RESEARCH PAPER

A Cross-Sectional Study of Stakeholders' Perceptions of the Effectiveness of Artificial Intelligence in Enhancing Public Health Service Delivery in Rural and Tribal Communities of India

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ABSTRACT

Background: The use of AI in community wellbeing is becoming more common. It can help identify and trail diseases sooner than before. However, since digital capabilities are not consistent across all areas of India, there is concern that some communities may have less equitable access to AI than others.

Objectives: We evaluate stakeholders' awareness of the use of Artificial Intelligence in enhancing the services of public health systems in rural and tribal regions in India, as well as assessing the perceived effectiveness of these AI applications.

Methods: Using a cross-sectional survey of 210 public health workers in India was administered a standardised questionnaire. To review the data descriptive analysis, a one-sample t-test was used as an inferential statistic to test the hypothesis.

Results: Respondents reported high levels of knowledge regarding AI applications in identifying diseases (81.9%), maternal/child health (78.1%) and using AI to increase the efficiency of public health delivery (81.3%). Respondents indicated that early warning systems for disease detection (74.6%) would benefit from the use of AI. Internet connectivity (86.2%), infrastructure (81.4%), digital literacy (78.4%), and availability of appropriate data (72.3%) were cited as significant barriers to adopting AI into each respondent's public health department. Stakeholders demonstrated significant positive perceptions of AI effectiveness ($t=29.57$, $p<0.001$).

Conclusion: While there appears to be a strong scope for AI to progress India's public health delivery, a critical need exists to fund and implement programs to address and potentially widen inequities in rural and tribal communities.

Keywords: Artificial Intelligence, Public Health, Disease Surveillance, Digital Health, Health Informatics.

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1. INTRODUCTION

Digital technologies are expected to exert influence on community wellbeing systems globally through the use of advanced capabilities for analysing vast amounts of complex data to support the analysis of disease surveillance, forecasting of potential outbreak situations and early detection/diagnosis of diseases; as well as the creation of evidence-based decision-making processes regarding health resource allocation (1). India's public health system provides services to a vast and diverse population. The country is experiencing an epidemiologic transition, and there continues to be shortages of trained health personnel and inequality in the distribution of healthcare services across the nation (2). Near the ground stages and shortages of public health workers.

The Government has recently implemented National Programs (Ayushman Bharat Digital Mission and Integrated Health Information Platform) to encourage the implementation of Digital Health and AI for strengthening health care systems. While there have been advancements in the application of National Programs at a Policy Level, the Practical Application of the programs is very diverse (3). Studies have indicated that AI has the capacity to improve these public health functions (1,5) and optimise limited health resources through digital technologies (5). Most of the literature available today focuses on the technical feasibility and policy development surrounding the implementation of Artificial Intelligence, and very few studies focus on the experiences of frontline public health workers working in underserved areas.

AI-based tools are being increasingly deployed to support public health functions (4). However, there has not been an adequate assessment of the real-world application of these smart intelligence tools to assist health promotion programs in the underserved areas of the country. Therefore, it is essential to understand public health stakeholders' perceptions of AI, current usage of AI, and the barriers to using AI to ensure that AI is appropriately and sustainably incorporated into India's Public Health System (7).

Background of the Study

The Indian public health system covers over 1.4 billion people in geographically and socio-economically diverse settings. Rural and tribal populations experience barriers to digital health, largely due to inadequate infrastructure, limited Internet access, a shortage of public health workers, and near-ground stages of digital literacy (8). While national efforts have introduced AI-based tools for public health functions, the degree to which public health practitioners understand and can effectively utilise the tools that have been developed has yet to be studied (6). There are also additional ethical concerns surrounding the use of smart AI in community wellbeing, including privacy of patient information, potential biases in algorithms, and accountability when it hails from the use of smart technology-based solutions (10). Thus, without consideration for how AI will be adapted to fit local context, there exists the risk that AI could widen existing health inequities, demonstrating the need for evaluations focused on public health stakeholders to guide development of equitable public health policy.

Problem Statement

Although AI technology has been implemented with increasing frequency and has received growing policy attention in recent years, little primary empirical data exists to illustrate the perceptions and use of AI among public health stakeholders in India. Most existing studies have focused on urban-based healthcare delivery systems, pilot projects, or secondary analysis of previously collected data. A critical research gap therefore exists as a result of the need for primary stakeholder-level evidence illustrating awareness, perceived effectiveness and barriers to using AI within rural and tribal-based public health contexts. To develop inclusive public health digital strategies, this critical research gap must be addressed.

Research Objectives

To determine the level of knowledge that is possessed by public health stakeholders in rural and tribal areas of India concerning the application of Artificial Intelligence.

To assess whether or not there is a perception on the part of public health stakeholders in rural and tribal areas of India that Artificial Intelligence will enhance their ability to provide public health services, and to conduct disease surveillance.

Hypothesis

H0: There is no statistically significant mean perceived effectiveness of AI, and the neutral midpoint mu = 3.0 among stakeholders in rural and tribal areas.

H1: There is a statistically significant mean perceived effectiveness of AI, and the neutral midpoint mu ≠ 3.0 among stakeholders in rural and tribal areas.

2. REVIEW OF LITERATURE

Evolution of AI

Numerous studies of the growing use of AI within various components, including the detection of disease, the early warning signs of outbreaks, and the efficiency of the operation of health systems (11). Additionally, there is evidence that demonstrates the effectiveness of

using AI-based algorithms for detecting tuberculosis (1), for conducting real-time intensive care of maternal health (1), and for predicting the risk of non-communicable diseases. The utilisation of AI can increase the speed, accuracy, and cost-effectiveness of public health interventions if they occur within a country with a strong underlying digital infrastructure and adequate education/training for healthcare professionals (12). Most of these studies utilise secondary data, pilot projects, or small-scale studies, which may not mirror the understandings of frontline community health practitioners (14). Furthermore, studies that focus on policy issues emphasise that there is a need for governmental structures, ethical guidelines, and statistics interoperability to support the application of smart technology in community health (13).

Conversely, empirical studies identify several barriers to the implementation of AI in public health, including, but not limited to, workforce preparedness and digital literacy (13). Overall, the literature indicates that AI has significant potential for improving public health, but it must be contextualised, and meaningful partnerships must exist among stakeholders to ensure the continued success of AI's long-term implementation in community wellbeing. More recently, the scholarly literature has emphasised the importance of the context and systems needed for the effective integration of AI, through the recognition of a number of factors such as digital infrastructure, a ready workforce, ethical governance, and data interoperability (7,13). In the case of India, journal findings have also been recognizing that, although there is a high level of promise in the ability of AI to increase the effectiveness of public health, the actual level of success of AI to produce positive results in a variety of public health contexts continues to be inconsistent and can vary significantly depending on the availability of infrastructure, the level of digital literacy among the population, and gaps in the implementation of policies, especially in rural and tribal communities (8,10).

Theoretical Gaps

Most of the previously studied literature has been based upon secondary data, pilot implementations or urban-based healthcare delivery systems. Therefore, very little information exists in the literature about the experiences and perceptions of frontline public health personnel operating in rural or tribal settings (6,12). The dominant focus of the current literature has been on the technical capacity and efficiency of AI systems, with a relative lack of theory development around human factors influencing AI tool usage, including awareness of stakeholders, perceptions of usefulness, confidence with digital technologies and adaptability to specific contexts (7,13). Ethical issues surrounding data privacy, algorithmic bias, and governance have been recognised by researchers, but few studies provide empirical evidence examining how these concerns affect acceptance and trust in smart technology among community health practitioners (10). As a result, the literature does not include an integrated stakeholder-centred theoretical framework connecting AI tool adoption, perceived impact, systemic barriers and equity impacts within decentralised public health delivery systems similar to those found in India (15).

Comparative Analysis of Existing Models

Comparative Analysis of Successful AI-Based Public Health Models Developed by Other Regions/Countries and Their Potential for Integration into Indian Public Health. Several developing Countries have adopted AI use in their public health systems and therefore provide valuable lessons for India. A comparative review of the most successful international AI-based public health models demonstrates that AI will be most effectively integrated into a nation's public health system when there is alignment between the system's capacity, the structure of governance, and the workforce's preparedness for AI-based technologies.

Rwanda's AI-Enabled Public Health System

Rwanda was able to develop and integrate AI-based digital platforms into its disease surveillance and maternal/child health programs at the community level despite limited resources available for health care infrastructure. The community collected data is then digitally sent back to be analysed to help identify and/or predict disease outbreaks and to inform the timing of early public health responses. This methodology is based on a human-AI collaborative approach, where the role of AI will be to enhance or support the frontline public health professional. It demonstrated the need for governmental coordination, the creation of standardized health data systems and the need for ongoing education/training for healthcare workers as well. In addition, by mixing A technology into existing public health programs, it becomes possible to have scalable and sustainable AI solutions. While several factors make it difficult to reproduce Rwanda's model in India, such as population size and governance structures, examples can provide many useful lessons for how India may use AI in its rural and tribal areas.

3. METHODOLOGY APPLIED

Study Framework

A cross-sectional framework is used, with a quantitative methodology to determine public health stakeholders' knowledge, perception of efficacy, and perceived barriers to utilising AI in rural and tribal India.

Sampling Size and Sampling Technique

Stratified random sampling was utilised to represent both rural and tribal public health settings and to enable the comparison of perceptions among respondents based on each type of setting. In order to focus only on assessing the issue of equity, access, and the feasibility of implementing AI to deliver public health services to underserved populations. Participants included all public health stakeholders, Medical Officers, Public Health Professionals, Health Administrators, Community

Health Workers, Postgraduate Students and Researchers in Public Health. A total of 210 participants completed the survey instrument. The determination of sample size was influenced by a variety of aspects, as well as the confirmatory nature of the study.

Information Sources

Direct data were collected through a self-administered questionnaire that was circulated to public health stakeholders. It provided the opportunity to gather information about their perceptions of their knowledge of AI applications, their beliefs about the effectiveness of AI, and the barriers that they perceive to exist for the implementation of AI in rural and tribal areas.

Data Collection Tools

Respondents completed a self-administered questionnaire that contained questions about socio-demographic characteristics, awareness of AI applications, perceived effectiveness of AI in several characteristics of collective health practice, and obstacles to the use of smart intelligence in community wellbeing. A five-point Likert scale was employed to measure respondents' perceived effectiveness of AI, which included the following response options. "Responses were recorded on a 5-point Likert-type scale and then categorised in terms of three levels, so that they could be used for statistical analyses."

Data Analysis Framework

Quantitative data were analyzed by utilizing descriptive statistics (i.e., mean, SD, frequencies). A one-sample t-test (test value of 3.0) was used to analyze perception. Cohen's d was used to evaluate the size of the effect 3.

Ethical Consideration

Before collecting data, all participants provided informed consent.

No personal information was collected from participants.

The collected data were used exclusively for study and research purposes.

4. RESULT AND DATA ANALYSIS

Descriptive Statistics

210 participants took part in this research project. Each participant is employed in either a role associated with the delivery of public health services, implementation of programs, or administrative support.

Table 1. The participants' demographic characteristics of (n=210)

Parameters	Segment(years)	Rate	Ratio
Population bracket	18–25	35	16.67
	26–35	41	19.52
	36–45	40	19.05
	46–55	55	26.19
	Above 55	39	18.57
Gender category	Female	107	50.95
	Male	103	49.05
Work Setting	Rural	59	28.10
	Tribal	61	29.05

Summary

This table provides demographic information on the age, gender, and type of job that the study participants had. The demographics show nearly equal amounts of males and females participating in the study, as well as a high percentage of participants from rural and tribal settings.

Table 2. Awareness of AI applications used in public health (n=210)

AI Application Area	Aware (n)	Awareness (%)
Disease Surveillance	172	81.90
Maternal & Child Health	164	78.10
Telemedicine	149	70.95
Tuberculosis Screening	146	69.52
NCD Screening	134	63.81

Summary

The second table shows how aware the study participants are of various public health applications of artificial intelligence (AI). The participants showed the greatest awareness of AI applications used for disease surveillance and maternal and child health.

Table 3. Participants' perceived effectiveness of AI applications (Likert scale; n=210)

AI Application Area	Effective n (%)	Neutral n (%)	Not Effective n (%)	Mean	SD
Improving Efficiency	170 (80.95)	31 (14.76)	9 (4.29)	3.767	0.516
Early Disease Detection	156 (74.29)	31 (14.76)	23 (10.95)	3.633	0.673
Outbreak Prevention	147 (70.00)	31 (14.76)	32 (15.24)	3.548	0.745
Decision Support	162 (77.14)	31 (14.76)	17 (8.10)	3.690	0.614
Overall Score	635 (75.60)	124 (14.76)	81 (9.64)	3.660	0.646

Summary

Stakeholder perceptions of how effective the use of AI was to be assessed using a 5-point Likert scale. Table 3 indicates that the overall average for stakeholder perceptions of AI effectiveness is 3.66 (Standard Deviation=0.65), with the value of 3 being the neutral middle of the Likert scale. The individual means also indicated that "Improving Efficiency" had the highest individual mean at 3.77, suggesting that Frontline Workers have a perception that AI is used as a primary operational efficiency optimization tool.

Table 4. Identified barriers to implementing AI in rural and tribal communities

Barrier	Respondents Reporting (%)
Poor Internet Connectivity	86.19
Inadequate Infrastructure	81.43
Limited Digital Literacy	78.10
Data Availability Constraints	72.38
Language Barriers	65.71

Summary

According to this table, poor internet connectivity and a lack of adequate infrastructure were the primary ins and outs that prevented the implementation of Artificial intelligence in the rural and tribal communities.

Inferential statistics

Table 5. Results from a one-sample t-test to examine the overall participants' perceived effectiveness

Parameter	Value
Sample Mean	3.66
Test Value (Neutral Point)	3.000
Standard Deviation	0.6455
t-statistic	29.5686
Statistical Degrees of Freedom	839
Exact P-value	< 0.000001
95% Confidence Limits	3.616 – 3.703
Cohen’s d	1.0202
Effect Size	Large

Summary

As shown by this table, the study participants provided an overall mean perceived effectiveness rating of the use of Artificial Intelligence that is statistically greater than the midpoint of the Likert scale, which indicates a highly statistically significant positive perception of the effectiveness of AI applications.

Table 6. Results from a one-sample t-test to examine differences in perceived effectiveness across different areas of AI application

AI Application Area	Mean	SD	t-value	p-value	Result
Improving Efficiency	3.767	0.516	21.547	< 0.001	Significant

AI Application Area	Mean	SD	t-value	p-value	Result
Early Detection	3.633	0.673	13.630	< 0.001	Significant
Outbreak Prevention	3.548	0.745	10.651	< 0.001	Significant
Decision Support	3.690	0.614	16.287	< 0.001	Significant

Summary

As indicated by the data in this table, each of the perceived effectiveness ratings of the use of AI applications in each area was also significantly higher than the midpoint of the Likert scale.

5. HYPOTHESIS TESTING RESULTS

The result of a one-sample t-test indicated that a statistically significant difference was found; t (839) = 29.57, $p < .001$. The observed mean (M = 3.66, SD = 0.65) was significantly greater than the neutral midpoint. The H0 was rejected in favour of the alternative H1.

Comparative Analysis of Settings

Secondary analysis with Kruskal-Wallis H and Chi-Square Tests was applied to determine if perceptions differed among Rural and Tribal stakeholders. The data indicated that there were no statistically significant differences ($p > 0.05$)

6. DISCUSSION

Interpretation of findings

Descriptive Statistics

The respondents also indicated moderate to high levels of knowledge about AI applications. Also indicated that they had relatively low knowledge about the use of AI in non-communicable disease screenings. The perceived effectiveness of AI was significantly higher than the neutral point (t = 29.57, p <0.001) with a large effect size (Cohen's d = 1.02), indicating strong stakeholder buy-in.

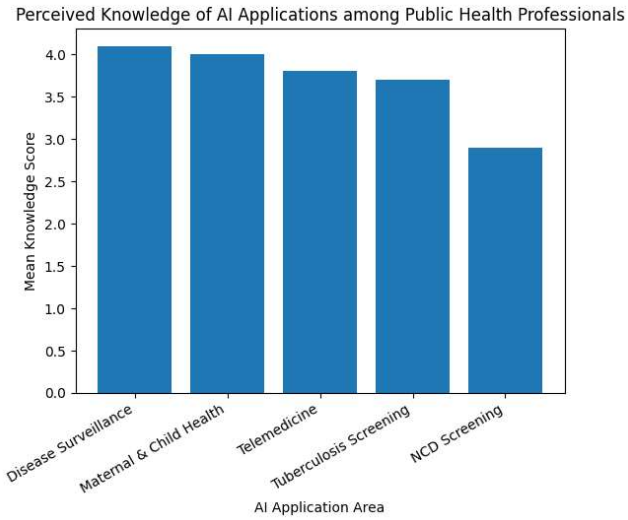

Figure 1: Perceived Knowledge of AI Applications among Public Health Professionals

Inferential Statistics

No significant difference was found between rural and tribal communities regarding AI perception *($p > 0.05$),* suggesting a uniform professional outlook.

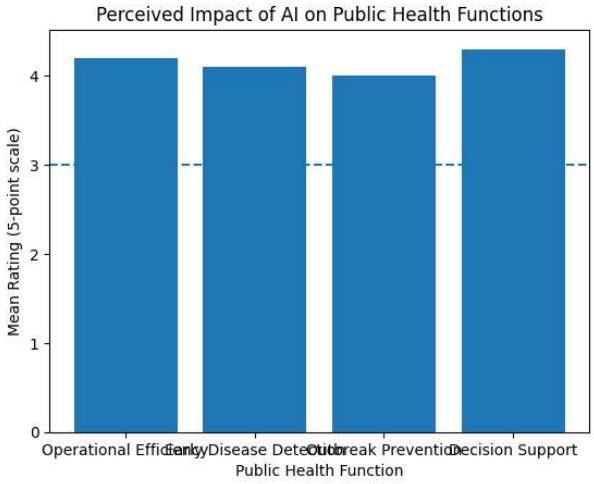

Figure 2: Comparison of AI Perception Scores between Rural and Tribal Professionals

Challenges

To transition AI from an abstract concept to a practical solution in India's tribal belts and other rural areas, the policy must prioritize the lack of high-speed Internet and stable power grids.

Digital literacy should focus on educating stakeholders about the specific applications of AI that were identified in the research as being the most effective and beneficial in the field of public health.

To avoid the possibility of AI exacerbating the health inequities that exist, deployments of AI must be "rural-first" and not urban-centric.

7. CONCLUSION AND SUGGESTIONS

8. CONCLUSION

There was a statistically significant positive view toward the effectiveness of AI in improving the delivery of public health services in rural and tribal areas. The results indicate a statistically positive perception of the effect of AI by stakeholders in rural and tribal areas. The results were significant. It has been previously stated that the level of awareness of AI has been shown to be very high — especially in regards to maternal health and disease tracking — however, the "digital divide" continues to represent a major risk factor. Overall, an intelligent system has significant capacity to increase efficiency and evidence-based health planning; however, achieving this potential will depend upon the development and implementation of contextualised and equity-oriented strategies to implement smart technology in community health systems.

Suggestions

Provide increased digital infrastructure in rural/tribal areas (i.e. improved internet availability, power and public health facility equipment)

Ensure that the workforce has been trained to implement and sustainably maintain AI in community Health

Evaluate whether Artificial Intelligence is being utilised in Public Health programs that align with national programs to avoid duplication

Establish an ethical/risk regulatory framework to protect information security, machine learning bias, disclosure and liability for Artificial Intelligence systems in community health.

Future Direction

Empirical Baseline Evidence to Understand Awareness, Perceived Effectiveness and Barriers of using AI in Rural/Tribal Areas of India's Public Health System.

Can Inform Policy Development at both the State and national levels regarding an equitable and Sustainable Combination of Artificial Intelligence in community wellness.

Lays the Foundation for Future Longitudinal and Comparative Research to Measure Changes in AI Adoption Readiness Across Regions.

Highlights the Need for Advanced Analytical and Interdisciplinary Studies that Link AI Adoption with Measurable Public Health Outcomes

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