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Analysis data spatial for nutrition programs: a review using geographic information system

Bedjo Utomo[1], Triwiyanto[1], Sari Luthfiyah[1], Sugeng Iwan Setyobudi[2]
[1]Department of Medical Electronics Technology, Health Polytechnic Ministry of Health Surabaya, Surabaya, Indonesia
[2]Department of Nutrition, Health Polytechnic of Malang, Malang, Indonesia

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ABSTRACT

Nutritional problems are public health problems that are still found in developing countries, one of the prevention efforts requires nutritional data information. Geographic information systems (GIS) is an information system application that can analyze spatial data, such as population distribution, regional boundaries, and access to health centers. This study aims to examine the use of spatial data analysis with GIS in monitoring nutrition programs. The methods used in data retrieval use scientific database searches such as PubMed, Scopus, and Google Scholar as well as VOSviewer application with Keywords such as "spatial data analysis", "Geographic Information System", "Nutrition program", and design and implementation. The results of this study state that the GiS has a broad impact on the dissemination of nutritional status information, especially in areas with nutritional vulnerability, GIS spatial analysis can help understand the factors that contribute to malnutrition, as well as environmental factors that influence the success of nutrition programs. The results of the study concluded that priority areas of nutrition program intervention on the use of Geographic Information Systems can be used to make decisions and analyze spatial data to reduce the burden of disease in these areas. Furthermore, this review further enhances the understanding of the use of GiS for nutrition program interventions in improving the success of nutrition programs.

Corresponding Author:

Bedjo Utomo
Department of Medical Electronics Technology, Health Polytechnic Ministry of Health Surabaya
Surabaya, Indonesia
Email: bedjo65@poltekkesdepkes-sby.ac.id

1. INTRODUCTION

Determining the right policies and decisions to address nutritional problems requires accurate and up-to-date information about the nutritional status of the population. However, the available information is not available in real-time, so it is very difficult to evaluate or monitor the development of nutritional status effectively [1]. Geographic information systems (GIS) have become a very useful tool in the field of public health, including the distribution of nutritional data [2]. GIS enables the integration and visualization of geographic data, such as demographic, social, and health data in the form of maps, which makes it easier to understand information and to enable monitoring the development of nutritional status in the health sector [3], [4]. Therefore, this paper aims to evaluate the effectiveness of GIS use in the distribution of nutritional status data in health areas. To reach the aims mentioned beforehand, a thorough discussion on how GIS can assist in making nutritional status information available in real-time and enable monitoring of nutritional status progression will be elaborated. By doing so, this paper will provide adequate recommendations for practices and policies on how GIS can be utilized to distribute nutritional status data effectively over time [5].

In recent years, the use of GIS in nutrition studies has been a rapidly growing area of research. GIS provides powerful tools for analyzing the spatial distribution of nutritional status, understanding the environmental factors that influence nutrition, and supporting better decision-making in nutrition programs. One of the key aspects of using GIS in nutrition studies is its ability to map and analyze nutrition data. By utilizing spatial data and associated attributes, GIS allows visualization of the distribution of nutritional status in each area to aid nutrition researchers and practitioners in identifying spatial patterns as well as high-risk areas. Not only identifying such matters but also helps researchers and practitioners to understand geographic variability in nutritional health. Moreover, GIS is also applicable in integrating nutrition data with environmental, social, and economic data. By integrating these various data sources, GIS can provide a more comprehensive understanding of the determinants of nutrition and help in identifying effective interventions. By way of illustration, GIS can be used to map the accessibility to health facilities or nutrition resources, identify areas of high nutrition inequality, or analyze the impact of environmental change on nutrition. In addition, the use of GIS in nutrition status can help improve the efficiency of data collection and spatial modeling. By using GIS technology, better preparation for conducting surveys, including their planning, optimization, and data collection, can be conducted with greater accuracy. In addition, GIS also allows the integration of data from various sources, such as satellite imagery, census data, or health data, which enriches nutrition analyses. However, several challenges need to be overcome in using GIS in nutrition studies. These include limited availability of spatial data, gaps in technical skills and analytical capacity among researchers and practitioners, and complexities in integrating data across sectors.

Since the use of GIS plays a significant role in the health sector as a means of assistance, GIS is said to be proven a very helpful tool for researchers. The method regarding the development of identifications of socio-demographic characteristics, be it areas or risks and controls regarding a disease, is also improving into more decent methods. A particular case on this matter is seen from the COVID-19 case which is shown by some research related to epidemiology of the disease in some countries. For the development of epidemiological maps that can be utilized for analyzing cases during the COVID-19 pandemic, analyses regarding spatial and geospatial, such as disease distribution analysis, management decision-making in health services, public health monitoring, health risk factor analysis, and disease vector control become more compelling. Hence, Figure 1 shows an overview of the distribution of areas that include settlements, trade/services, public facilities, industries, military areas, and green open spaces in Surabaya. This spatial data can be developed for health service purposes.

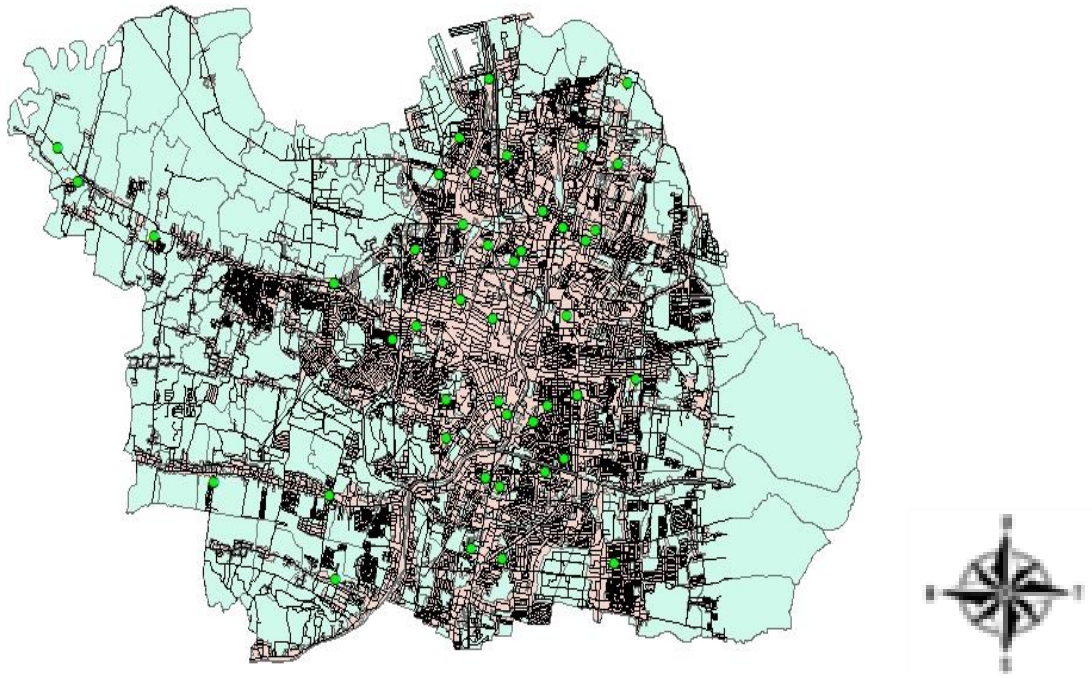

Figure 1. Map of Surabaya city area with its various attributes

Some overviews of GIS can be a valuable tool in assisting and deciding healthcare location, one of which utilization of GIS has been used to select a suitable location for a pandemic hospital based on specific criteria, such as accessibility and population density [6], [7]. Furthermore, the application of GIS for multi-criteria analysis for hospital site selection has been used for selecting the most suitable sites for building new hospitals by considering some factors, such as accessibility and geological hazards [8]. A comprehensive evaluation method, as in construction land suitability and health service accessibility, is also deemed as the perfect method for assisting the establishment of new health facilities in areas prone to geological hazards. By using those references, relevant and adequate decision-making can be done wisely [9].

Overall, by using GIS, establishing pandemic hospital sites can be done more efficiently. By integrating data on accessibility, population density, and other factors, site selection can be based on clear criteria, such as ease of access and population needs. In addition, GIS is also useful in planning and evaluating healthcare locations. By analyzing health needs, accessibility, and service utilization, determining the decisions that ensure health resources are evenly distributed and able to cover areas that require additional services is possible. Such a thing is mandatory should healthcare provider wants to achieve equitable health accessibility across the region [10], [11]. GIS also assists in administrative decision-making in the context of public health. Using spatial analysis, the placement of public health care centers at the local level can be better determined, ensuring the availability of necessary services to local communities. Site selection of new hospitals can also be improved by using GIS. By combining multicriteria analysis and considerations, such as accessibility, security, and geographical needs, deciding on location can be made on a stronger and more informed basis [12]. The purpose of this research is to examine the use of GIS in healthcare location decision-making in this context, GIS assists decision-makers in identifying optimal locations for healthcare facilities, ensuring equitable accessibility, improving service efficiency, and optimizing resource allocation [13], [14]. The contributions of this research are:

i) Healthcare personnel can utilize GIS in making decisions on priority location of nutrition interventions.
ii) Providing support for more effective resource allocation, especially the distribution of nutritional status in areas that require more attention.
iii) Applying the principles of GIS to improve accessibility, equity, and efficiency of health services.
iv) As a reference for Future Research that may focus on identifying areas with high rates of malnutrition.

2. METHOD

2.1. Keyword network visualization

Several journals that support reviews related to the optimization of nutritional interventions using GIS include 242 articles. These results were visualized using the VOSviewer application, which is a tool used for supporting the analysis of nutrition intervention, priority area, and GIS keyword grouping solutions as shown in Figure 2 [15]. Figure 2 shows the spread of keywords divided into four clusters, on which Cluster 1. focuses on analysis at the aggregate level such as on topics/items supporting the optimization of nutritional interventions using GIS, in Cluster 1, a strong network is shown, in which articles are cited more frequently compared to other clusters.

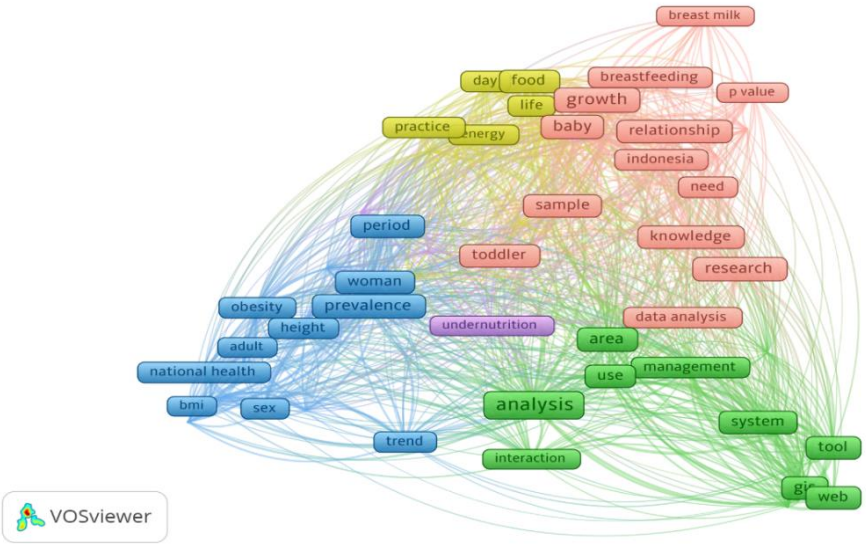

Figure 2. Network created using keyword analysis with a VOSviewer

2.2 Density visualization

This research is influenced by the main keywords, such as nutritional interventions for determining the location of dissemination using GIS, namely distribution of nutritional status, management, disease, assessment, survey, and development of GIS application system as in Figure 3. This figure shows that the darker yellow color indicates the number of articles written on the cases of nutritional topics as well as citations mentioning the articles written on it. Next, keywords are grouped into 29 topics/items consisting of 4 clusters as shown in Figure 2.

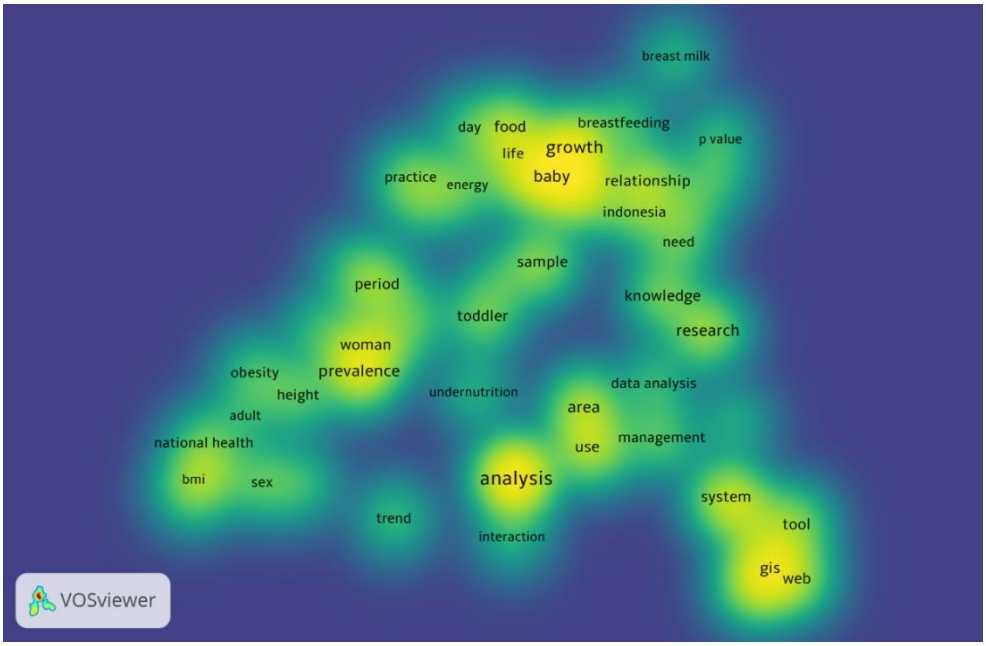

Figure 3. Density visualization of cited articles using VOSviewer

3. RESULTS AND DISCUSSION

This keyword network analysis aims to visualize the relationship between related keywords in the context of GIS in health policy as shown in Figure 2. In Figure 3, each keyword is represented by a topic/item, while the relationship between keywords is represented by a line. The thickness of the line indicates the degree of relatedness between the connected keywords. Through this visualization, it is seen the extent to which keywords are related in the context of GIS in health policy interventions. Closely related keywords will be closely connected, while weaker-related keywords will be connected at longer distances.

By analyzing this network of keywords, it is possible to identify emerging patterns and trends in the literature on the optimization of nutritional interventions using GIS. Moreover, there is a possibility to look at the most dominant and frequent keywords in this context, as well as how these keywords are interrelated and form topic groups. Keywords are grouped into four areas. The results of this paper reveal some important findings.

In Table 1 shows several keywords related to studies that review the use of GIS to determine nutrition program policies, namely priority areas for nutrition interventions, where in determining nutrition program policies a nutrition intervention is needed, so that the use of resources can be utilized optimally [16]. Furthermore, Table 2 illustrates the use of GIS in patterns of spread in high-risk areas, including in certain studies, in cases of COVID-19 disease based on spatial data, the use of GIS in identifying health service gaps, developing targeted programs for certain groups and can help determine data-based policies.

Table 1. Factors related to the review of GIS studies to determine nutrition program policies

Cluster	Keywords
1	Association, Cross-sectional study, diseases, life, management, Nutrition examination survey, nutrition intervention, nutritional status, relationship, treatment
2	Adolescent, child, food, food insecurity, implementation, knowledge, nutritional education, police, questioner, school, survey
3	Application, approach, consumption, food, assessment, GIS
4	Infant, literature, recommendation

Table 2. Spatial analysis of nutritional status with GIS: findings and implications for health facilities

Research	Methods and findings
[17]	GIS is used for finding severely affected areas and taking appropriate action in an area. As a result, GIS is suitable for spatial data analysis in certain diseases (COVID-19). It can develop easy-to-use, transparent methods to simulate outbreak data. Technical infrastructure, such as hardware and software for implementing GIS analysis may not be fully available in all regions of Pakistan.
[18]	Researchers used data from local government publicity for COVID-19 as a reliable source. Using verified data from local governments, researchers estimate spatial patterns of case distribution for case growth. Researchers conducted service areas and origin-destination (OD) cost mats to support existing referral hospitals and created standard deviational ellipse (SDE) models to determine the spatial distribution of COVID-19. Researchers were able to identify more than 12.4 million people (86.7%) by distance-based service area, living in well-served areas in referral hospitals. Results from the cost matrix, OD in the range of 10 km showed a total of 908 unestablished cases from 24 centroids of patients highly concentrated in West Jakarta
[19]	Data collection, GIS, and spatial analysis techniques to identify areas with high levels of disability, identify gaps in health facility accessibility, and design effective and relevant interventions to improve the health of children with disabilities. The results are very promising in research on mental retardation/developmental disabilities. GIS is useful for hypothesis generation and for developing more efficient patterns of service delivery and treatment, at least in healthcare systems designed to serve entire populations.
[20], [21]	Data collection techniques, data preparation and integration, GIS mapping, spatial analysis, statistical analysis to improve understanding of health patterns, targeted interventions, resource allocation, improved surveillance and monitoring, policy planning and development, collaboration, and communication. The result shows that GIS applications can describe the source and geographic distribution of disease agents and identify areas in space and time where people may be exposed to environmental and biological agents. They are also able to map and analyze spatial and temporal patterns in health outcomes.
[22]	Spatial analysis has become and increasingly used analytical approach to describe and analyze the spatial characteristics of disease burden, but the depth and scope of its use for health survey data in Sub-Saharan Africa (SSA) is unknown. Researchers recommend that for future spatial analyses using health survey data in SSA regions (samples), there should be increased recognition and awareness of the potential dangers of simple application of spatial statistical methods.
[23]	The use of GIS web systems can show the system requirement process flow, models, and data collection processes by using multi-attribute utility theory (MAUT). In short, the creation of web-GIS applications may help identify tropical disease-prone areas in East Java Province.

3.1. Application of GIS in nutrition status

The paper highlights that the use of GIS in the dissemination of nutritional status has made a significant contribution to mapping the geographic zone distribution of nutritional status of populations [24], [25]. Through the integration of nutrition data with spatial data, researchers can identify areas of varying severity of nutrition problems [25]–[27]. This allows for more effective planning and allocation of resources to address nutrition problems in developing countries [28].

3.2. Analysis of environmental factors

This paper shows that spatial analysis using GIS can help in understanding the environmental factors that contribute to nutritional problems [29]. With integrated cross-sectoral nutrition interventions and community contributions, it can reduce stunting nutrition [30], [31], as well as an accessibility integration model for improving human resources through knowledge enhancement [32]. Existing infrastructure, sanitation, and environmental conditions researchers can see the relationship between these factors and the nutritional status of the population. This provides deeper insight into the determinants of nutrition and enables the design of interventions that are more appropriate to the geographical context.

3.3. Evaluation and monitoring of nutrition programs

The condition of existing infrastructure, sanitation, and environmental factors that are taken into consideration in the success of nutrition programs, will provide a deeper understanding of the determinants of nutrition and enable the design of interventions that are more appropriate to the geographical context [33], [34]. Through geographical mapping, it will reduce gaps in inadequate resource allocation as well as challenges in multi-sectoral coordination and nutrition governance [35]. GIS users can identify trends and patterns of nutritional problems. This allows for a more accurate evaluation of the effectiveness of existing nutrition programs and enables decision-making regarding program adjustments and improvements.

3.4. Integrated information system

This paper highlights the need for the development of an integrated information system that integrates nutrition data with spatial data [36], especially when combined with an analytic hierarchy process (AHP) system that will facilitate decision-making [37]. Such an information system would facilitate easy and integrated access to relevant nutrition data and spatial data [38]. This will strengthen the capacity of decision-makers to combine and analyze information more efficiently, as well as facilitate information exchange between stakeholders involved in nutrition status as shown in Table 3 [39]–[48].

Table 3. The keywords of GIS for Health are clustered into four areas (*continue*)

Author	Title	Method	Result
[42]	COVID-19 challenge to Pakistan: Is GIS analysis useful for drawing solutions?	The research focuses on developing a transparent user-friendly method to simulate the outbreak data	By using such information, it is quite easy for authorities to locate the highly affected area and take appropriate actions in that area. However, GIS techniques, resources, and methods can be used in Pakistan for more effective investigation of vulnerable geographical locations.
[43]	Development of a spatial sampling protocol using GIS to measure health disparities in Bobo-Dioulasso, Burkina Faso, a medium-sized African city	This article describes the methodology used to develop a multi-stage sampling protocol to select a population for a demographic survey that investigates health disparities in the medium-sized city of Bobo-Dioulasso, Burkina Faso	The result shows that alternative development on the methods emphasizing the urban space typology, geographical surveys, and spatial analysis allows the selection of a subset from a population living in areas representing the uneven urbanization process. It's also beneficial in determining the categorization of their health statuses by paying attention to several indicators, such as nutritional status, communicable or non-communicable diseases, and anemia.
[44]	Applying GIS and spatial analysis to health studies in children with disabilities	Literature study, data collection, GIS analysis	Two findings can be drawn from this article. First, the use of GIS and spatial analysis makes a significant contribution to the study of the health of children with disabilities. These methods allow researchers to understand spatial patterns and relationships between children with disabilities, health and environmental factors. Second, by using GIS tools and techniques, this study can assist in identifying areas with high levels of disability, identifying gaps in accessibility of health facilities, as well as designing effective and relevant interventions to improve the health of children with disabilities.
[45]	E-government integration through web-based GIS implementation on public health monitoring in Jembrana Regency, Bali	Literature review, data collection, web-based GIS development, integration of e-government services, evaluation, and feedback	From the article, it can be said that the implementation of web-based GIS in community health monitoring in Jembrana Regency, Bali, has several significant benefits for integration between e-government services with GIS technology facilitates more efficient data management, improves decision-making processes, and enhances communication between stakeholders.
[46]	GeoDa: An introduction to spatial data analysis	GeoDa Application Design, a free software program specialized as a graphical and easy-to-use introduction to spatial analysis for non-GIS specialists	GeoDa provides an "introduction to spatial data analysis" that includes functionality ranging from simple mapping to exploratory data analysis, visualization of global and local spatial autocorrelation, and spatial regression and allows a growing number of social scientists to be exposed to explicit spatial perspectives.
[47]	GIS is an epidemiological tool to monitor the spatial-temporal distribution of tuberculosis in the large game in a high-risk area in Portugal	A GIS project to analyze the epidemiology risk area for tuberculosis in pigs and deer in Idanha-a-Nova (Application of Special National Law no:01/2011)	Results using GIS-based spatial analysis, allowed researchers to state that both species showed irregular tuberculosis patterns for the period 2006-2016, and identified several specific high-risk areas for both species, demonstrating the potential of GIS tools to evaluate, on the ground, outcomes, and efficacy of leGISlation to ensure correct implementation of cost-effective mitigation strategies.
[48]	Public health, GIS, and spatial analytics tools	Data collection, data preparation, and integration, GIS mapping, spatial analysis, statistical analysis	The findings and implications that can be summarized from the article are the improvement in understanding of health patterns, targeted intervention and resource allocation, enhanced surveillance, and monitoring, planning and policy development, collaboration, and communication
[49]	The application of GIS in environmental health sciences: Opportunities and limitations	Development and implementation of a prototype system called environmental mental and public health data analysis system (EMPHASIS) to facilitate the management, analysis, display, and presentation of environmental, socio-demographic, and health outcome data	GIS applications can significantly add value to environmental and public health data in areas such as exploratory data analysis, hypothesis generation, confirmatory data analysis, and decision-making.
[20]	Explore the role of GIS during problem-solving public health assessments: the experience of public health professionals	Qualitative interviews, case studies, and data analysis.	The conclusion from this study shows the importance of GIS in solving several problems of community health assessment. It demonstrates how GIS enhances data visualization, supports evidence-based decision-making, fosters collaboration, and improves communication among public health professionals. By so, the emphasis on the value of integrating GIS into the community health assessment process may enable more effective and targeted interventions, which can improve community health outcomes.
[50]	Remote sensing and GIS as applied public health and; environmental epidemiology	Data collection, image processing, and analysis, data integration, spatial analysis, spatial analysis:	The conclusion that can be drawn from this article is that GIS aids in faster and better health mapping and analysis than the conventional Methods. i.e., Spatial Mapping and Analysis, Disease Spread Prediction and Monitoring, Evidence-Based Decision Making, and Data Integration. The system gives health professionals quick and easy access to big data.

3.3. Importance of utilizing GIS

Some uses of GIS applications to analyze nutrition status in developing countries provide several advantages, including in-depth spatial analysis, the ability to enable the identification of uneven patterns of nutrition distribution, the identification of areas with high nutritional risk, and the mapping of the need for nutrition services and accessibility of nutrition services [39]. By using GIS, nutrition status can become more efficient, accurate, and targeted in collecting and analyzing nutrition data. Despite its great potential, several challenges may hinder the application of GIS in analyzing nutrition status in developing countries.

Some of the challenges include the limited spatial data available, the need for intensive training in GIS analysis, and the complexity of integrating nutrition data with other health and socio-economic data. These challenges need to be addressed through collaborative efforts and capacity building at various levels. Sustainability and scalability, it is important to ensure sustainability and scalability of the use of GIS in nutrition status in developing countries. This involves developing policies and frameworks that support the use of GIS in nutrition status, including monitoring and maintenance of spatial data infrastructure, regular data updates, and ongoing training for personnel involved [40].

From the advantages, it can be inferred that the utilization of GIS in nutrition status also has significant implications for decision-making and policy-planning in the field of nutrition. With a better understanding of nutrition distribution patterns and associated determinants, policies and interventions can be designed in a more targeted and effective manner. Thus, a positive impact on public health and the reduction of nutrition problems in developing countries can be accomplished over time [41].

4. CONCLUSION

Determination of priority areas of nutrition intervention using GIS, among others, can be used to find the most appropriate areas, assist wise choice-making, and analyze spatial data characteristics of the burden of a disease condition. Meanwhile, the scope of using survey data can increase knowledge about health patterns, targeted interventions, resource allocation, improved surveillance, and policy planning and development. In addition, collaboration and communication also support the identification of disease-prone areas. Furthermore, the results of this paper are expected to be applied to analyze nutritional status in developing countries to improve understanding of the spatial distribution of nutritional problems and assist in making decisions on such matters. The results of the research review are expected to improve understanding of the spatial distribution of nutritional problems and help better decision-making. However, corrective steps are needed to address the constraints and challenges associated with GIS use to ensure its effectiveness and sustainability in improving nutritional health in developing countries. Lastly, it is expected that future research will be focused on developing web-GIS methodologies that are more efficient and accurate in mapping and analyzing nutritional status.

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BIOGRAPHIES OF AUTHORS

Bedjo Utomo Born in Surabaya, Indonesia in 1965. Completed his S2 Master of Health study at Airlangga University, Surabaya, in 2009. Experience has handled a clean water supply project in Bengkulu and as a book writer. Books that have been published such as Management of Physical Facilities and Infrastructure in Hospitals, Occupational Diseases, and Prevention have become best sellers. His research interests explore the determinants of the health environment and health information. He can be contacted at email: bedjoutomo123@gmail.com.

Triwiyanto Born in Surabaya, Indonesia in 1973. He received a B.S. degree in Physics from Airlangga University, an M.S. degree in Electronic Engineering from the Institut Teknologi Sepuluh Nopember Surabaya, Indonesia in 2004, and a Ph.D. degree in Electrical Engineering from Gadjah Mada University, Yogyakarta, Indonesia, in 2018. In 2015, he joined IEEE, and up to this day, he is still active as a member of the organization. His current research interests include biomedical signal processing, Rehabilitation Engineering, and surface electromyography (sEMG)-based physical human-robot interactions. He can be contacted at email: triwyanto123@gmail.com.

Sari Luthfiyah Lecturer at the Department of Electromedical Engineering, Health Polytechnic of the Ministry of Health Surabaya. As a lecturer with more than 23 years of experience teaching Anatomy Physiology, English, Diagnostic Equipment, Life Support Equipment, Therapy Equipment, and Public Health Science courses. Experience as a researcher and presenter of research results, as well as a writer in national and international journals. Her research interests are ECG signals, EMG signals, Cardiovascular, and Telehealth. She can be contacted at email: sarilut@poltekkesdepkes-sby.ac.id.

Sugeng Iwan Setyobudi Born in Malang 1966. Completed S2 Master of Health Studies majoring in Health Promotion and Behavior Science at Unair Surabaya in 2011. Lecturer of the Department of Nutrition, at Poltekkes Kemenkes Malang. Experience As a lecturer with more than 25 years teaching, Nutritional Status Assessment, Nutrition Training, and Education. Experience as a researcher and presenter of research results, as well as a writer in national and international journals. Research interests are nutritional consumption, nutritional status under 5 years, and the influence of nutrition education. He can be contacted at email: sugeng_iwan@poltekkes-malang.ac.id.