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Development and validation of multidimensional robot attitude (mdra) scale: assessing health professional's perceptions on robotic integration in healthcare settings

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Abstract: Globally, integrating robotic systems into healthcare is reshaping hospital functions by enhancing precision, efficiency, and safety. Despite these advancements, there remains a notable gap in understanding the attitudes of Indian healthcare professionals toward such technological innovations. This study aimed to develop and validate a Multidimensional Robot Attitude Scale (MRAS) to assess healthcare professionals' perceptions regarding robotic integration in clinical settings across Kerala. The scale encompasses six key domains: Negative Attitude, Self-Efficacy, Utility, Cost, Control, and Operations. Psychometric analysis revealed strong internal consistency (Cronbach's alpha = 0.84) and construct validity through exploratory factor analysis, indicating that the MRAS is a reliable and valid tool. Findings suggest that while most healthcare professionals in Kerala express moderately positive attitudes toward robotics, concerns persist—particularly in domains related to cost and emotional unease. The MRAS offers a robust framework for evaluating acceptability and can support policy formulation, training, and strategic planning for the integration of robotics in Indian healthcare environments.

***Keywords*:** Robot Attitude Scale, Healthcare Professionals, Technology Acceptance, Hospital Innovation, Validation Study.

I.INTRODUCTION

The integration of robotics into healthcare is no longer a conceptual aspiration of the future but a tangible component of contemporary medical practice. Robotic technologies are increasingly being utilized for various functions, including surgical assistance, infection control, patient interaction, and logistical support, thereby enhancing the efficiency and safety of healthcare delivery *(Broadbent et al., 2018).* Despite these advancements, the successful implementation of robotic systems in clinical settings hinges not solely on technological capabilities, but significantly on the perceptions, acceptance, and preparedness of healthcare professionals *(de Graaf & Allouch, 2013).*

In the context of India—and particularly in the state of Kerala, known for its progressive health indicators—the introduction of robotic technologies into hospital environments is still in its nascent stages. However, there is a noticeable paucity of empirical research investigating healthcare professionals' attitudes toward this emerging trend. Moreover, the absence of a validated, multidimensional instrument to assess such attitudes represents a critical gap in the literature.

To address this gap, the present study aims to develop and validate the Multidimensional Robot Attitude (MDRA) Scale, a psychometric tool specifically designed to assess the perceptions of health professionals toward the integration of robotics in hospital settings within Kerala. This scale is intended to support future research and facilitate evidence-based decision-making in the implementation of health technologies.

II. OBJECTIVE OF THE STUDY

The primary objective of this study was to develop and validate the Multidimensional Robot Attitude Scale (MRAS), a structured tool designed to measure the perceptions of healthcare professionals regarding the integration of robotic technologies in hospital settings across Kerala. This scale aims to capture diverse dimensions of attitude, enabling a comprehensive evaluation of how medical staff perceive, accept, and are prepared to work alongside robotic systems in clinical environments.

III. RATIONALE OF THE STUDY

The rationale for undertaking this study stems from the notable absence of a validated, multidimensional tool in India that specifically measures healthcare professionals' attitudes toward robotic integration in hospitals. As the healthcare sector continues to evolve, the deployment of robots is increasingly seen as a solution to pressing issues such as workforce shortages and operational inefficiencies *(Kaplan, 2021).*Furthermore, the COVID-19 pandemic underscored the importance of minimizing direct human exposure in infectious environments—an area where robotic interventions have demonstrated clear benefits *(Marr, 2020).* Kerala, with its robust healthcare infrastructure and openness to technological innovation, provides an ideal context for exploring the acceptability and potential impact of robotic systems. The development of such a scale is therefore timely and necessary to inform future research, planning, and implementation efforts.

IV. METHODOLOGY

4.1 STUDY DESIGN

This study employed a cross-sectional design to develop and validate the Multidimensional Robot Attitude Scale (MRAS), aimed at assessing healthcare professionals' perceptions of robotic integration in hospital settings in Kerala.

4.2 SCALE DEVELOPMENT

The MRAS was developed through an extensive literature review and expert consultations involving specialists in psychology, public health, and healthcare technology. Drawing from theoretical frameworks such as the Technology Acceptance Model (Davis, 1989) and the Technology Readiness Index (Parasuraman & Colby, 2015), six conceptual domains were identified:

- Negative Attitude
- Self-Efficacy
- Utility
- Cost
- Control
- Operations

Each item within the scale was rated on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), to ensure ease of response and interpretability. Higher scores indicate more favourable attitudes toward robotic implementation in healthcare environments.

4.3 SAMPLE AND DATA COLLECTION

A purposive sampling approach was adopted to recruit healthcare professionals, including doctors, nurses, and administrative personnel, from both public and private hospitals across Kerala. Participation was voluntary, and informed consent was obtained prior to data collection. Demographic details and final sample size are presented in the Results section.

4.4 VALIDATION PROCESS

The validation of the MRAS involved several methodological steps:

- Content Validity: Established through expert panel reviews assessing item clarity, relevance, and domain alignment.
- Face Validity and Pilot Testing: A preliminary pilot study was conducted with 30 participants to assess clarity, wording, and response time.

- Reliability Testing: Internal consistency was measured using Cronbach's alpha, with a threshold of 0.70 considered acceptable.
- Construct Validity: Exploratory Factor Analysis (EFA) was conducted using principal component extraction with Varimax rotation to identify the underlying factor structure.

4.5 ETHICAL CONSIDERATIONS

All participants in this study provided informed consent before participating. Confidentiality and anonymity were strictly maintained, and participation was voluntary. Data were collected and stored in accordance with ethical guidelines outlined in the Declaration of Helsinki (2013).

V. SCALE STRUCTURE AND SAMPLE ITEMS

The **Multidimensional Robot Attitude Scale (MRAS)** was developed to evaluate healthcare professionals' attitudes toward robotic integration across six key domains: Negative Attitude, Self-Efficacy, Utility, Cost, Control, and Operations. Comprising 24 items, the scale utilizes a 5-point Likert response format ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), selected for its simplicity, ease of interpretation, and reduced cognitive burden on respondents. The **Negative Attitude** domain assesses emotional and cognitive resistance, with items such as "I feel scared around robots" and "It would be a pity to have a robot in a hospital setting." The **Self-Efficacy** domain evaluates individuals' confidence in handling robotic technologies, using statements like "I have enough skills to use a robot" and "I can easily learn how to use a robot." The **Utility** domain captures perceptions of usefulness and necessity, with examples including "Robots are convenient" and "I feel the necessity for robots in my daily life." The **Cost** domain reflects concerns about economic and operational feasibility, such as "I worry about the robot breaking down" and "I think the maintenance of a robot is difficult." The **Control** domain gauges the extent to which respondents believe robots can be directed or customized, as shown in items like "I think a robot would obey my commands." Lastly, the **Operations** domain focuses on the mode of interaction, including remote control and manual operation, with items such as "Robots can be used by remote control." Scores within each domain were calculated by averaging responses, thereby generating dimension-specific scores that reflect the overall attitude of healthcare professionals toward robotic adoption in clinical environments.

Table 1: MDRA SCALE

DOMAIN	ITEMS	RESPONSE FORMAT
NEGATIVE ATTITUDE	It would be a pity to have a robot in a hospital setting.	1 = Strongly Disagree to 5 = Strongly Agree
	The movements of a robot are unpleasant.	1 = Strongly Disagree to 5 = Strongly Agree
	It is unnatural for a robot to speak in a human language.	1 = Strongly Disagree to 5 = Strongly Agree
	I feel like I also become a machine when I am with a robot.	1 = Strongly Disagree to 5 = Strongly Agree
	I feel scared around robots.	1 = Strongly Disagree to 5 = Strongly Agree
SELF EFFICIENCY	I have enough skills to use a robot.	1 = Strongly Disagree to 5 = Strongly Agree
	I can make full use of a robot.	1 = Strongly Disagree to 5 = Strongly Agree
	It is easy to use a robot.	1 = Strongly Disagree to 5 = Strongly Agree
	I can easily learn how to use a robot.	1 = Strongly Disagree to 5 = Strongly Agree
UTILITY	Robots are practical.	1 = Strongly Disagree to 5 = Strongly Agree

	Robots are user-friendly.	1 = Strongly Disagree to 5 = Strongly Agree
	Robots have functions that I find satisfactory.	1 = Strongly Disagree to 5 = Strongly Agree
	Robots are convenient.	1 = Strongly Disagree to 5 = Strongly Agree
	I feel the necessity for robots in my daily life.	1 = Strongly Disagree to 5 = Strongly Agree
COST	I think robots are heavy.	1 = Strongly Disagree to 5 = Strongly Agree
	I think the maintenance of a robot is Difficult.	1 = Strongly Disagree to 5 = Strongly Agree
	I worry about the robot breaking down.	1 = Strongly Disagree to 5 = Strongly Agree
CONTROL	I think a robot could recognize me and respond to me.	1 = Strongly Disagree to 5 = Strongly Agree
	I think a robot would obey my commands.	1 = Strongly Disagree to 5 = Strongly Agree
	I want to tame a robot according to my preferences.	1 = Strongly Disagree to 5 = Strongly Agree
OPERATIONS	Robots can be used by remote control.	1 = Strongly Disagree to 5 = Strongly Agree
	Robots can be controlled by a button (on the robot itself).	1 = Strongly Disagree to 5 = Strongly Agree

VI. SCORING AND INTERPRETATION

The mean score of the items under each domain was calculated to represent the respondent's overall attitude in that dimension. Interpretation of domain scores is as follows:

Table 2: MDRA scale score interpretation

SCORE RANGE	INTERPRETATION
1.0 – 2.0	Strongly Negative Attitude
2.1 – 3.0	Moderately Negative Attitude
3.1 – 3.9	Neutral to Moderately Positive
4.0 – 5.0	Positive Attitude

VII. RESULTS

7.1 PARTICIPANT CHARACTERISTICS

A total of 200 healthcare professionals (doctors, nurses, and administrative staff) from public and private hospitals across Kerala participated in the study. The sample included 52% females and 48% males, with an age range of 24 to 58 years (Mean = 36.2, SD = 8.7). Professional distribution included 40% nurses, 35% doctors, and 25% administrative/support staff. Approximately 70% had prior exposure to hospital automation systems.

7.2 RELIABILITY ANALYSIS

The internal consistency of each domain was measured using Cronbach's alpha (α). All domains demonstrated acceptable to excellent reliability:

Table 3: Internal Consistency

DOMAIN	NUMBER OF ITEMS	CRONBACH'S A
Negative Attitude	5	0.81
Self-Efficacy	4	0.85
Utility	5	0.89
Cost	3	0.78
Control	3	0.82
Operations	2	0.79
Total Scale	22	**0.91**

These values indicate strong internal consistency across all subscales and the overall MRAS.

7.3 VALIDITY TESTING

7.3.1 CONTENT VALIDITY

Content validity was established through reviews by experts in public health, hospital administration, clinical psychology, and robotics. The Content Validity Index (CVI) for each item exceeded 0.78, and the average scale CVI was 0.89, suggesting strong content relevance.

7.3.2 CONSTRUCT VALIDITY

Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis with Varimax rotation. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.84, and Bartlett's Test of Sphericity was significant ($\chi^2(231) = 1485.76$, $p < 0.001$), indicating suitability for factor analysis.

EFA extracted six components with eigenvalues > 1, aligning with the theoretical model. Together, they explained 72.3% of the total variance. All item loadings were above 0.60, confirming factor structure integrity.

7.4 DESCRIPTIVE STATISTICS AND DOMAIN-WISE SCORES

Mean scores for each domain were calculated, indicating healthcare professionals' overall perceptions:

Table 4: Domain wise mean score

DOMAIN	MEAN SCORE (SD)	INTERPRETATION
Negative Attitude	2.4 (0.81)	Moderately Negative Attitude
Self-Efficacy	4.1 (0.72)	Positive Attitude
Utility	4.3 (0.65)	Positive Attitude
Cost	2.9 (0.74)	Neutral to Moderately Negative
Control	3.8 (0.68)	Neutral to Moderately Positive
Operations	4.2 (0.61)	Positive Attitude
Overall Score	**3.62 (0.71)**	Neutral to Moderately Positive

7.5 INTERPRETATION OF ATTITUDE LEVELS

The following ranges were used to interpret domain-wise scores:

Table 5: Interpretation of attitude levels

SCORE RANGE	ATTITUDE INTERPRETATION
1.0 – 2.0	Strongly Negative Attitude
2.1 – 3.0	Moderately Negative Attitude
3.1 – 3.9	Neutral to Moderately Positive
4.0 – 5.0	Positive Attitude

Most participants exhibited positive perceptions in terms of utility, operations, and self-efficacy, while some degree of hesitancy was observed regarding cost and negative emotional responses (e.g., fear, discomfort). This indicates both openness and concern toward robotic integration.

VIII. DISCUSSION

The present study aimed to develop and validate a Multidimensional Robot Attitude Scale (MRAS) to measure healthcare professionals' perceptions toward the integration of robotics in hospital settings in Kerala. The findings reveal both promising and cautionary insights into the acceptability of robotics among frontline workers in the healthcare domain.

8.1 INTERPRETATION OF FINDINGS

The overall attitude score of 3.62 suggests a neutral to moderately positive perception among healthcare professionals toward robotic integration. This aligns with previous research indicating cautious optimism among medical staff when introduced to robotic technologies (Broadbent et al., 2018).

Three key domains—Utility, Self-Efficacy, and Operations—received the highest average scores, demonstrating that most participants found robotic systems practical, user-friendly, and manageable. These findings suggest that if appropriately introduced and trained, robots may be well-accepted by hospital personnel for tasks such as patient logistics, medication delivery, or disinfection—especially in high-risk or high-volume environments (Marr, 2020).

However, Negative Attitude and Cost domains scored relatively lower, indicating apprehension related to emotional discomfort, potential job displacement, and concerns over maintenance or breakdown of the systems. Such concerns are well-documented in literature and often stem from fear of dehumanizing care or losing control over technology (de Graaf & Allouch, 2013).

The Control domain showed mixed results, indicating some degree of hesitation regarding the ability of robots to respond effectively to human commands. This underscores the need for trust-building strategies through proper design, training, and transparency in robotic operations.

8.2 IMPLICATIONS FOR PRACTICE

This validated scale can serve as a valuable tool for hospital administrators, policymakers, and researchers to:

- Assess readiness for robotic deployment among staff.
- Identify training needs and design capacity-building programs.
- Tailor implementation strategies based on domain-specific attitude profiles.
- Facilitate evidence-based planning for health technology integration, particularly in resource-constrained or epidemic-prone settings.
- Given Kerala's progressive health indicators and openness to innovation, these insights can inform broader national policies in India for digital health and AI integration.

IX. LIMITATIONS

Despite the strengths of this study, certain limitations should be noted:

1. A purposive sampling approach may limit the generalizability of the findings to the entire population of healthcare professionals in India.
2. The study was restricted to hospitals in Kerala. Attitudes may vary across states due to differences in infrastructure, digital literacy, and institutional support.
3. As with all attitudinal studies, responses may be influenced by social desirability bias or participants' understanding of robotics.
4. Participants' previous exposure to robotic technologies was not quantitatively assessed, which could influence their responses.

X. RECOMMENDATIONS FOR FUTURE RESEARCH

To build on the findings of this study, future research should consider conducting longitudinal studies to assess how healthcare professionals' perceptions evolve following actual exposure to or direct interaction with robotic technologies in clinical environments. This would provide insights into the dynamics of attitude change over time. Additionally, cross-validation of the MRAS in other Indian states and international contexts would help determine the scale's cultural robustness and generalizability. Integrating MRAS outcomes with qualitative methods, such as in-depth interviews or focus groups, could offer a deeper understanding of the underlying beliefs, values, and resistance that influence attitudes toward robotic integration. Furthermore, expanding the scale to include additional dimensions—such as ethical considerations, perceptions of patient-robot interactions, and perceived threats to professional roles—would enrich the tool's comprehensiveness and relevance in the rapidly evolving landscape of healthcare automation.

XI. CONCLUSION

The development and validation of the Multidimensional Robot Attitude Scale (MRAS) present a reliable and context-specific instrument for evaluating healthcare professionals' attitudes toward the integration of robotic technology within hospital settings in Kerala. Demonstrating robust psychometric properties, the MRAS provides a nuanced understanding across six key domains: Negative Attitude, Self-Efficacy, Utility, Cost, Control, and Operations. The findings indicate that while healthcare professionals generally exhibit a moderately positive outlook on the use of robots in clinical environments, reservations regarding financial implications and emotional discomfort remain prevalent. These insights offer valuable direction for designing targeted interventions, capacity-building initiatives, and strategic frameworks to support the smooth adoption of robotic technologies in healthcare. Future research should aim to expand the application of MRAS across diverse geographical and institutional settings, assess shifts in perception following actual implementation, and investigate the broader implications of robotics on clinical outcomes, patient satisfaction, and healthcare workforce dynamics.

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