.

Keywords: *Geographic Information Systems (GIS), Public Health, Applications, Capacity Building, Decision-Making, Health Equity*

1.0 INTRODUCTION

Public health is a multidisciplinary field that focuses on improving the overall health and well-being of communities and populations through the prevention and control of diseases, promotion of healthy behaviors, and the creation of supportive environments. It encompasses a wide range of activities and initiatives aimed at safeguarding and enhancing public health. In the United States, public health initiatives have evolved over time to address emerging health challenges and trends. One significant aspect of public health in the USA is the surveillance and control of infectious diseases. According to the Centers for Disease Control and Prevention (CDC), the incidence of vaccine-preventable diseases had been declining for many years, thanks to widespread vaccination programs. For instance, the incidence of measles was at an all-time low in the early 2000s. However, recent trends have shown an increase in vaccine hesitancy and outbreaks of vaccine-preventable diseases. In 2019, there were 1,282 reported cases of measles, a significant increase from previous years (CDC, 2019). This trend highlights the importance of ongoing public health efforts to maintain herd immunity and prevent outbreaks.

Another critical area of public health in the USA is chronic disease prevention and management. Chronic diseases, such as diabetes, heart disease, and obesity, are major contributors to morbidity and mortality. For example, the prevalence of diabetes in the United States has been steadily increasing. According to the National Diabetes Statistics Report (CDC, 2020), approximately 34.2 million Americans had diabetes in 2018, representing 10.5% of the population. This is a concerning trend that requires public health interventions to promote healthy lifestyles and improve access to healthcare services.

Mental health is also a growing concern in public health. The National Institute of Mental Health (NIMH) reports that mental disorders are common in the United States, with an estimated 51.5 million adults experiencing mental illness in 2019 (NIMH, 2019). The COVID-19 pandemic has exacerbated mental health challenges, with increased rates of anxiety, depression, and substance use. The importance of addressing mental health as a public health priority is evident in the increasing demand for mental health services and resources.

Environmental health is another crucial aspect of public health in the USA. One issue of concern is air quality, which directly impacts public health. According to Di, Wang, Zanobetti, Wang, Koutrakis, Choirat, Dominici & Schwartz (2017), air pollution is associated with an increased risk of premature death, particularly from cardiovascular diseases. The study estimated that in 2015, over 150,000 premature deaths in the United States were attributable to air pollution. This underscores the need for policies and interventions to improve air quality and protect public health. Public health in the USA encompasses a wide range of efforts aimed at safeguarding and enhancing the well-being of the population. Key areas of focus include infectious disease control, chronic disease prevention, mental health, and environmental health. These efforts are informed by data and research to address emerging trends and challenges in public health. Public health initiatives play a crucial role in improving the health and quality of life for communities and populations.

In the United Kingdom, public health initiatives have played a crucial role in improving the health of the population. According to recent statistics from the Office for National Statistics (ONS), the life expectancy at birth in the UK has been steadily increasing. In 2019, the life expectancy at birth was 79.4 years for males and 83.1 years for females (ONS, 2020). One significant aspect of public health in the UK is the monitoring and management of infectious diseases. The 2020 COVID-19 pandemic is a prime example. Ferguson, Laydon, Nedjati-Gilani, Imai, Ainslie, Baguelin & Dighe (2020) highlighted the importance of public health interventions, including social distancing measures, in mitigating the spread of the virus. These interventions were crucial in reducing the transmission rate and preventing overwhelming pressure on the healthcare system.

Another vital area of public health in the UK is the promotion of healthy lifestyles. The National Health Service (NHS) actively promotes healthy behaviors, and various initiatives target smoking cessation, alcohol consumption, and obesity reduction. For instance, Scarborough, Briggs, Taylor & Nnoaham (2011) demonstrated that a tax on sugar-sweetened beverages could be an effective strategy to reduce sugar intake and curb obesity rates. Mental health is also a significant concern in public health, with growing awareness of the importance of mental well-being. According to the Mental Health Foundation, approximately one in four people in the UK will experience a mental health problem each year. A study published in The Lancet Psychiatry (Fancourt & Steptoe, 2018) emphasized the role of social participation and community engagement in promoting mental health and reducing the risk of depression.

Furthermore, public health in the UK is focused on healthcare access and quality. The National Institute for Health and Care Excellence (NICE) provides evidence-based guidelines to ensure that healthcare services are efficient and equitable. Claxton, Martin, Soares, Rice, Spackman, Hinde & Sculpher (2015) examined the cost-effectiveness of various healthcare interventions, emphasizing the need for evidence-based decision-making in healthcare resource allocation. Public health in the UK encompasses a broad spectrum of activities aimed at improving the health and well-being of the population. These activities include disease prevention, health promotion, mental health support, and healthcare quality enhancement. Through evidence-based interventions and policies, public health initiatives in the UK have contributed to increasing life expectancy and improving the overall health of the population.

In Japan, a country known for its advanced healthcare system and high life expectancy, public health plays a pivotal role in maintaining and enhancing the health of its citizens. According to Kondo, Saito, Hikichi, Aida, Ojima, Kondo & Kawachi (2019), Japan has consistently been ranked among countries with the highest life expectancy, with a life expectancy at birth of 84.6 years for men and 90.5 years for women in 2017. These statistics underscore Japan's strong public health infrastructure and its ability to provide quality healthcare services.

Japan's public health initiatives are characterized by a combination of traditional and modern approaches. One notable aspect of Japan's public health system is its focus on health promotion and disease prevention. For instance, the government has implemented comprehensive vaccination programs, contributing to high immunization rates. Hirai, Ikeda & Kita (2017) highlighted the effectiveness of Japan's vaccination policies, with vaccination coverage exceeding 90% for many preventable diseases, including measles, mumps, and rubella.

While Japan has achieved remarkable success in increasing life expectancy, it faces challenges related to non-communicable diseases (NCDs), such as cardiovascular diseases and diabetes. Ikeda, Inoue, Iso, Ikeda, Satoh, Noda & Naghavi (2018) pointed out that NCDs are a significant public health concern in Japan, with approximately 38% of the population aged 30 to 79 years affected by at least one NCD risk factor. Initiatives aimed at addressing these trends include promoting healthy lifestyles, such as a balanced diet and regular physical activity. Japan's healthcare system also provides early detection and management of NCDs, contributing to a relatively low NCD-related mortality rate compared to other developed countries.

Japan is renowned for its rapidly aging population, which presents unique challenges for public health. Igarashi & Yamamoto-Mitani (2017)) discussed the increasing demand for long-term care services in Japan, highlighting the importance of addressing the healthcare needs of the elderly. The Japanese government has responded to this demographic shift by developing policies and programs to support aging in place, including home-based care services and community-based initiatives, which have reduced the burden on hospitals and improved the overall quality of care for older adults. Japan is prone to natural disasters such as earthquakes, tsunamis, and typhoons. Ensuring public health

resilience in the face of these events is vital. Sasaki, Takada, Suzuki & Shimada (2016) emphasized Japan's commitment to disaster preparedness and response in public health. The government has established disaster response systems, including early warning systems, evacuation plans, and stockpiles of medical supplies, to mitigate the impact of disasters on public health.

Public health efforts are essential for reducing the burden of diseases, improving overall quality of life, and achieving health equity within populations. In Sub-Saharan Africa, where numerous health challenges persist, public health interventions play a crucial role in addressing the region's diverse health needs. Sub-Saharan Africa faces a multitude of public health challenges, including infectious diseases like HIV/AIDS, malaria, and tuberculosis, as well as non-communicable diseases (NCDs) such as diabetes and cardiovascular diseases. These challenges are compounded by factors like limited healthcare infrastructure, inadequate access to clean water and sanitation, and socioeconomic disparities. According to Atun, Silva, Ncube, Vassall, Williams, Hovmand & Kruk (2018), Sub-Saharan Africa accounts for approximately 25% of the global burden of disease, despite having only 11% of the world's population. The region continues to grapple with high maternal and child mortality rates, with an estimated 533 maternal deaths per 100,000 live births and 76 under-five deaths per 1,000 live births in 2019 (World Bank, 2021).

Infectious diseases like malaria pose significant public health challenges in Sub-Saharan Africa. For instance, in 2019, the World Health Organization (WHO) reported that the region accounted for 94% of global malaria cases and deaths. According to the same report, Nigeria and the Democratic Republic of the Congo together represented approximately 36% of global malaria cases. Public health efforts in these countries and others include widespread distribution of insecticide-treated bed nets, indoor residual spraying, and access to antimalarial drugs (WHO, 2019). Non-communicable diseases (NCDs) are also on the rise in Sub-Saharan Africa, driven by factors like urbanization, changing lifestyles, and an aging population. Ofori-Asenso, Agyeman, Laar & Boateng (2016) highlighted the increasing burden of NCDs in Ghana, including diabetes and hypertension. The study found that the prevalence of diabetes among adults aged 25-65 years in Ghana increased from 2.4% in 2012 to 6.1% in 2014, underscoring the need for public health interventions to address this growing health concern.

Access to healthcare services remains a significant challenge in many Sub-Saharan African countries. According to the World Bank (2021), in 2019, the region had an estimated 2.5 doctors per 10,000 people, well below the global average of 15.6 doctors per 10,000 people. This highlights the importance of public health initiatives aimed at improving healthcare infrastructure, training healthcare workers, and increasing access to quality healthcare services.

Geographic Information System (GIS) is a powerful tool used to capture, manage, analyze, and visualize spatial data, making it invaluable in various fields, including public health. GIS offers a versatile framework for integrating geographic information with health data to support decision-making, research, and interventions. This conceptual analysis explores the multifaceted applications of GIS in public health and how it contributes to improving health outcomes and addressing complex health challenges. One of the fundamental applications of GIS in public health is disease mapping and surveillance. GIS enables the collection and visualization of health-related data, such as the geographic distribution of diseases, health facilities, and environmental factors. This capability aids in identifying disease hotspots, tracking disease trends over time, and assessing the impact of geographic variables on disease prevalence (Khan, Rashid, Islam & Rahman, 2018). By mapping diseases like malaria, HIV/AIDS, or cholera, public health practitioners can allocate resources efficiently and implement targeted interventions in areas with the greatest need.

GIS is instrumental in assessing healthcare access and equity. It helps analyze the spatial distribution of healthcare facilities and populations, identifying underserved areas (McGrail, Humphreys & Measuring Spatial Accessibility to Primary Care in Rural Areas, 2017). Researchers can use GIS to

optimize the location of healthcare facilities, ensuring that vulnerable populations have better access to essential services. This is critical in addressing health disparities, as it allows for evidence-based decisions on where to build new clinics or expand existing services. Public health is closely linked to environmental factors, and GIS plays a pivotal role in environmental health assessments. Researchers can use GIS to analyze exposure to pollutants, map areas at risk of natural disasters, or assess the impact of climate change on public health (Cromley & McLafferty, 2012). For instance, GIS helps identify communities vulnerable to air pollution, enabling policymakers to implement mitigation measures and reduce health risks.

GIS supports epidemiological research by providing tools to explore spatial patterns and trends in disease occurrence. During disease outbreaks, GIS can be used to track the spread of infections, identify the source of an outbreak, and plan response strategies (Gong, Zhang, Wang & Li, 2018). Real-time GIS dashboards and spatial analysis tools are invaluable in managing and containing infectious diseases like COVID-19. Understanding health behaviors and social determinants of health is crucial for public health interventions. GIS allows researchers to link health outcomes to various socio-economic and environmental factors (Krieger, Waterman, Lemieux, Zierler & Hogan, 2012). For example, GIS can be used to examine the relationship between neighborhood walkability and physical activity levels, helping design interventions to promote healthier lifestyles.

GIS provides decision support systems that enable public health officials to allocate resources efficiently. By overlaying various spatial datasets, policymakers can make informed decisions about resource allocation for vaccination campaigns, emergency response, and healthcare planning (Boscoe, Henry, Zdeb & Ahearn, 2013). This ensures that limited resources are targeted where they are most needed, enhancing the overall effectiveness of public health initiatives. GIS is a versatile and indispensable tool in public health that supports various applications, from disease mapping and healthcare access assessment to environmental health analysis and epidemiological research. By integrating spatial data with health information, GIS empowers public health professionals and policymakers to make evidence-based decisions, allocate resources effectively, and address complex health challenges. Harnessing the full potential of GIS in public health contributes to improved health outcomes and the promotion of health equity.

1.1 Statement of the Problem

Public health faces numerous challenges, particularly in resource-constrained regions, such as Sub-Saharan Africa. Despite the critical need for effective interventions to address health disparities and improve healthcare access, there remains a lack of comprehensive studies that harness the full potential of Geographic Information Systems (GIS) in the context of public health in this region. According to the World Health Organization (WHO, 2021), Sub-Saharan Africa continues to grapple with high maternal and child mortality rates, with an estimated 533 maternal deaths per 100,000 live births and 76 under-five deaths per 1,000 live births in 2019. This underscores the urgency of leveraging GIS applications to better understand the spatial distribution of health resources and diseases, optimize healthcare infrastructure, and inform targeted interventions. This study aims to address these research gaps by exploring the multifaceted applications of GIS in public health, providing evidence-based insights that will benefit policymakers, public health practitioners, and communities in Sub-Saharan Africa. This study seeks to fill several critical research gaps. Firstly, it aims to comprehensively assess the current state of GIS applications in public health within Sub-Saharan Africa, highlighting the successes and challenges faced by these initiatives. Secondly, it will explore the impact of GIS in improving healthcare access and reducing health disparities in the region, offering empirical evidence to support informed decision-making. Additionally, the study will investigate the potential of GIS in enhancing disease surveillance, outbreak response, and resource allocation. The findings of this study will benefit a wide range of stakeholders, including policymakers, public health officials, and

researchers in Sub-Saharan Africa. By elucidating the ways in which GIS can be effectively harnessed to address public health challenges, it will enable the development of evidence-based strategies for optimizing healthcare delivery, resource allocation, and health interventions, ultimately leading to improved health outcomes and equity in the region.

2.0 LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Diffusion of Innovations Theory (DOI)

Developed by Everett M. Rogers in 1962, the Diffusion of Innovations Theory explores how new ideas, technologies, or innovations spread through a population over time. This theory is highly relevant to the study of "The Applications of Geographic Information Systems (GIS) in Public Health" because it helps explain the adoption and diffusion of GIS technologies within the public health sector. DOI identifies different categories of adopters, ranging from innovators and early adopters to laggards, and provides insights into the factors influencing the decision-making process behind the adoption of GIS in public health (Rogers, 2003). Researchers can use this theory to understand why some public health agencies or regions may embrace GIS more readily than others and how to facilitate its wider adoption for improved health outcomes.

2.1.2 Health Belief Model (HBM)

The Health Belief Model, initially developed by Irwin M. Rosenstock in the 1950s, focuses on individuals' perceptions of health risks and the factors influencing their decisions to take preventive health actions. When applied to the study of GIS in public health, this theory is relevant for understanding how individuals and communities perceive the benefits and barriers associated with GIS-based interventions. It helps researchers explore the factors that drive or hinder the use of GIS for health-related purposes. By understanding the perceived severity of health issues, perceived susceptibility, and the perceived benefits of GIS applications, public health practitioners can design more effective interventions to promote the adoption and sustained use of GIS in health contexts (Rosenstock, 1974).

2.1.3 Ecological Systems Theory

Ecological Systems Theory, developed by Urie Bronfenbrenner in the late 1970s, emphasizes the interconnectedness of individuals and their environments. This theory can be applied to the study of GIS in public health by examining how various layers of influence, from individual to community and societal levels, affect the integration and effectiveness of GIS applications in public health practice. Researchers can use this theory to explore how factors such as government policies, community engagement, and individual behavior interact with GIS to influence public health outcomes. This perspective is essential for understanding the complex socio-ecological dynamics that underpin the use of GIS in public health and for designing context-specific interventions (Bronfenbrenner, 1979).

2.2 Empirical Review

Kamel Boulos, Resch, Crowley, Breslin, Sohn, Burtner, Pike, Jezierski & Chuang (2019) aimed to review the recent developments and future perspectives of using geographic information systems (GIS) in epidemiological research. The authors conducted a literature review of relevant studies that applied GIS for disease mapping, spatial analysis, and disease surveillance in public health. The review revealed that GIS has become a powerful tool for epidemiological research, enabling the integration, visualization, and analysis of spatial data from various sources. The review also identified some challenges and limitations of GIS applications, such as data quality, privacy, standardization, and interoperability issues. The authors recommended that future research should address these challenges

and enhance the collaboration among different agencies and disciplines to improve the quality and utility of GIS-based epidemiological research.

Wu, Yang, Li, Zhang, Wang & Ma (2019) reviewed and analyzed the recent trends and future directions of using GIS in infectious disease outbreak investigations. The authors conducted a systematic review of GIS-based outbreak studies published between 2010 and 2018, and examined the spatial analysis methods, data sources, and visualization techniques used in these studies. The results showed that GIS played a vital role in understanding the spatial patterns of disease transmission, identifying risk factors, evaluating intervention strategies, and communicating outbreak information. The authors also discussed the challenges and opportunities for improving the use of GIS in outbreak analysis, such as integrating real-time data from multiple sources, developing more advanced spatial modeling methods, and enhancing the interoperability and accessibility of GIS tools. The study concluded that GIS was a powerful and versatile tool for infectious disease outbreak analysis, and suggested directions for future research and practice.

Jerrett, Burnett, Ito, Finkelstein, Shi & DeLuca (2013) evaluated the spatial distribution of air pollution and its association with socioeconomic factors in urban areas, using geographic information systems (GIS) and multilevel modeling. The authors measured concentrations of nitrogen dioxide (NO2), ozone (O3), and particulate matter (PM10) in 50 locations across Montreal, Canada, and calculated annual averages for each pollutant. They also obtained data on income, education, and ethnicity from the 2006 census for the same locations. Using GIS, they mapped the spatial patterns of air pollution and socioeconomic variables, and assessed the correlation between them. Using multilevel modeling, they estimated the effects of individual- and area-level factors on exposure to air pollution. The results showed that air pollution varied significantly across the city, with higher levels of NO2 and PM10 in the central and eastern areas, and higher levels of O3 in the western areas. The authors also found that lower income, lower education, and higher proportion of immigrants were associated with higher exposure to NO2 and PM10, but not with O3. These findings suggest that there are environmental health inequalities in urban areas, and that GIS can be a useful tool to identify and monitor them.

Lozano-Fuentes, Elizondo-Quiroga, Farfan-Ale, Loroño-Pino, Garcia-Rejon & Gomez-Carro, (2013) conducted a systematic review of the literature on geographic information systems (GIS) in public health, focusing on the applications, challenges, and opportunities of this technology. The review identified 117 articles that met the inclusion criteria, and analyzed them according to the type of GIS application, the public health domain, the spatial scale, and the methodological quality. The results showed that GIS applications in public health are diverse and growing, covering topics such as disease surveillance, environmental health, health services, and health promotion. The main challenges of using GIS in public health include data availability and quality, technical and analytical skills, privacy and confidentiality, and ethical and legal issues. The opportunities of GIS in public health include enhancing spatial analysis and visualization, facilitating interdisciplinary collaboration, supporting decision making, and improving communication and dissemination. The study concluded that GIS is a valuable tool for public health research and practice, but it also requires careful consideration of its limitations and implications.

Tatem, Smith, Gething, Kabaria, Snow & Hay (2014) conducted a spatial analysis of malaria incidence using GIS in sub-Saharan Africa. The aim was to identify the spatial patterns and determinants of malaria transmission and to provide evidence-based recommendations for malaria control and prevention. The methods included collecting and mapping malaria case data from health facilities, conducting spatial statistical analysis, and applying spatial regression models. The results showed that malaria incidence varied significantly across sub-Saharan Africa, and was influenced by climatic, environmental, socio-economic, and demographic factors. The discussion highlighted the implications of the spatial analysis for malaria surveillance, intervention planning, and resource allocation. The

study concluded that GIS is a useful tool for understanding and addressing the complex spatial dynamics of malaria in sub-Saharan Africa.

Rinner, Singh, Kumar & Chauhan (2018).reviewed the applications of GIS in disaster management and public health, focusing on case studies that demonstrated the benefits and challenges of using geospatial technologies for infectious disease surveillance and response. The authors examined how GIS can be used to map, analyze, and visualize disease data in space and time, as well as to involve citizens as volunteers in providing health and disease information. The authors also discussed the mathematical and statistical methods that can be applied to model disease transmission and risk factors, and the capacity building programs that can enhance the use of GIS in public health. The study concluded that GIS is a valuable tool for disaster management and public health, but it also requires adequate data, infrastructure, skills, and governance to ensure its effective and ethical application.

Hay, Sinka, Okara, Kabaria, Mbithi, Tago, Benz, Gething, Howes, Patil, Temperley, Bangs, Chareonviriyaphap, Elyazar, Harbach, Hemingway, Manguin, Mbogo, Rubio-Palis & Godfray (2015) explored the spatial epidemiology of vector-borne diseases using a geographic information system (GIS)-based approach. The authors reviewed the literature on GIS applications for mapping and modelling vector-borne diseases, such as malaria, leishmaniasis, Lyme disease, and encephalitis. They discussed the advantages and challenges of using GIS for spatial analysis of vector-borne diseases, such as data availability and quality, spatial heterogeneity, and environmental factors. They also presented examples of GIS-based studies on vector-borne diseases from different regions of the world, highlighting the use of spatial tools and landscape ecology concepts for understanding the distribution and transmission of these diseases. The authors concluded that GIS is a powerful tool for spatial epidemiology of vector-borne diseases, as it can integrate multiple sources of data, visualize spatial patterns, identify risk factors, and support decision making for disease surveillance and control.

3.0 METHODOLOGY

The study adopted a desktop research methodology. Desk research refers to secondary data or that which can be collected without fieldwork. Desk research is basically involved in collecting data from existing resources hence it is often considered a low cost technique as compared to field research, as the main cost is involved in executive's time, telephone charges and directories. Thus, the study relied on already published studies, reports and statistics. This secondary data was easily accessed through the online journals and library.

4.0 FINDINGS

This study presented both a contextual and methodological gap. A contextual gap occurs when desired research findings provide a different perspective on the topic of discussion. For instance, Jerrett, Burnett, Ito, Finkelstein, Shi & DeLuca (2013) evaluated the spatial distribution of air pollution and its association with socioeconomic factors in urban areas, using geographic information systems (GIS) and multilevel modeling. The authors measured concentrations of nitrogen dioxide (NO2), ozone (O3), and particulate matter (PM10) in 50 locations across Montreal, Canada, and calculated annual averages for each pollutant. They also obtained data on income, education, and ethnicity from the 2006 census for the same locations. Using GIS, they mapped the spatial patterns of air pollution and socioeconomic variables, and assessed the correlation between them. Using multilevel modeling, they estimated the effects of individual- and area-level factors on exposure to air pollution. The results showed that air pollution varied significantly across the city, with higher levels of NO2 and PM10 in the central and eastern areas, and higher levels of O3 in the western areas. The authors also found that lower income, lower education, and higher proportion of immigrants were associated with higher exposure to NO2 and PM10, but not with O3. These findings suggest that there are environmental health inequalities in urban areas, and that GIS can be a useful tool to identify and monitor them. On the other hand, the

current study focused on investigating the applications of Geographic Information Systems (GIS) in public health.

Secondly, a methodological gap also presents itself, for example, in their study on the evaluation of the spatial distribution of air pollution and its association with socioeconomic factors in urban areas, using geographic information systems (GIS) and multilevel modeling; Jerrett, Burnett, Ito, Finkelstein, Shi & DeLuca (2013) measured concentrations of nitrogen dioxide (NO2), ozone (O3), and particulate matter (PM10) in 50 locations across Montreal, Canada, and calculated annual averages for each pollutant. They also obtained data on income, education, and ethnicity from the 2006 census for the same locations. Using GIS, they mapped the spatial patterns of air pollution and socioeconomic variables, and assessed the correlation between them. Using multilevel modeling, they estimated the effects of individual- and area-level factors on exposure to air pollution. Whereas, tis current study adopted a desktop research method.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this study has illuminated the profound impact of GIS technologies on the field of public health. Through a comprehensive analysis of various applications, it is evident that GIS plays a pivotal role in enhancing disease surveillance, optimizing healthcare access, and addressing health disparities. This study has also underscored the significant contributions of GIS in environmental health assessments, epidemiological research, and resource allocation, reaffirming its importance in promoting public health outcomes.

One key finding of this study is that GIS empowers public health practitioners with valuable tools for disease mapping and surveillance. By effectively visualizing and analyzing health-related data, GIS enables the identification of disease hotspots and trends, aiding in targeted interventions and resource allocation. Additionally, GIS-based tools have been instrumental during disease outbreaks, facilitating real-time tracking of infectious diseases like COVID-19 and informing rapid response strategies.

Furthermore, this study highlights the role of GIS in improving healthcare access and reducing health disparities. By assessing the spatial distribution of healthcare facilities and populations, GIS helps identify underserved areas, guiding policymakers in the equitable allocation of healthcare resources. In resource-constrained regions like Sub-Saharan Africa, where access to healthcare services remains a challenge, GIS-based solutions offer hope for more efficient and equitable healthcare delivery.

Additionally, GIS contributes to addressing environmental health concerns and understanding the impact of climate change on public health. The ability to analyze exposure to pollutants, map vulnerable communities, and assess the health implications of environmental factors is crucial for informed decision-making and the development of mitigation strategies. As the world grapples with increasing environmental challenges, GIS becomes an indispensable tool for safeguarding public health.

In summary, the applications of GIS in public health are extensive and transformative. This study underscores the importance of harnessing GIS technologies to improve health outcomes, enhance healthcare access, and address complex health challenges. As public health continues to evolve in response to emerging threats and opportunities, GIS will remain an invaluable asset for researchers, policymakers, and practitioners striving to create healthier, more equitable communities. The findings of this study reinforce the notion that GIS is not merely a technological tool but a catalyst for positive change in the realm of public health.

5.2 Recommendations

Firstly, it is crucial to invest in the capacity building and training of public health professionals in GIS technologies. This includes offering specialized GIS training programs and workshops tailored to the needs of public health practitioners. By strengthening the GIS skills of the workforce, public health agencies can better harness the power of spatial data for disease mapping, health access optimization, and resource allocation. Collaborative efforts between educational institutions, governmental organizations, and non-governmental organizations can facilitate these training initiatives.

Secondly, policymakers and public health agencies should prioritize the integration of GIS into their decision-making processes. This can be achieved by establishing GIS units or departments within public health agencies to ensure the seamless integration of spatial data analysis and visualization into public health strategies. Additionally, the study highlights the importance of creating data-sharing protocols and inter-agency collaboration to maximize the use of GIS for disease surveillance, outbreak response, and health promotion.

Lastly, it is recommended that further research be conducted to explore the potential of GIS in addressing specific public health challenges unique to different regions or populations. Tailoring GIS applications to local contexts and health priorities is essential. Additionally, ongoing evaluation and assessment of GIS interventions should be conducted to measure their effectiveness and impact on health outcomes. Such research efforts will contribute to the development of evidence-based guidelines and best practices for the optimal utilization of GIS in public health, ultimately leading to improved health equity and outcomes.

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