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Digital-Based Surveillance to Detect Stunting: A Systematic Literature Review

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DIGITAL-BASED SURVEILLANCE TO DETECT STUNTING: A SYSTEMATIC LITERATURE REVIEW

Abstract: Stunting remains a global health issue. Effective surveillance is crucial for the prevention and control of stunting. Aim study to evaluate digital-based surveillance systems capable to detect toddlers' stunting. This study used PRISMA guidelines. Sources of articles used for review are those published between 2013 and February 2024, written in English. We used a combination of MeSH terms in 4 databases to identify articles. Based on the established inclusion criteria across 4 databases, the literature search resulted in 219 articles, of which 4 were included in the final review. iCHRCloud, the GROWIN App, Joint Spatial Mapping, and the SMART Methodology can detect stunting. iCHRCloud and the GROWIN App can be considered digital surveillance systems. These systems automate the recording and monitoring children's health data, including growth parameters, enabling real-time health monitoring. iCHRCloud used cloud technology to provide a secure and integrated platform. The GROWIN App uses mobile technology to monitor children's growth and detect potential stunting automatically. It is designed to assist in the early detection of stunting. Joint Spatial Mapping and the SMART Methodology are approaches for digital surveillance. Digital surveillance can detect stunting earlier. It can reduce child mortality rates and improve overall child health.

Keywords: Surveillance, Digital-Based, Stunting, Detection

Introduction

Child development is a continuous process. The first five years are critical for a child's brain development and lifelong well-being (Singh *et al*., 2017). Malnutrition in children, such as stunting, is a public health problem that has impact carries significant consequences when they grow up, such as risk of chronic disease, disability, or effect on overall quality of life (Adeyemi *et al*., 2019).

Proper documentation of children's growth and development is essential. Errors in manually plotting parameters on growth charts can lead to missed opportunities for the early detection of stunting in children (Singh *et al*., 2017). Early detection efforts for stunting cases need to be carried out to reduce the incidence of stunting (Indrayadi *et al*., 2023). This effort can utilize information technology with artificial intelligence technology. It can strengthen the national health system through good health planning. Good planning is based on the availability of various health information at the individual and community levels (Indrayadi *et al*., 2023).

Public health and epidemiological surveillance must play a role in the digital development process within the National Health System. Significant changes are needed in public health surveillance, which must be integrated at all levels of health services (Samuel *et al*., 2022). Nutritional surveillance is a system that aims to provide regular, up-to-date information about the nutritional status of the population and the factors that influence it through regular and continuous collection and analysis of dietary data. This information will be the basis for those responsible for planning, formulating policies, managing nutrition programs, determining immediate, short-term, and long-term actions or interventions, and evaluating programs (Jahari, 2022). Child health surveillance, including systematic nutritional surveillance, is essential to reduce child morbidity and mortality (Singh *et al*., 2017).

This research aims to evaluate a digital-based surveillance system capable of detecting toddlers' stunting. What is a surveillance procedure that can capture data to get a picture of stunting that utilizes a digital basis that can increase early awareness and response to stunting cases?

Methodology

Eligibility and Study Selection.

Table 1: The inclusion and Exclusion Criteria

	Inclusion	Exclusion
Source	Scopus, PubMed, ProQuest, Cochrane (central)	Other databases
Dates	Published range 2013- February 2024	Studies published before or after this period
Language	English	Other languages
Population	Toddlers	Other
Exposure	Digital Based Surveillance	Other Exposure
Outcome measures	Detection of Stunting	Other Outcomes
Study/studies	All types of study	-
Type of Publication	Academic journal and availability of documents (free) and published through the area of public health	Other publications and paid

The inclusion and exclusion criteria used in this systematic literature review include inclusion criteria, including studies from Scopus, PubMed, ProQuest, and Cochrane (Central databases). The studies were published between 2013 and February 2024. The studies were written in English and focused on the toddler population. Research exposure takes the form of digital-based surveillance, and the results measured must be related to stunting detection. All types of studies are acceptable as long as they are published in freely available academic journals and are in the area of public health.

Exclusion criteria included studies originating from databases other than those mentioned studies published before 2013 or after February 2024. Studies written in languages other than English or that focused on populations other than toddlers. Exposures other than digital-based surveillance and results unrelated to stunting detection will also be excluded. Additionally, paid publications or other publications not in the field of public health were not included in this review.

Protocols and Registration

Trial Registration at PROSPERO 2024 ID 505408. A systematic literature review was carried out by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Haddaway, 2023). We use CEBM tools for critical appraisal.

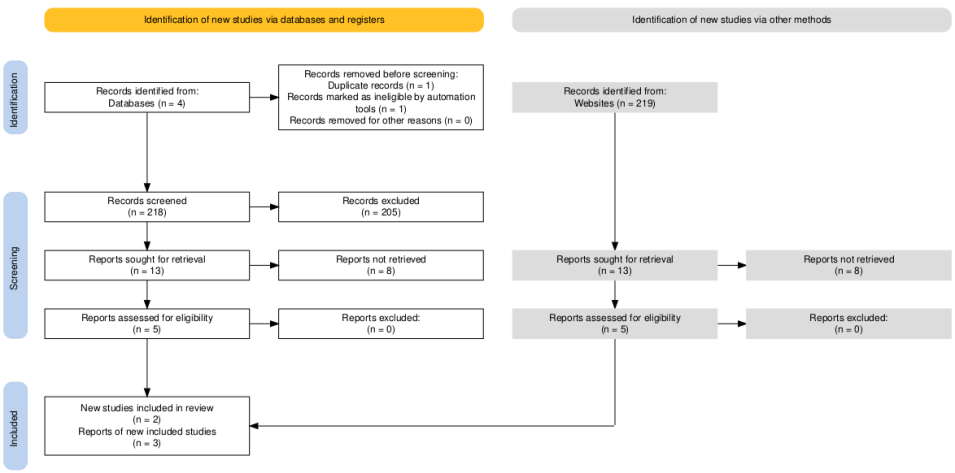

Figure 1: PRISMA Flow Diagram

Information Sources and Search Strategies

A systematic search was conducted in February 2024 in 4 databases. The databases used included Scopus, PubMed, ProQuest, and Cochrane. Search using MeSH (Medical Subject Headings) search keywords. The complete search strategy can be found at https://bit.ly/Appendix1_SearchStrategies.

Study Selection and Critical Appraisal

Two researchers independently checked for duplication of articles from 4 databases. Then, select studies based on their titles and abstracts to identify eligible studies based on inclusion and exclusion criteria. Disagreements between the two researchers were consulted with author 3. Next, critical appraisal was carried out, and data extraction was carried out by authors 4 and 5, with author 6 as the mediator. Author 7 as a proofreader.

Results

The results of the systematic literature review obtained four selected studies. 2 are implementation evaluation studies, namely studies (de Arriba Muñoz *et al*., 2022) and (Singh *et al*., 2017); 2 are observational studies, namely studies conducted (Kiarie *et al*., 2021) and (Adeyemi *et al*., 2019).

Table 2: Article Characteristic

No	Author/Year	Study Period/ Country	Method	Sampling Method/ Sample size	Application/ Data Sets	Objectives	Inputs
1	(de Arriba Muñoz *et al.*, 2022)	Three years Spanish, Latin American	Evaluate of Implementation, namely assessing the functionality and feasibility of the GROWIN application in promoting early detection of growth disorders in children, support intervention early, And increasing	Total sampling A total of 21,633 users. 1200 recommendations were for low height and 550 for low weight 2567 initial nutrition questionnaires	GROWIN App 1200 recommendations were for low height and 550 for low weight Demographic data growth data mainly focuses on stunting, diet, and follow-up recommendations.	Monitoring in children and screening of growth disorders, including stunting, by using a scientific-mathematical algorithm and creating predictive models of the risk of developing obesity	Families should register each child and add some initial data: name, gender; data at birth (birth date, weeks of gestation, height [cm], weight [kg], country,

No	Author/Year	Study Period/ Country	Method	Sampling Method/ Sample size	Application/ Data Sets	Objectives	Inputs
			style life children.				and region), parents' height (cm) to calculate the height potential and find out the growth potential, and the use treatments
2	(Singh *et al*., 2017)	The study began in February 2016 and is ongoing to collect and analyze child health data. The data analyzed in the pilot study India	is observational and is a pilot study	Convenience sampling The study analyzed 16,490 child health records from various healthcare centres, including three large hospitals and one clinic, covering both urban and rural populations, providing a substantial dataset that allowed for meaningful analysis of health trends and outcomes across different demographic regions.	Demographic information, growth parameters, vaccinations, medical visits Data is taken from the iCHRCloud application, which is integrated with the hospital information system (HIS) to ensure the accuracy and completeness of the information.	Development of integrated systems, growth surveillance, and vaccination, reducing child mortality, parental participation, health service innovation Mobile Interface: This allows parents to access their children's health records via smartphones securely. Parents	Some data is input by health workers and some by parents. Health workers input the child's identity, growth parameters, health history, medical visits, and vaccination records. Data input by parents: children's eating patterns and physical activity and can

No	Author/Year	Study Period/ Country	Method	Sampling Method/ Sample size	Application/ Data Sets	Objectives	Inputs
						can register their child with a hospital or clinic and retrieve documents using a unique patient identifier and mobile number.	provide feedback on their children's health through the application

The study (de Arriba Muñoz *et al*., 2022) assessed the functionality and feasibility of the GROWIN application in promoting early detection of growth disorders in children, supporting early intervention, and improving children's lifestyles by analyzing data collected over three years. The GROWIN application can detect growth disorders and provide relevant recommendations for improving children's health. The dataset used includes child demographic data, growth parameters (height, weight, BMI, abdominal circumference), interview results with nutritional questionnaires, and recommendations provided by the application. The main output of this application is the early detection of growth disorders and the improvement of eating habits. The results show that using the application can improve nutritious eating habits. However, there are limitations to the data analysis, including the absence of a control group and the privacy of user data. GROWIN is a collaborative network between parents and doctors to support children's health.

Research (Singh *et al*., 2017) implemented the iCHRcloud application that monitors child health and increases parental involvement—java-based web portal (Enterprise Service Bus and Hibernate). The study was observational and a pilot study involving 16,490 children from 20 health centres in Delhi NCR. Data collected through the app includes vaccination and growth information. Analyzes were conducted to identify data errors and compare urban and rural populations. Indicators of success include reducing data errors, increasing vaccinations, and parental satisfaction. The study began in February 2016 and adhered to ethical standards in data collection. iCHRcloud is a cloud-based Integrated Child Health Record that can monitor children's growth in real-time (Singh *et al*., 2017). The iCHRCloud mobile interface can help parents access their children's health records on their smartphones. Parents register their child with a hospital or clinic and then access their child's records via secure encryption over the Internet. Patient registration requires a unique patient identifier and the cell phone number the patient used to register.

Table 3: Outcome Study

No	Author/Year	Outcome	
		Primary	Secondary
1	(de Arriba Muñoz *et al.*, 2022)	1. Early detection of growth disorders, such as stunting 2. Health recommendations 3. Improve habits in fulfilling nutrition	1. Surveillance 2. User Engagement 3. Analyze changes in eating habits 4. Communication between parents and health workers via m Health
2	(Singh *et al.*, 2017)	Improving the quality of children's healthcare Surveillance	1.Increasing parental awareness 2.Vaccination reminder 3.Potential for broader data analysis for health policy.
3	(Karie *et al.*, 2021)	Prevalence of wasting, underweight, stunting problems	Identify predictor factors associated with the risk of each aspect of under-nutrition.
4	(Adeyemi *et al.*, 2019)	Prevalence of Anemia, Stunting and Wasting Spatial map	Multivariate analysis using the CAR (Conditional Autoregressive) model to evaluate the relationship between various child health indicators. This study provides a deeper understanding of the interactions between anaemia, stunting, and wasting

Studies focus on early detection, prevalence, and risk factors related to growth problems such as stunting, wasting, being underweight, and anaemia in children. The research also emphasizes the importance of improving children's health care through surveillance and increasing parental awareness and communication with health workers. Additionally, multivariate analysis and spatial approaches are used to understand the complex relationships between child health indicators, supporting the development of more informative and practical health policies.

GROWIN can be considered a form of digital-based surveillance. The app uses mobile technology to automatically monitor a child's growth, enabling real-time data collection and analysis to detect potential growth and nutritional problems. The GROWIN application is designed to assist in the early detection of growth disorders, including stunting. By monitoring growth parameters such as height and weight, this application can provide early indications of growth problems, including stunting, which is a condition in which children have a height that is lower than the standard for their age and gender (de Arriba Muñoz *et al.*, 2022).

Using the GROWIN application, if parameters deviate from the standards, parents will receive recommendations from the application, resulting in improvements in healthy nutritional habits, namely positive changes in how a person consumes more nutritious and balanced food to support better health. Therefore, GROWIN represents an innovative solution for families to monitor growth and support personalized medical care with individualized advice, which can lead to positive changes and healthy living habits. Additionally, it can provide a collaborative m-Health network between parents/caregivers and physicians (de Arriba Muñoz *et al.*, 2022).

We found that digital-based stunting surveillance is also part of other surveillance, such as the iCHRCloud application in India. iCHRCloud, apart from real-time child growth monitoring, is also for affordable automatic vaccination and is connected to India's first hospital. iCHRcloud utilizes information technology to provide a secure digital platform based on HTTPS protected by 256-bit encryption with a mobile interface and doctor module to ensure the confidentiality of data in motion. iCHRcloud provides a comprehensive and sustainable solution that ensures the continuity of quality services to reduce child mortality. This software eliminates the need for server maintenance to store child health records. Java-based web portal (enterprise Service Bus and Hibernate) for healthcare practitioners with various modules to create patient identification sheets, standardize prescription uploads, generate dynamic growth curves, and automate immunization records and reminders. Mobile interfaces on iOS and Android platforms are built to empower parents with their child's health records. With the iCHRcloud application, every child can now be tracked, and all information remains stored in digital form. This application is connected to 20 hospitals and clinics and has 16,490 children registered from 3 hospitals & 1 clinic (Singh *et al*., 2017).

The system in India still relies on conventional methods. An effective healthcare system must include digital networks that can be seamlessly interoperable in a better, holistic, and cost-effective operational manner to ensure the continuity of quality services with adequate coverage. iCHRCloud is web-based and can reach a wide range of consumers. iCHRCloude is also a mobile interface that can significantly increase the number of users (Singh *et al*., 2017).

Using the cloud has advantages in terms of accessibility. Users can access data and applications anywhere and anytime if connected to the Internet. By using cloud services, organizations can reduce information technology infrastructure and maintenance costs because they do not need to manage their physical servers. Cloud computing allows users to scale up quickly or down resources as required, which is especially useful for applications that experience fluctuations in demand (Taheri-abed *et al*., 2023).

This iCHRCloud application provides a secure and integrated platform for managing child health data, an essential element in digital-based health surveillance. iCHRCloud is designed to monitor child growth parameters, which include height and weight measurements. By tracking this growth regularly and comparing it with WHO standards, this system can help identify growth problems, including stunting in toddlers. Early detection of growth problems such as stunting is essential for appropriate intervention and prevention of long-term health problems. However, this study is more observational, iCHRCloud functions as a digital intervention aimed at improving child health monitoring and parental involvement in their child's healthcare process (Singh *et al*., 2017).

The application has its weaknesses. iCHRCloud does not provide an automatic computing feature for vaccination due dates and cannot send timely reminders to parents. Additionally, it does not offer a print feature for all of a child's vaccination records that may be needed to apply for school admission and visas. There are also no automatic growth charts according to clinical standards (Singh *et al*., 2017).

Digital interventions have tremendous potential to promote healthy lifestyles. Impact of digital interventions on adopting healthier lifestyles. How digital interventions impact lifestyle management and address existing deficiencies. Digital interventions can focus on designing, developing, testing, and evaluating the creation of personalized lifestyle recommendations as part of a digital health intervention (Chatterjee *et al*., 2021).

There are two main approaches to digital health intervention: the Smartphone Application-Based Approach and the Web-Based Approach. An application-based platform uses various technologies such as Chatbot Multimedia media (text, video, audio, games, images), wearable technology, and GPS-based location social media. This application-based approach can be feedback-based and adaptive. Web-based approaches also use multimedia media (text, video, audio, games, images). Web-based approaches also have feedback-based features, are based on social media, and are adaptive (Chatterjee *et a*l., 2021).

Two other studies reviewed in this systematic literature review are SMART Methodology and joint spatial mapping research. In research conducted by (Karie *et al*., 2021), SMART Methodology does not explicitly mention the use of digital-based surveillance. This research focuses more on anthropometric measurements and direct interviews with child caregivers to collect data on nutritional status and related factors. This research includes measurements of children's nutritional status, including stunting, measured using height for age (HAZ) based on WHO child growth standards. By using this method, research can detect stunting in toddlers aged 6 to 59 months. The results of this measurement provide information about the prevalence of stunting in the population studied (Karie *et al*., 2021).

The joint spatial mapping research also did not explicitly state that the method used included digital-based surveillance. However, approaches used in data analysis, such as multivariate models and spatial mapping, can be integrated with digital-based surveillance systems to improve the collection and analysis of child health data. Digital-based surveillance can help collect data more quickly and accurately and monitor the prevalence of malnutrition in real time. This research can detect stunting in toddlers using a multivariate analysis model, which evaluates the prevalence of stunting, wasting, and anaemia among children under five years. Results show geographic variations in stunting prevalence and associations with certain risk factors. Thus, the method used in this study is effective for identifying and analyzing the prevalence of stunting in the population studied (Adeyemi *et al*., 2019).

Research from the four articles that have been reviewed has not discussed surveillance as carried out by (Hanieh *et a*l., 2019). Hanieh's research suggests the importance of implementing appropriate surveillance and early intervention that can be used to prevent stunting. Surveillance is also helpful in providing health workers with tools to carry out risk assessments quickly and effectively so that preventive measures can be implemented before it is too late (Hanieh *et al*., 2019). The research creates a prediction model that allows primary healthcare workers at the community level to rapidly assess the estimated future risk of stunting in children. We enable the implementation of early prevention strategies in the first 1000 days of life, when the most significant impact is most likely to be achieved and before it is too late to change the growth trajectory. Second, these algorithms are based on standard clinical variables that may be available during assessment and can be developed centrally to track stunting risk at a national level. The development of accessible and sustainable methods for early detection of stunting risk has the potential to provide a targeted prevention approach, which, if successful, would significantly reduce the burden of childhood morbidity and the associated risks of chronic disease in vulnerable populations (Hanieh *et al*., 2019).

Public health surveillance is a continuous and systematic process of collecting, consolidating, and evaluating relevant data and disseminating the results quickly to authorities to take action. Effective disease control programs depend on solid surveillance and response systems. Increasing disease surveillance capacity helps countries identify disease prevention priorities, plan optimal health for communities, provide education, focus evidence-based interventions, and monitor trends to measure impact and detect problems that need to be addressed.

Surveillance must be an integrated public service with similar structures, processes, and resources while recognizing that certain diseases, such as stunting, may require special surveillance. Implementing core and supporting functions must seek synergies for efficiency and effectiveness.

Stunting surveillance is part of nutritional surveillance and can also be part of child health surveillance. The Monitoring Nutritional Status and Food Safety Events (MNF) Unit of WHO defines nutrition surveillance indicators and systems, manages and maintains nutrition databases, monitors nutrition

trends, and measures the impact of food and nutrition policies in countries. This unit manages INFOSAN and collaborates with WHE to handle significant incidents related to food safety, including PHEICs (WHO, 2024).

Nationally representative household surveys (e.g., DHS, MICS, SMART surveys, and LSMS surveys) are the most common nationally representative data sources, which typically collect child nutrition data on height, weight, and age of children under five and can be used to produce national-level prevalence estimates for overweight. Some administrative data sources (e.g., from surveillance systems) are also included if population coverage is high (UNICEF, 2024).

Conclusion

Digital surveillance can detect stunting earlier. It can reduce child mortality rates and improve overall child health. Digital applications such as GROWIN and iCHRcloud have great potential in detecting early child growth disorders and improving health habits through digital-based monitoring. GROWIN enables early detection of problems such as stunting, provides health recommendations, and improves children's eating habits. Despite limitations, such as the absence of a control group, this application enhances communication between parents and health workers.

Other research, such as iCHRcloud shows the effectiveness of real-time monitoring of child growth and vaccination and increasing parental awareness. However, there are still weaknesses in the automatic vaccination reminder feature and printing of health records. Other studies (Karie *et al*., 2021; Adeyemi *et al*., 2019) emphasize the importance of digital surveillance in overcoming health problems such as stunting, wasting, and anaemia. Overall, this research emphasizes that digital applications can be an essential tool to support public health surveillance and early intervention regarding child nutrition problems.

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