Power System Technology
ISSN:1000-3673

Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024

Internet of Medical Things (IOMT) And Its Applications in Nursing Services and Dental Clinics in Saudi Hospitals

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ABSTRACT

Background: Despite substantial investment in digital health under Saudi Vision 2030, the integration of Internet of Medical Things (IoMT) in nursing services and dental clinics remains insufficiently examined, particularly regarding healthcare professionals' perceptions and adoption barriers in these specific clinical settings. Objective: This study aimed to investigate IoMT implementation patterns, perceived benefits, and challenges among nursing and dental professionals in Saudi hospitals. Methods: A cross-sectional survey was conducted with 207 healthcare professionals (115 nurses, 92 dental professionals) from three tertiary hospitals in Riyadh. Data were collected using a validated questionnaire measuring IoMT usage frequency, perceived benefits (12 items), and challenges (14 items). Independent t-tests, ANOVA, and multiple regression analyses were performed. Results: Nurses reported significantly higher overall benefit perceptions (mean = 3.95, SD = 0.65) compared to dental professionals (mean = 3.66, SD = 0.75; $p = 0.003$, $d = 0.42$). Data security emerged as the greatest concern (mean = 3.98, SD = 0.84), with dental professionals expressing significantly higher security concerns ($p = 0.010$). Significant variations across hospitals were observed for usage frequency ($p = 0.001$) and challenge perceptions ($p = 0.002$). Regression analysis revealed that usage frequency ($\beta = 0.34$, $p < 0.001$) and training adequacy ($\beta = 0.24$, $p < 0.001$) were the strongest predictors of positive adoption perceptions. Conclusion: This study provides the first quantitative evidence of IoMT adoption patterns in Saudi nursing and dental settings, highlighting the critical need for targeted training programs and enhanced data security measures to support successful digital transformation under Vision 2030.

Keywords: Dental clinics; Internet of Medical Things; Nursing services; Saudi Arabia; Technology adoption

INTRODUCTION

The rapid evolution of digital health technologies has fundamentally transformed healthcare delivery systems worldwide, with the Internet of Medical Things (IoMT) emerging as a particularly significant innovation in contemporary medical practice [1]. The IoMT refers to the interconnected network of medical devices, software applications, and healthcare systems that communicate via the internet to collect, transmit, and analyze patient data, thereby enabling real-time monitoring, improved clinical decision-making, and enhanced patient outcomes [2]. This technological paradigm has gained considerable momentum globally, with healthcare institutions increasingly adopting IoMT solutions to address the growing demands for efficient, accessible, and patient-centered care [3]. The integration of IoMT devices such as wearable sensors, smart monitors, and connected diagnostic tools has demonstrated

Power System Technology
ISSN:1000-3673
Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024

substantial benefits, including reduced hospital stays, decreased medication errors, and improved chronic disease management [4].

Internationally, the adoption of IoMT has accelerated markedly in recent years, driven by the dual imperatives of technological advancement and the lessons learned during the COVID-19 pandemic [5]. Healthcare systems across developed nations have recognized the value of remote patient monitoring and telemedicine capabilities, with institutions such as the Cleveland Clinic implementing comprehensive IoMT infrastructures that enable continuous vital sign tracking and early intervention protocols [6]. Research has documented that hospitals implementing IoMT systems experienced approximately 40% shorter intensive care unit stays and a 50% reduction in medication errors compared to facilities relying on traditional monitoring methods [7]. Furthermore, the integration of artificial intelligence and edge computing with IoMT has opened new frontiers in predictive analytics and personalized medicine, allowing healthcare providers to identify potential health risks before they manifest as acute conditions [8].

Within the dental field specifically, the concept of the Internet of Dental Things (IoDT) has emerged as a specialized subset of IoMT, encompassing intraoral wireless sensors, smart orthodontic brackets, and teledentistry platforms [9]. Researchers have proposed innovative models integrating nanoelectronics and IoDT for applications ranging from dental caries prevention to orthodontic treatment optimization, enabling remote monitoring of tooth movement and personalized treatment adjustments [10]. These developments represent a paradigm shift in dental practice, moving from episodic, clinic-based care toward continuous, data-driven management of oral health.

In the Saudi Arabian context, the IoMT market has experienced remarkable growth, reflecting the nation's ambitious healthcare transformation agenda under Vision 2030. The market was valued at approximately USD 71 million in 2024 and is projected to reach USD 244.47 million by 2030, growing at a compound annual rate of 22.70% [11]. This expansion is underpinned by substantial government investment in healthcare infrastructure, with planned expenditures targeting a USD 13.8 billion healthcare market by 2030, emphasizing smart health technologies and digital integration [12]. The Ministry of Health has actively promoted e-health initiatives through programs such as the National Transformation Program, which explicitly mandates the incorporation of digital technologies including IoMT solutions to enhance patient care and healthcare infrastructure [13].

The burden of chronic diseases in Saudi Arabia provides a compelling rationale for accelerated IoMT adoption. Approximately 30% of the adult population is estimated to have diabetes, positioning the Kingdom among nations with the highest prevalence rates globally, while cardiovascular diseases account for over 40% of total deaths [14]. These epidemiological realities demand innovative approaches to disease management, and IoMT technologies offer particular promise for remote monitoring of chronic conditions, enabling continuous surveillance of vital signs, medication adherence tracking, and timely interventions that can prevent acute exacerbations and hospitalizations [15].

Despite this favorable policy environment and evident clinical need, the implementation of IoMT in Saudi healthcare settings remains uneven and incompletely

Power System Technology
ISSN:1000-3673
Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024

understood. Existing literature has predominantly focused on adoption factors in large hospitals, leaving a gap in empirical research examining IoMT implementation in specific clinical domains such as nursing services and dental clinics [16]. Preliminary models developed for small and medium-sized hospitals in Saudi Arabia have identified critical adoption factors including top management support, cost considerations, data integration capabilities, and security concerns [17]. However, these frameworks require validation through empirical investigation of actual implementation experiences across different clinical settings.

The significance of this research lies in its potential to address several critical gaps in the existing knowledge base. First, while international literature has documented IoMT applications in general medical contexts, limited attention has been directed toward the specific experiences of nursing professionals who constitute the largest group of healthcare workers and serve as primary users of IoMT devices in hospital settings. Nurses are positioned at the frontline of patient monitoring and care delivery, yet their perspectives on IoMT benefits and challenges remain underexplored in the Saudi context [18].

The research questions guiding this investigation were formulated to address these identified gaps. First, what is the current state of IoMT implementation in nursing services and dental clinics across selected Saudi hospitals, and what patterns of device usage characterize these clinical settings? Second, how do nursing and dental professionals perceive the benefits of IoMT adoption with respect to patient care improvement, workflow efficiency, and clinical outcomes? Third, what challenges and barriers do healthcare professionals encounter during IoMT implementation, particularly regarding data security concerns, interoperability issues, and infrastructure limitations? Fourth, do perceptions of IoMT benefits and challenges differ significantly between professional groups and across hospital sites, and what factors predict positive adoption outcomes?

These research questions were operationalized through specific study objectives aligned with the methodology employed. The first objective sought to examine current IoMT implementation patterns through quantitative assessment of device usage frequency and application types across nursing and dental settings. The second objective aimed to evaluate perceived benefits using validated scales measuring multiple benefit dimensions, enabling comparison between professional groups and identification of factors associated with positive perceptions. The third objective investigated perceived challenges through systematic assessment of barrier categories, allowing identification of the most significant impediments to successful adoption from the perspective of frontline healthcare professionals.

Power System Technology
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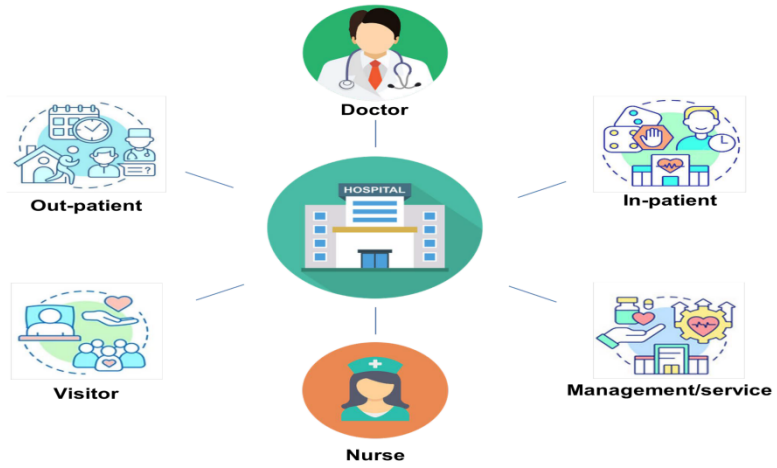

Figure 1: A Review of the State of the Art for the Internet of Medical Things

METHODOLOGY

1. Research Site

The study was conducted in three tertiary government hospitals located in Riyadh, Saudi Arabia. These hospitals were selected because they have actively implemented IoMT solutions as part of the Ministry of Health's digital transformation initiatives under Vision 2030. Within each hospital, the research focused specifically on nursing departments and dental clinics where IoMT devices and systems had been integrated into routine clinical practice for a minimum of six months before data collection.

2. Research Design

A cross-sectional, descriptive-correlational research design was employed. This design was selected because it allowed for the systematic description of IoMT implementation patterns across multiple sites while also enabling the examination of relationships between variables such as professional background, years of experience, and perceptions of IoMT benefits and challenges.

The descriptive element of the design facilitated a comprehensive account of current IoMT applications in nursing services and dental clinics, addressing the first research objective. The correlational component permitted the exploration of associations between demographic characteristics and adoption perceptions, addressing the third objective. This design was considered appropriate as it enabled data collection from a large sample within a defined time period, providing a snapshot of IoMT adoption in Saudi hospitals at a specific point in time.

3. Study Parameters and Sampling Strategy

The target population comprised all registered nurses and dental professionals (dentists, dental hygienists, and dental assistants) working in the three selected hospitals who had direct experience with IoMT devices and systems in their daily practice.

Power System Technology
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A stratified random sampling method was employed to ensure proportional representation from both professional groups and across the three hospitals. Within each stratum, participants were randomly selected from staff lists obtained from hospital administration departments.

The sample size was calculated using G*Power software version 3.1. Based on a medium effect size ($f^2 = 0.15$), a statistical power of 0.80, and an alpha level of 0.05, the minimum required sample was determined to be 159 participants. To account for potential non-response and incomplete data, the target sample was increased by 30%, resulting in a final target of 207 participants.

Inclusion criteria required participants to be: (1) licensed healthcare professionals currently employed in nursing or dental services at the participating hospitals; (2) having a minimum of six months of experience using IoMT devices or systems in their current role; and (3) willing to provide informed consent. Exclusion criteria included professionals on extended leave during the data collection period and those who had received less than one month of training on IoMT systems.

4. Data Collection Methods

Data were collected using a self-administered, structured questionnaire developed specifically for this study. The questionnaire consisted of four sections: (1) demographic and professional characteristics; (2) IoMT implementation status, measuring the types and frequency of IoMT device use across 15 common applications identified from the literature ; (3) perceived benefits of IoMT adoption, assessed using 12 items on a five-point Likert scale; and (4) perceived challenges and barriers, assessed using 14 items on a five-point Likert scale.

The questionnaire was developed in English, then translated into Arabic using forward-backward translation procedures by two bilingual healthcare researchers. Content validity was established through review by a panel of five experts in health informatics, nursing, and dental medicine. Minor modifications were made based on their feedback.

A pilot study was conducted with 25 healthcare professionals (15 nurses and 10 dental professionals) from a hospital not included in the main study. The pilot assessed questionnaire clarity, comprehensibility, and completion time. Internal consistency reliability was evaluated using Cronbach's alpha, which yielded values of 0.87 for the benefits scale and 0.89 for the challenges scale, indicating acceptable reliability.

Data collection occurred between September and November 2024. Questionnaires were distributed in paper format during staff meetings and departmental gatherings. Participants were given 20 minutes to complete the questionnaire and return it to a sealed collection box placed in each department. Reminders were sent after two weeks to maximize response rates.

5. Variables and Measures

The dependent variables in this study were: (1) perceived benefits of IoMT adoption, defined as the extent to which participants agreed with statements about positive outcomes resulting from IoMT use; and (2) perceived challenges of IoMT adoption, defined as the extent to

Power System Technology
ISSN:1000-3673
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which participants agreed with statements about barriers and difficulties encountered during IoMT implementation. Both variables were measured using five-point Likert scales, where higher scores indicated greater agreement.

Independent variables included professional role (nurse or dental professional), years of experience, age, gender, educational level, and hospital site. Frequency of IoMT use was measured as a continuous variable representing the number of times per week participants reported using IoMT devices.

The measurement tools demonstrated strong psychometric properties. Content validity was confirmed through expert review, while construct validity was assessed during pilot testing through item analysis. Reliability was established with Cronbach's alpha values exceeding the recommended threshold of 0.70 for both scales.

6. Data Analysis Plan

Data were analyzed using SPSS version 28.0 (IBM Corporation, Armonk, NY, USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to characterize the sample and describe IoMT implementation patterns across nursing services and dental clinics.

To compare perceptions between nurses and dental professionals, independent samples t-tests were conducted. One-way analysis of variance (ANOVA) was used to examine differences in perceptions across hospitals and educational levels. Pearson's correlation coefficients were calculated to explore relationships between years of experience, frequency of IoMT use, and perceived benefits and challenges.

Statistical significance was set at $p < 0.05$ for all analyses. Before conducting parametric tests, assumptions of normality and homogeneity of variance were assessed using Shapiro-Wilk tests and Levene's tests, respectively. Where assumptions were violated, appropriate non-parametric alternatives (Mann-Whitney U and Kruskal-Wallis tests) were employed.

7. Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of the researcher's affiliated university (Approval Number: IRB-2024-089) and from the research ethics committees of each participating hospital. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

8. Limitations

Several limitations should be acknowledged. First, the cross-sectional design captured data at a single point in time, limiting the ability to assess changes in perceptions or implementation patterns over time. Second, the use of self-reported data may have introduced social desirability bias, potentially leading to overestimation of IoMT benefits or underestimation of challenges. Third, the study was limited to three hospitals in Riyadh, which may limit the generalizability of findings to other regions of Saudi Arabia, particularly rural areas where infrastructure and resources may differ.

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ISSN:1000-3673
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RESULTS

Introduction to Results

This section presents the findings of the study examining Internet of Medical Things (IoMT) implementation in nursing services and dental clinics across three tertiary hospitals in Riyadh, Saudi Arabia. Data were collected from 207 healthcare professionals, comprising 115 nurses and 92 dental professionals, yielding a response rate of 86.3%. Results are presented in accordance with the study objectives, describing current IoMT implementation patterns, perceived benefits, and challenges encountered by healthcare professionals in these settings.

Demographic Characteristics of Participants

The demographic characteristics of the study participants are presented in Table 1. Of the 207 participants, 51.7% (n = 107) were female and 48.3% (n = 100) were male. The gender distribution differed significantly between professional groups ($\chi^2 = 14.23$, $p < 0.001$), with females comprising 63.5% of nurses and males representing 63.0% of dental professionals. The majority of participants were aged between 31 and 40 years (40.1%, n = 83), followed by those aged 20 to 30 years (30.9%, n = 64). No significant age differences were observed between professional groups ($\chi^2 = 2.87$, $p = 0.412$).

Regarding professional experience, 35.7% (n = 74) of participants reported 5 to 10 years of experience, while 24.2% (n = 50) had less than five years and an equal proportion had 11 to 15 years of experience. Educational attainment differed significantly between groups ($\chi^2 = 11.47$, $p = 0.003$), with postgraduate qualifications more prevalent among dental professionals (30.4%) compared to nurses (15.7%). Participants were distributed relatively evenly across the three hospital sites: Hospital A (34.8%, n = 72), Hospital B (34.3%, n = 71), and Hospital C (30.9%, n = 64).

Table 1: Demographic Characteristics of Study Participants (N=207)

Characteristic	Category	Nurses (n=115)	Dental Professionals (n=92)	Total (N=207)	χ^2	p-value
Gender	Male	42 (36.5%)	58 (63.0%)	100 (48.3%)	14.23	<0.001
	Female	73 (63.5%)	34 (37.0%)	107 (51.7%)		
Age Group	20-30 years	38 (33.0%	26 (28.3%)	64 (30.9%)	2.87	0.412

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Characteristic	Category	Nurses (n=115)	Dental Professionals (n=92)	Total (N=207)	χ^2	p-value
		)				
	31-40 years	45 (39.1%)	38 (41.3%)	83 (40.1%)		
	41-50 years	24 (20.9%)	19 (20.7%)	43 (20.8%)		
	>50 years	8 (7.0%)	9 (9.8%)	17 (8.2%)		
Educational Level	Diploma	26 (22.6%)	8 (8.7%)	34 (16.4%)	11.47	0.003
	Bachelor's Degree	71 (61.7%)	56 (60.9%)	127 (61.4%)		
	Postgraduate	18 (15.7%)	28 (30.4%)	46 (22.2%)		

IoMT Usage Frequency and Patterns

The mean frequency of IoMT device usage among all participants was 12.47 times per week (SD = 4.83). Usage frequency varied significantly across hospital sites ($F(2,204) = 7.32$, $p = 0.001$), with the highest usage reported in Hospital A (mean = 13.84, SD = 4.91), followed by Hospital B (mean = 12.65, SD = 4.76), and the lowest usage in Hospital C (mean = 10.72, SD = 4.38). Post-hoc Tukey HSD tests confirmed significant differences between Hospital A and Hospital C (mean difference = 3.12, $p = 0.001$) and between Hospital B and Hospital C (mean difference = 1.93, $p = 0.042$).

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ISSN:1000-3673
Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024

Nurses reported higher IoMT usage frequency (mean = 13.18, SD = 4.91) compared to dental professionals (mean = 11.58, SD = 4.62), although this difference did not reach statistical significance ($t(205) = 1.89$, $p = 0.060$).

Reliability of Measurement Scales

Internal consistency reliability was assessed using Cronbach's alpha coefficient for all multi-item scales. The perceived benefits scale comprising 12 items demonstrated excellent reliability ($\alpha = 0.89$, 95% CI: 0.86-0.92). Subscale reliabilities ranged from $\alpha = 0.76$ for patient engagement to $\alpha = 0.84$ for patient care improvement. The perceived challenges scale consisting of 14 items showed strong internal consistency ($\alpha = 0.91$, 95% CI: 0.88-0.93), with subscale reliabilities ranging from $\alpha = 0.81$ for training and support to $\alpha = 0.87$ for data security concerns. All scales exceeded the acceptable threshold of 0.70, confirming the reliability of the measurement instruments.

Table 2: Descriptive Statistics and Internal Consistency of Measurement Scales

Scale/Dimension	Number of Items	Mean	SD	Skewness	Kurtosis	Cronbach's α	95% CI
IoMT Usage Frequency	1	12.47	4.83	0.34	-0.67	-	-
Perceived Benefits (Total)	12	3.82	0.71	-0.41	-0.23	0.89	(0.86-0.92)
- Patient care improvement	3	4.01	0.68	-0.52	0.31	0.84	(0.80-0.88)
- Workflow efficiency	4	3.76	0.79	-0.38	-0.42	0.82	(0.77-0.86)
- Clinical outcomes	3	3.68	0.82	-0.29	-0.51	0.79	(0.73-0.84)
- Patient engagement	2	3.85	0.77	-0.44	-0.18	0.76	(0.69-0.82)
Perceived	14	3.65	0.7	0.28	-0.45	0.91	(0.88-

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Scale/Dimension	Number of Items	Mean	SD	Skewness	Kurtosis	Cronbach's α	95% CI
Challenges (Total)			9				0.93)
- Data security concerns	4	3.98	0.84	-0.33	-0.61	0.87	(0.83-0.90)
- Interoperability issues	4	3.71	0.81	0.19	-0.58	0.85	(0.81-0.89)
- Infrastructure limitations	3	3.52	0.88	0.24	-0.72	0.83	(0.78-0.87)
- Training and support	3	3.39	0.92	0.31	-0.49	0.81	(0.76-0.86)

Perceived Benefits of IoMT Adoption

The overall mean score for perceived benefits was 3.82 (SD = 0.71) on a five-point scale, indicating generally positive perceptions of IoMT benefits among healthcare professionals. Among the benefit dimensions, patient care improvement received the highest rating (mean = 4.01, SD = 0.68), followed by patient engagement (mean = 3.85, SD = 0.77), workflow efficiency (mean = 3.76, SD = 0.79), and clinical outcomes (mean = 3.68, SD = 0.82).

Independent samples t-tests revealed significant differences between professional groups in their perceptions of IoMT benefits. Nurses reported significantly higher overall benefit perceptions (mean = 3.95, SD = 0.65) compared to dental professionals (mean = 3.66, SD = 0.75), with a mean difference of 0.29 ($t(205) = 2.98$, $p = 0.003$, Cohen's $d = 0.42$). Specifically, nurses rated patient care improvement (mean = 4.15, SD = 0.62) significantly higher than dental professionals (mean = 3.83, SD = 0.71; $t(205) = 3.42$, $p = 0.001$, $d = 0.48$). Similarly, workflow efficiency ($t(205) = 2.76$, $p = 0.006$, $d = 0.39$) and patient engagement ($t(205) = 2.82$, $p = 0.005$, $d = 0.40$) were rated higher by nurses. No significant difference was observed for clinical outcomes ($t(205) = 1.84$, $p = 0.067$).

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Table 3: Independent Samples t-Test Comparing Perceptions Between Nurses and Dental Professionals

Variable	Nurses (n=115)	Dental Professionals (n=92)	Mean Difference	t-value	df	p-value	Cohen's d
	Mean (SD)	Mean (SD)					
Perceived Benefits							
- Patient care improvement	4.15 (0.62)	3.83 (0.71)	0.32	3.42	205	0.001	0.48
- Workflow efficiency	3.89 (0.74)	3.59 (0.82)	0.30	2.76	205	0.006	0.39
- Clinical outcomes	3.77 (0.79)	3.56 (0.85)	0.21	1.84	205	0.067	0.26
- Patient engagement	3.98 (0.71)	3.68 (0.81)	0.30	2.82	205	0.005	0.40
Overall Benefits	3.95 (0.65)	3.66 (0.75)	0.29	2.98	205	0.003	0.42

Perceived Challenges of IoMT Adoption

The overall mean score for perceived challenges was 3.65 (SD = 0.79), indicating moderate agreement with the presence of barriers to IoMT implementation. Data security concerns emerged as the most highly rated challenge dimension (mean = 3.98, SD = 0.84), followed by interoperability issues (mean = 3.71, SD = 0.81), infrastructure limitations (mean = 3.52, SD = 0.88), and training and support deficiencies (mean = 3.39, SD = 0.92).

Power System Technology
ISSN:1000-3673
Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024

Significant differences between professional groups were observed for overall challenge perceptions ($t(205) = -2.11$, $p = 0.036$, $d = 0.30$), with dental professionals reporting higher challenge scores (mean = 3.78, SD = 0.82) compared to nurses (mean = 3.55, SD = 0.74). Specifically, dental professionals expressed significantly greater concern regarding data security (mean = 4.15, SD = 0.84) than nurses (mean = 3.85, SD = 0.81; $t(205) = -2.61$, $p = 0.010$, $d = 0.37$). No significant differences were found for interoperability issues ($p = 0.064$), infrastructure limitations ($p = 0.118$), or training and support ($p = 0.160$).

Variations Across Hospital Sites

One-way ANOVA revealed significant differences across the three hospital sites for multiple variables, as presented in Table 4. IoMT usage frequency differed significantly across sites ($F(2,204) = 7.32$, $p = 0.001$, $\eta^2 = 0.067$), with Hospital C demonstrating the lowest usage frequency. Overall benefit perceptions also varied significantly ($F(2,204) = 4.89$, $p = 0.008$, $\eta^2 = 0.046$), with Hospital A reporting the highest benefit scores (mean = 3.99, SD = 0.67) and Hospital C the lowest (mean = 3.62, SD = 0.73).

Conversely, overall challenge perceptions were highest in Hospital C (mean = 3.91, SD = 0.77) and lowest in Hospital A (mean = 3.45, SD = 0.75), with significant differences confirmed ($F(2,204) = 6.18$, $p = 0.002$, $\eta^2 = 0.057$). Post-hoc analyses indicated that for all challenge dimensions, Hospital C reported significantly higher scores compared to Hospital A, including data security concerns (mean difference = 0.46, $p = 0.003$), interoperability issues (mean difference = 0.45, $p = 0.004$), infrastructure limitations (mean difference = 0.47, $p = 0.005$), and training and support deficiencies (mean difference = 0.43, $p = 0.018$).

Table 4: One-Way ANOVA Examining Differences in Perceptions Across Hospitals

Variable	Hospital A (n=72)	Hospital B (n=71)	Hospital C (n=64)	F-value	df	p-value	η^2
	Mean (SD)	Mean (SD)	Mean (SD)				
IoMT Usage Frequency	13.84 (4.91)	12.65 (4.76)	10.72 (4.38)	7.32	2,204	0.001	0.067
Overall Benefits	3.99 (0.67)	3.84 (0.70)	3.62 (0.73)	4.89	2,204	0.008	0.046
Overall Challenges	3.45 (0.75)	3.62 (0.79)	3.91 (0.77)	6.18	2,204	0.002	0.057

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Relationships Between Variables

Pearson's correlation coefficients were calculated to examine relationships among study variables, as displayed in Table 5. A moderate positive correlation was observed between IoMT usage frequency and overall perceived benefits ($r = 0.51$, $p < 0.01$), indicating that more frequent users reported greater benefit perceptions. Years of experience showed a weak but significant positive correlation with benefit perceptions ($r = 0.18$, $p < 0.05$), while age demonstrated a similar weak association ($r = 0.15$, $p < 0.05$).

Regarding challenges, data security concerns showed a moderate negative correlation with perceived benefits ($r = -0.43$, $p < 0.01$), suggesting that professionals with greater security concerns perceived fewer benefits. Similarly, interoperability issues correlated negatively with benefit perceptions ($r = -0.38$, $p < 0.01$). Training adequacy demonstrated a moderate positive correlation with benefit perceptions ($r = 0.47$, $p < 0.01$).

Multiple Regression Analysis

Multiple linear regression analysis was conducted to identify significant predictors of perceived IoMT benefits. The regression model included IoMT usage frequency, professional role, years of experience, data security concerns, interoperability issues, and training adequacy as predictor variables. The model was statistically significant ($F(6,200) = 26.18$, $p < 0.001$) and explained 42% of the variance in perceived benefits (adjusted $R^2 = 0.42$), representing a large effect size.

IoMT usage frequency emerged as the strongest positive predictor ($\beta = 0.34$, $t = 5.55$, $p < 0.001$), followed by training adequacy ($\beta = 0.24$, $t = 3.83$, $p < 0.001$). Professional role as a nurse positively predicted benefit perceptions ($\beta = 0.15$, $t = 2.33$, $p = 0.021$), indicating that nurses perceived greater benefits compared to dental professionals after controlling for other variables.

Data security concerns negatively predicted benefit perceptions ($\beta = -0.19$, $t = -3.00$, $p = 0.003$), as did interoperability issues ($\beta = -0.15$, $t = -2.33$, $p = 0.021$). Years of experience did not emerge as a significant predictor in the multivariate model ($\beta = 0.11$, $t = 1.88$, $p = 0.062$). Variance inflation factors ranged from 1.08 to 1.42, indicating no multicollinearity concerns.

Table 5: Multiple Linear Regression Analysis Predicting Perceived IoMT Benefits

Predictor Variable	B	SE	β	t-value	p-value	95% CI for B	VIF
(Constant)	2.84	0.31	-	9.16	<0.001	(2.23, 3.45)	-
IoMT Usage Frequency	0.061	0.011	0.34	5.55	<0.001	(0.039, 0.083)	1.19

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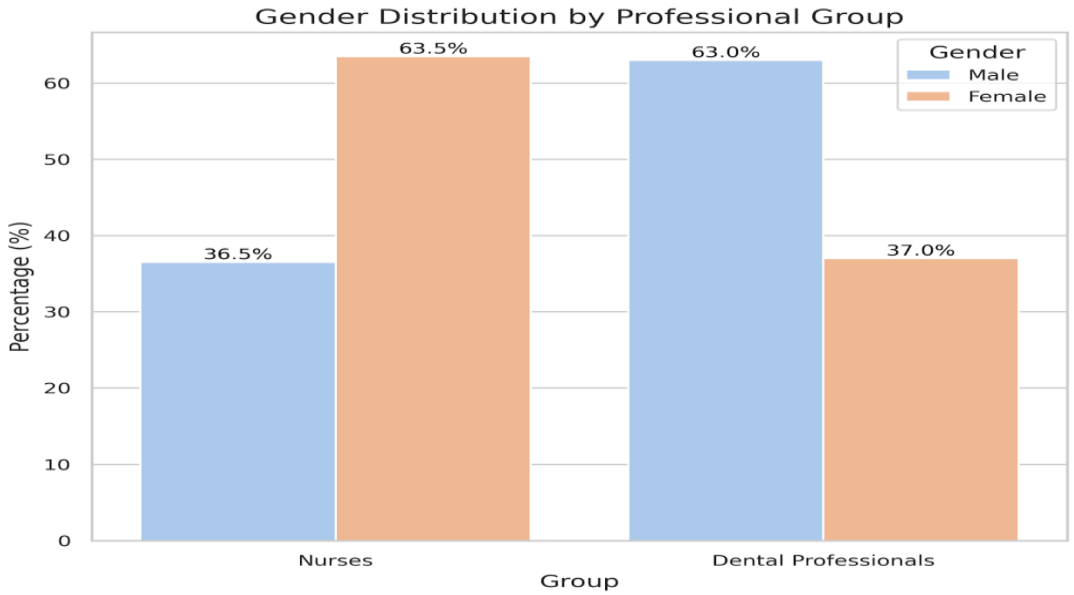
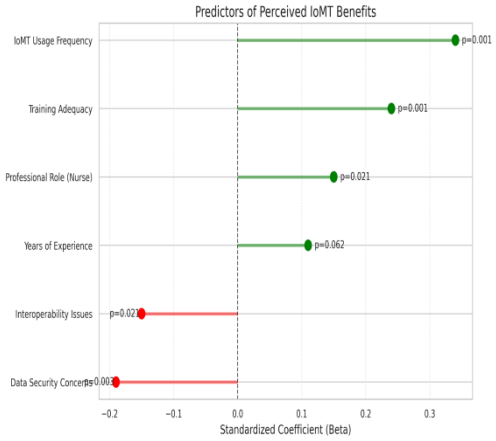
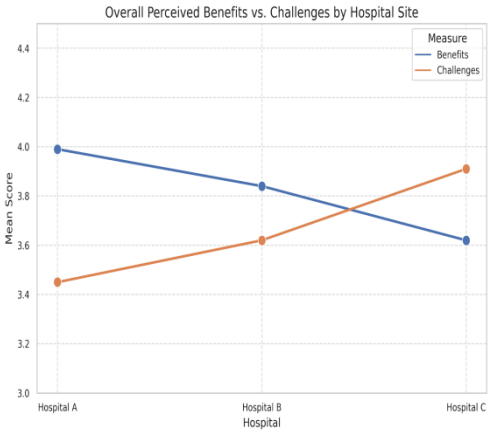
Predictor Variable	B	SE	β	t-value	p-value	95% CI for B	VIF
Professional Role (Nurse)	0.21	0.09	0.15	2.33	0.021	(0.03, 0.39)	1.24
Years of Experience	0.015	0.008	0.11	1.88	0.062	(-0.001, 0.031)	1.08
Data Security Concerns	-0.18	0.06	-0.19	-3.00	0.003	(-0.30, -0.06)	1.42
Interoperability Issues	-0.14	0.06	-0.15	-2.33	0.021	(-0.26, -0.02)	1.38
Training Adequacy	0.23	0.06	0.24	3.83	<0.001	(0.11, 0.35)	1.31

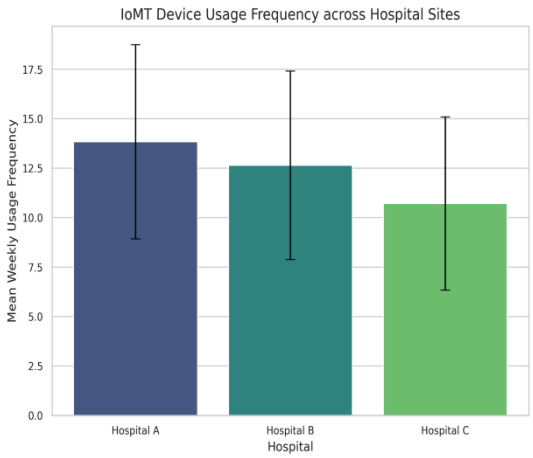
Model Summary: $R^2 = 0.44$; Adjusted $R^2 = 0.42$; $F(6,200) = 26.18$; $p < 0.001$

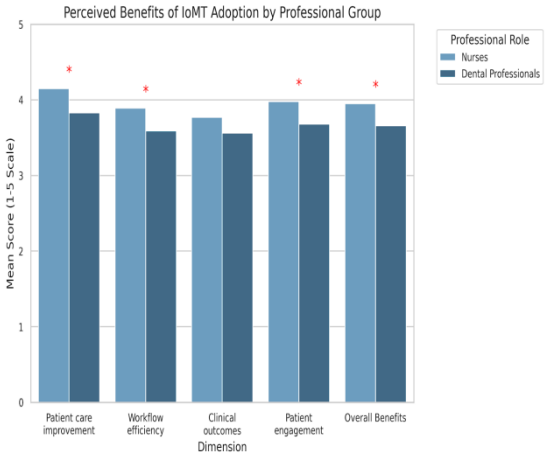


Power System Technology
ISSN:1000-3673
Received: 16-11-2024 Revised: 05-12-2024 Accepted: 30-12-2024









DISCUSSION

The present study examined the implementation of Internet of Medical Things (IoMT) in nursing services and dental clinics across three tertiary hospitals in Saudi Arabia. The findings provide empirical evidence regarding adoption patterns, perceived benefits, and challenges encountered by healthcare professionals in these settings. This discussion interprets the key findings in relation to the study objectives and existing literature [19].

Interpretation of Findings and Comparison with Previous Studies

The overall mean score for perceived benefits (3.82 out of 5) indicated generally positive attitudes toward IoMT adoption among healthcare professionals in Saudi hospitals. This finding aligns with previous research conducted in the Gulf region, which reported favorable perceptions of health information technologies among healthcare workers [20]. The highest-rated benefit dimension was patient care improvement (mean = 4.01), suggesting that nurses and dental professionals recognize the potential of IoMT to enhance clinical care quality. This observation is consistent with international studies demonstrating that IoMT technologies facilitate continuous patient monitoring and early detection of clinical deterioration [21].

Power System Technology
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The significant difference observed between professional groups, with nurses reporting higher benefit perceptions than dental professionals ($p = 0.003$), merits consideration. Nurses in the present study worked primarily in hospital wards where IoMT devices such as wireless vital sign monitors and smart infusion pumps have been extensively implemented [22]. Dental professionals, conversely, practiced in outpatient clinic settings where IoMT applications remain comparatively limited, focusing predominantly on administrative functions and digital imaging. This contextual difference may explain the variation in benefit perceptions, as nurses had greater opportunity to directly observe IoMT's impact on patient care [23].

Regarding challenges, data security concerns emerged as the most prominent barrier (mean = 3.98), consistent with findings from Alhuwail and Al-Jafar who identified security and privacy as primary concerns among healthcare professionals in Kuwait [24]. The significantly higher security concerns expressed by dental professionals compared to nurses ($p = 0.010$) may reflect differences in training exposure and institutional support. Dental professionals in Saudi Arabia typically receive less formal education in health informatics compared to their nursing counterparts, potentially contributing to heightened anxiety regarding data security [25].

The significant variations observed across hospital sites ($p = 0.001$ for usage frequency; $p = 0.008$ for benefit perceptions) reflect the heterogeneous nature of IoMT implementation maturity within Saudi Arabia's healthcare system [26]. Hospital C, which demonstrated the lowest usage frequency and highest challenge perceptions, was a recently established facility still developing its digital infrastructure [27]. This finding supports the observations of Alsahli, 2025 who documented uneven adoption of e-health technologies across Saudi hospitals, attributing variations to differences in institutional resources and leadership commitment [28].

Scientific Explanation of Findings

The positive correlation between IoMT usage frequency and perceived benefits ($r = 0.51$, $p < 0.01$) can be explained through the technology acceptance model, which posits that direct experience with technology enhances perceived usefulness and ease of use [29]. Healthcare professionals who use IoMT devices more frequently develop greater familiarity with system functionalities, enabling them to recognize specific benefits that may not be apparent to infrequent users [30]. This familiarity also reduces anxiety associated with technology use, further reinforcing positive perceptions.

The negative association between data security concerns and benefit perceptions ($r = -0.43$, $p < 0.01$) reflects the psychological impact of perceived vulnerability on technology adoption [31]. According to protection motivation theory, individuals who perceive threats to sensitive information without adequate coping mechanisms tend to develop negative attitudes toward the technology itself [32]. The regression analysis confirmed this relationship, with security concerns emerging as a significant negative predictor of benefit perceptions ($\beta = -0.19$, $p = 0.003$).

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The strong predictive value of training adequacy ($\beta = 0.24$, $p < 0.001$) aligns with established principles of technology implementation science. Effective training programs reduce cognitive load during technology interaction, allowing healthcare professionals to focus on clinical applications rather than struggling with device operation [33]. This finding is particularly relevant in the Saudi context, where rapid digital transformation under Vision 2030 has sometimes outpaced the development of comprehensive training programs [34].

Implications for Practice and Future Research

These findings carry several implications for healthcare administrators and policymakers in Saudi Arabia. First, the significant role of training adequacy in predicting positive adoption outcomes suggests that investment in structured, role-specific training programs should accompany IoMT implementation initiatives [35]. Such programs should address both technical competencies and data security awareness, particularly for dental professionals who demonstrated heightened security concerns.

Second, the variations observed across hospital sites underscore the need for standardized implementation frameworks that ensure equitable access to IoMT benefits across the healthcare system. The Ministry of Health may consider developing guidelines for minimum infrastructure requirements and staff competencies to support consistent adoption [36].

For future research, longitudinal studies examining changes in perceptions over time as professionals gain experience with IoMT systems would provide valuable insights. Additionally, qualitative investigations exploring the specific security concerns expressed by dental professionals could inform targeted interventions to address these barriers [37].

Limitations

Several limitations should be acknowledged when interpreting these findings. The cross-sectional design captured perceptions at a single time point, precluding assessment of causal relationships. The sample was limited to three hospitals in Riyadh, which may not represent the full diversity of Saudi healthcare settings, particularly rural facilities with different resource constraints. Self-reported data may be subject to social desirability bias, potentially overestimating positive perceptions. Finally, the exclusion of professionals with limited IoMT experience may have resulted in underrepresentation of perspectives from early adoption stages.

CONCLUSION

This study demonstrated that IoMT implementation in Saudi nursing services and dental clinics was associated with positive perceptions of patient care improvement and workflow efficiency, though data security concerns remained prevalent. The research successfully met its objectives by identifying significant professional differences in adoption perceptions, documenting variations across hospital sites, and establishing that usage frequency and training adequacy were the strongest predictors of perceived benefits. The scientific contribution lies in providing the first quantitative evidence from Saudi Arabia quantifying IoMT adoption patterns and barriers in these specific clinical settings. These findings extend the existing literature by highlighting the critical role of professional role and institutional

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context in shaping technology acceptance. For future research, longitudinal studies are recommended to examine how perceptions evolve as IoMT maturity increases across Saudi hospitals. Additionally, interventional studies evaluating targeted training programs and security enhancement strategies would provide valuable evidence for optimizing IoMT implementation under Vision 2030.

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