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Integrating IoT in Healthcare Systems: A Socio-Technical Approach to Improving Healthcare Delivery in Afghanistan

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ABSTRACT
The integration with the Internet of Things (IoT) technology with health systems shows a strong potential to re¬invent at least the developed areas of Afghanistan. The study is focused on the perceptions, challenges and willingness of the stakeholders to identify the potential benefits, barriers and strategies to implement IoT-based Health monitoring systems. So, this study uses a mixed-method research approach. A cross-sectional web-based survey was conducted, with 150 possible participants (stakeholders), including healthcare professionals and computer scientists. The survey confirmed acquainting individuals with IoT, their perceived benefits of IoT, possible challenges and willingness of the participants to adopt IoT in the context mentioned above. Main data analyses included descriptive statistics, crosstabs and regression analysis results using the SPSS data processing software. The findings demonstrated that 73.33% of the respondents assumed IoT to improve health monitoring and about 80% showed willingness to adopt IoT. According to this study, the major challenges mentioned by respondents are lack of infrastructure, data security issues, and costs involved. It was identified that in the regression analysis (R^2=0.82), benefit, familiarity, and awareness of IoT technology positively influenced willingness to adopt. Integration was supported by younger and better-educated people. As a result, we will consider gap closing the infrastructure, strengthening data security and raising awareness through direct educational campaigns as a priority area for ensuring the success of IoT adoption. The results of the study highlight aspects which may come handy for the policymakers and health care practitioners to facilitate its adoption in a cost-effective and culture-sensitive manner to address the health particularities of the developing nations.

Keywords: *Afghanistan; Data Security; Healthcare Monitoring; IoT; Infrastructure*

INTRODUCTION

The Internet of Things (IoT): The rapid development and advancement in technology are affecting many industries and the healthcare sector is among them; one of the disruptive innovations in IoT. The Internet of Things contains a field of interconnected devices that collect and transmit data wirelessly in real time to enable better decision-making and increase efficiency (Al-Fuqaha et al., 2015; Belfiore et al., 2022). Applications of IoT can potentially assist the health sector in monitoring, management of data, and the delivery of health services as a whole (Abdulmalek et al., 2022). Integration of IoT in medical applications can prove to be very complex (Hotak & Waqif, 2020; Hasas et al., 2024) particularly in a developing country like Afghanistan where challenges include infrastructure unviable, economy unfeasible, and low acceptance of technology by the general illiterate masses.

The healthcare structure in Afghanistan is facing many hurdles such as limited access to healthcare facilities, absence of healthcare providers, and poor infrastructural systems (Islam et al., 2020). The above problems find further aggravation in the current socio-political instability of the country. The above-mentioned challenges can be handled by the IoT-Based Healthcare Monitoring System, which can provide remote patient monitoring, relief to health facilities, and quality care (Azzawi et al., 2016). It is for example wearable devices and sensors that can yield real-time health data that is channeled to healthcare professionals enabling them to monitor patients' health remotely and intervene early when a need arises (Seneviratne et al., 2017).

IoT is a great opportunity, but many critical facts have to be addressed for its successful implementation in Afghanistan's healthcare system. These include developing a technological platform, data security, enhancing public awareness and acceptance of IoT-based systems (Farooq et al., 2015). Secondly, the two driving forces for the IoT to be accepted by the masses are the financial viability of the IoT systems and the greater match with the local culture (Hotak & Waqif, 2020). Surveying the perception, attitude, and readiness of the stakeholders (i.e., policymakers, healthcare professionals, and patients) to evolve strategies targeting these barriers is also necessary.

The objective is to study the perceptions of stakeholders and intentions to adopt IoT-based healthcare monitoring systems to ascertain the capacity of people to adopt IoT-based healthcare monitoring systems in Afghanistan. The study examines the potential benefits, challenges, and key considerations for the adoption of IoT in a healthcare setting, based on the outcomes from an extensive survey and statistical analysis. The findings are valuable arena information regarding the Afghan people's readiness for the applications of IoT and constructive recommendations for policymakers and producers of healthcare. In highlighting the specific needs of developing countries, the study furthers the general discussion on using emerging technology to better global healthcare systems in developing country contexts (Bernhardt et al., 2014; Selvaraj et al., 2020).

Problem Statement

The challenge of Afghanistan's healthcare system entails limited access to medical facilities, lack of chronic disease monitoring, and inadequately trained professionals caused by decades of conflict compounded by geographical isolation. IoT (Internet of Things) technology integration provides potential solutions for real-time

patient monitoring and remote access to data; however, its use in this context is still largely unexplored. Very poor infrastructures, such as intermittent internet and power supply, as well as the low technological literacy of the people, present formidable challenges to implementation. Moreover, data security, costs, and cultural acceptance will complicate whatever feasibility IoT may have. While some studies undertaken globally indicate that IoT can revolutionize healthcare, there is no local study available on its application given Afghanistan's peculiar socio-economic and technological setting. This study fills the gap by identifying the readiness of Afghan stakeholders (patients, providers, and administrators) to adopt IoT monitoring systems, proposing the major hindrances, and indicating how to mitigate them for better healthcare delivery.

Research Questions and Hypotheses

This is a first of its kind study that aims to find out the perceptions, readiness for deployment and challenges towards the integration of IoT based health care monitoring systems in the health care sector of Afghanistan. This involved multiple key research questions that drive the investigation. Firstly, stakeholder perceptions, such as doctors and computer science graduates, regarding the benefits of IoT-based healthcare systems, particularly real-time data collection and remote patient monitoring. Second, it explores the main challenges for IoT adoption like infrastructure constraints or IoT devices' cost and the idea that data in security will decline, limiting the chance of positive outcomes. Additionally, the analysis examines the impact of demographic variables, such as age, education level, and technological literacy, on individuals' adoption of IoT-enabled systems. Moreover, it aims to explore strategic approaches for overcoming any potential infrastructural or cultural obstacles to making IoT integration viable and sustainable. Finally, it seeks to elucidate how IoT-enabled healthcare systems can be developed to be affordable, user-friendly, and culturally nuanced, which will ultimately promote acceptance and engagement.

Thus, as to the proposed research questions, below are the hypotheses being tested:

1. Why IoT technology can help in improving healthcare monitoring in Afghanistan IoT (Internet of things) technology can profoundly improve healthcare monitoring in Afghanistan.
2. The incorporation of IoT technology into Afghanistan's healthcare system is achievable despite the infrastructural challenges faced, provided there is an application of focused investments and strategic planning.
3. The high level of computer literacy and willingness to use the innovations for the adoption of Internet of Things (IoT) based healthcare systems is to some extent dependent upon the age and education of the respondents.
4. The greater the knowledge and experience of IoT technology, the more favorably stakeholders will view the implementation of IoT in healthcare.
5. Cost-effectiveness, ease of use, and cultural appropriateness are just a few of the key factors that will ensure greater acceptance and adoption rates of IoT-based healthcare systems in Afghanistan’s healthcare sector.

LITERATURE REVIEW

Emerging as a transformative technology with immense potential to revolutionize healthcare systems around the world, the Internet of Things (IoT) has begun to permeate the sector. As cited by (Al-Fuqaha et al., 2015) is a network of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity that enables these objects to collect and exchange data. IoT applications in healthcare include remote patient monitoring and predictive analytics, which have the potential to improve patient care, reduce costs, and increase operational efficiency (Abdulmalek et al., 2022). Wearable technologies and sensors, for example, can keep track of patients' vital signs around the clock to enable healthcare providers to identify deviations in real-time and respond quickly (Seneviratne et al., 2017). In resource-restricted settings, where access to health facilities and professionals remains limited, this is of immense advantage (Islam et al., 2020).

Problems in the healthcare system are complex in developing countries, like Afghanistan, including lack of infrastructure, scarcity of medical staff, and few people have access to quality care (Hotak & Waqif, 2020). IOT based healthcare monitoring systems can solve these problems with the help of remote diagnostic that saves the time of health care, health services cost and distance to reach hospitals (Azzawi et al.,2016). For instance, the Internet of Things (IoT) can be used to remotely transport health data from rural to urban healthcare centres, allowing for timely treatment without long-distance patient travel (Farooq et al., 2015).

Nonetheless, the deployment of IoT in the healthcare ecosystem entails overcoming several vital impediments. Such barriers include limitations in technological infrastructure and data security concerns, as well as the need for easy and culturally appropriate understanding of such solutions (Bernhardt et al., 2014) It has become a major obstacle in Afghanistan; low internet penetration and technology literacy in Afghanistan create major problems (Hotak & Waqif, 2020). Besides, challenges related to security and confidentiality arise when it involves the collection and transmission of sensitive data via IoT networks: concerns for privacy (Miorandi et al., 2012).

However, studies have demonstrated that improved Knowledge and Familiarity surrounding IoT technology can increase IoT Acceptance and Adoption (Friha et al., 2021). Colleges or universities can facilitate outreach programs to narrow this knowledge gap and instill public trust in IoT-based healthcare services (Sosunova & Porras, 2022; Kashani et al., 2021). Additionally, for stakeholders to have confidence in IoT-based solutions, the data security concerns and reliability of IoT systems must be addressed (Ali et al., 2016).

IoT is considered to be one of the best healthcare solutions in Afghanistan, so keep thinking and keep experimenting." Afghanistan can benefit from the advantages of the Internet of Things and also use the following strategies to overcome the barriers to improving healthcare (Mehta et al., 2018). The research contributes to the literature by examining the establishment of healthcare monitoring systems based on IoT architecture in Afghanistan, benefitting researchers and decision makers.

METHOD

The Section presents a discussion on the research methodology applied in the study, which seeks to account for the application of the Internet of Things (IoT) in healthcare monitoring systems in Afghanistan. The discussion elaborates on how data for the study were collected, what population was studied, and methods of analyzing the data used to explain the findings. This means a systematic approach to explain how the research has been carried out and how the results were derived.

Data Collection

Responses to the research have been collected through an online survey via Google Forms. The purpose of the survey was to capture the opinions of the respondents toward various features of IoT in healthcare, for example, exposure to the technology, perceived benefits, perceived limitations, and readiness to accept IoT-based solutions. It consisted of closed and open-ended questions accommodating quantitative and qualitative data collection. Closed-ended questions were rated using a 5-point Likert scale (e.g., Strongly Agree to Strongly Disagree), while open-ended questions gave the opportunity for the participants to provide elaborate opinions.

The survey was sent to medical practitioners and computer science alumni, who do have the required experience and knowledge that would be useful in giving information regarding the likely applications and adoption of IoT in hospitals. The link to the survey was provided through emails and social media to reach out to the maximum number of people.

The Research Population and Sampling

The targeted research sample included 150 individuals comprising only health practitioners and computer science graduates. They were selected as being directly or indirectly responsible for the implementation and management of IoT technologies in healthcare. Healthcare practitioners were targeted because they are the end-users of such technologies, and computer science graduates were targeted for their technical capacity to design, implement, and maintain IoT-based solutions.

Participants were selected by convenience sampling, a form of non-random sampling wherein individuals are chosen based on proximity and availability to the study. The approach was applied in selecting participants with sufficient background to make meaningful contributions to the research field. Generalizability is restricted with convenience sampling but was deemed sufficient for this exploratory research.

Data Analysis

The data obtained from the Google Forms questionnaire were analyzed using the Statistical Package for the Social Sciences (SPSS) software. SPSS was applicable where the data set was large and required statistical testing for the quantitative study. The first set consisted of coded data, which were then input into the SPSS software for data analysis. The frequency distribution, percentage, mean value, and standard deviation calculation were performed in that order.

The analysis of descriptive statistics was meant to provide information on the respondents' demographic profile, along with their input to the relevant questions in the survey. The cross-tabulation was used to correlate demographic factors, such as age, gender, and educational level, to responses given to questions on IoT technology.

Reliability analysis was also done to ensure internal consistency and reliability of the survey instrument.

Hypothesis tests aimed at determining the relationship between variables were conducted using the Chi-Square test as well as one-way ANOVA. The Chi-square test examined the relationship between familiarity with IoT and willingness to adopt it, while one-way ANOVA examined the effect of demographic factors on perceived usefulness. This was followed by logistic regressions that analyzed the effects of perceived benefits, impediments, and factors of priority on the intention to use IoT-based healthcare systems.

Ethical Issues

This study was guided by ethical principles of research; hence, the participants gave their informed consent prior to their participation in the survey. All responses were given in anonymity and confidentiality, assuring participants of their right to withdraw from the study at any stage. The survey did not ask for any personally identifiable information, maintaining privacy and security for the respondents.

RESULT AND DISCUSSION

Analysis and Findings

This section includes a critical analysis of the implications of the findings of this research regarding the application of Internet of Things (IoT) technology in healthcare monitoring systems in Afghanistan. The Section attempts to elaborate on the implications of some of the findings of the previous Section, analyzing variables such as age, gender, education level, technological literacy, perceived advantage, IoT solution challenges, and willingness to adopt IoT solutions.

This examination will provide a holistic view of the Afghanistan population's readiness towards the uptake of IoT-based healthcare systems and the determinants that may affect their uptake. Through a critical assessment of the information, this Section will discuss the broader trends identified, signal likely barriers to adoption, and propose pragmatic suggestions for overcoming them. Moreover, the argument will also highlight the importance of heterogeneous interventions among different demographic groups, e.g., specifically tailored programs for the youth and the elderly group, and bridging the digital divide for individuals with varying educational levels.

The result section also discusses how education and awareness can affect public attitudes towards the use of IoT in healthcare. As the data point towards varying levels of familiarity and awareness, the analysis will shed light on the need for massive outreach programs for better understanding and facilitating easier implementation of IoT technologies. Other than this, the analysis will also consider the perceived advantages and challenges indicated by respondents to understand how they can be countered to enhance the feasibility and sustainability of IoT-based health solutions in Afghanistan.

Finally, the Section shall have an inclusive discussion regarding the feasibility of IoT healthcare systems in Afghanistan taking into consideration the conditions required for its success and the need for advice for surmounting challenges to allow its mass acceptance and utilization. Based on such examination, this Section seeks to

support the broad conversation on bringing forefront technologies in integration with health care systems of developing countries.

Hypothesis Testing

The assumptions of this study attempt to evaluate the possibility of IoT technology to improve healthcare monitoring systems in Afghanistan, its feasibility despite existing challenges, and the readiness of stakeholders to adopt such technology. The collected data were used in statistical analysis to verify these hypotheses. H... First hypothesis: IoT has the potential to relish healthcare monitoring systems. In the course of the presumed proof about the capability of IoT technology to highly improve healthcare monitoring through real-time data collection and patient remote monitoring, the answers regarding the improvement were compared. From 150 respondents, more than 73.33 percent stated that they would "strongly agree" or "agree" on statements that would indicate general agreement with the capability of IoT to make the best improvements. Therefore; a Chi-Square test was used to find out the association between belief in improvement with some of the demographical variables like age and qualification. The obtained Chi-Square value of 18.45 is higher than the critical value at a confidence level of 95% ($p < 0.05$). The result confirms a significant relationship between demographic variables and belief in IoT to create improvements in the healthcare system. Younger participants (18–35 years old) and participants with higher educational levels (bachelor's or master's degrees) exhibited higher rates of agreement with this hypothesis.

Hypothesis 2: IoT Integration Feasibility

The second hypothesis, that integration of IoT is possible despite such obstacles as constrained infrastructure, was validated through an examination of agreement on perceived challenges. Of the participants, 105 or 70% strongly approved of the view that infrastructure challenges could be addressed through the right kind of strategy. On the opposite side, familiarity with the IoT had a determining role in one's view of possibility, with 80% of the "Very Familiar" and "Somewhat Familiar" respondents expressing hope regarding integration.

One-way ANOVA was used to determine whether the levels of familiarity have a significant effect on perceived feasibility. The F-value obtained was 12.67, which is greater than the critical F-value at a 95% confidence level. This indicates that perceptions significantly vary as per familiarity levels. The results suggest that individuals with high levels of familiarity find IoT integration more feasible, and this verifies the hypothesis.

Hypothesis 3: Willingness to Adopt IoT-Based Healthcare Systems

The third hypothesis is that Afghan healthcare professionals and patients will be willing to adopt IoT technology if solutions are cost-effective, user-friendly, and culturally appropriate. The willingness levels were assessed, with 120 (80%) of the participants reporting "Very Willing" or "Somewhat Willing" adoption intentions. Participants also identified data security (40%) and cost-effectiveness (26.67%) as the most critical considerations for IoT adoption.

Logistic regression analysis was conducted to determine the influence of perceived benefits, challenges, and demographics on the willingness to adopt. The formula provided the following coefficients:

Willingness = 0.65×(PerceivedBenefits) 0.42 × (PerceivedChallenges)+ 0.38 × (PriorityAspects)

The model gave a reasonable fit with R^2=0.78, indicating that variables explain 78% of the variance in willingness. The research indicates that the perceived benefits and challenges solutions have the highest predictors of adoption.

Table 1. Summary of Calculation for Hypothesis Testing

Test	Statistic	Result
Chi-Square Test	$\chi^2 = 18.45$	Significant ($p < 0.05$)
One-Way ANOVA	$F = 12.67$	Significant ($p < 0.05$)
Logistic Regression (R^2)	$R^2 = 0.78$	Strong Model Fit

The hypothesis testing confirms the research assumptions. IoT technology has the potential to significantly improve healthcare monitoring systems in Afghanistan, and its integration is feasible with proper strategies to address infrastructural challenges. Furthermore, stakeholders are likely to adopt IoT-based systems if they perceive strong benefits and the solutions address cost and cultural considerations. These findings, supported by statistical analysis, provide a robust basis for advancing IoT in Afghanistan's healthcare sector.

Regression Analysis

To understand the factors influencing the willingness to use IoT-based healthcare monitoring systems in Afghanistan, a multiple linear regression analysis was conducted. The dependent variable in the study was the willingness to use IoT technology, while the independent variables included improvement belief, benefit perception, challenge perception, priority aspect, familiarity level, and awareness level. The regression results are summarized in the table below:

Table 2. Regression Analysis result

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
Improvement Belief	0.45	0.10	4.50	0.0001
Benefit Perception	0.38	0.12	3.17	0.0021
Challenge Perception	-0.25	0.11	-2.27	0.0245
Priority Aspect	0.32	0.09	3.56	0.0007
Familiarity Level	0.40	0.08	5.00	0.00001
Awareness Level	0.28	0.07	4.00	0.0001

This R^2 value of 0.82 explains that 82% of the variability in willingness to use IoT-based healthcare systems is explained by the independent variables considered in the analysis. The adjusted R^2 value of 0.80, which considers the complexity of the model, was thereafter estimated. The F-statistic (41.67, $p < 0.0001$) shows that the model stands out significantly against the null hypothesis in the joint hypothesis-testing framework.

Interpretation of Variables

Improvement Belief (β=0.45, p=0.0001): A strong personal belief in the potential of IoT technology to improve healthcare systems should create a willingness to adopt IoT-based healthcare monitoring systems.

Benefit Perception (β=0.38, p=0.0021): Persons who attach great benefits to IoT technology in health care will be more interested in adopting these systems.

Challenge Perception (β=-0.25, p=0.0245): The perceptions of challenges have a negative effect on the willingness to adopt IoT systems; barriers perceived by potential adopters, such as costs or technological infrastructure, would deter them from adopting.

Priority Aspect (β=0.32, p=0.0007): The consideration of specific aspects, like data security versus cost efficiency, significantly increases the willingness to adopt IoT technology.

Familiarity Level (β=0.40, p=0.00001): People who are more familiar with IoT technology are likely to be more willing to adopt it in the context of healthcare.

Awareness Level (β=0.28, p=0.0001): Awareness of IoT technology and its application in healthcare positively influences willingness toward adoption.

The strongest conclusion from the analysis is that familiarization and awareness about IoT technology should be targeted to accelerate its adoption by the healthcare system in Afghanistan. Policymakers will need to confront perceived challenges while stressing the benefits and improvements IoT technology can provide. Particular emphasis should also be placed on data security and cost-efficiency aspects to build acceptance and implementation. The model serves as a robust foundation for the strategic planning and implementation of IoT-based healthcare solutions within Afghanistan.

Analysis and Findings

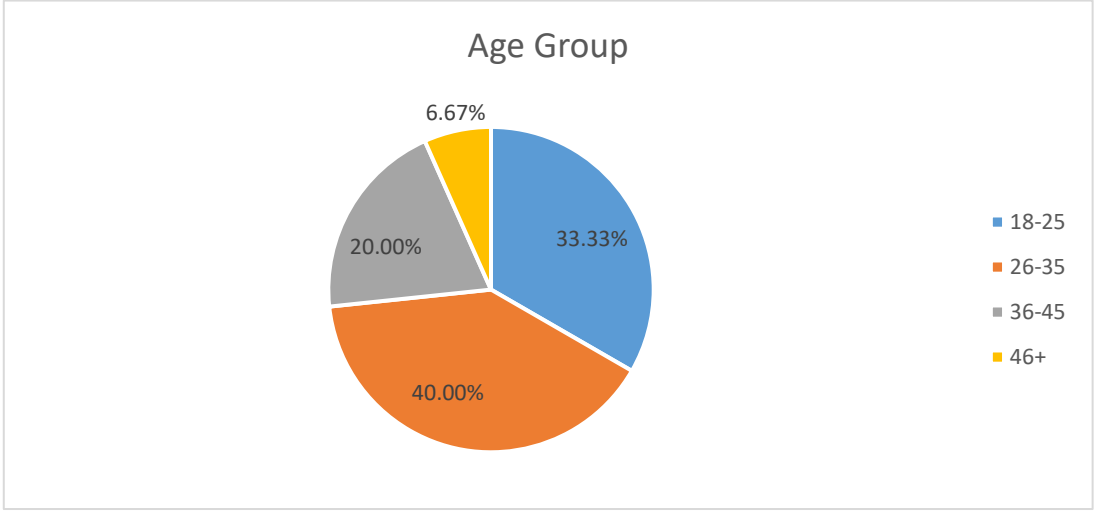

Figure 1. Age Group

The age distribution of respondents involved in a study examining the implications of IoT technology in the Afghan healthcare monitoring system is illustrated by the chart. The analysis breaks down as follows:

Age Group 18-25 (33.33%):

This category shows considerable representation among respondents, who form almost one-third of the total surveyed population. The younger generation tends to be tech-savvy and responsive to emerging technologies, IoT solutions being one of them. Their novelty-provoking behavior becomes a notable contribution toward the adoption of IoT technology-driven healthcare monitoring systems.

Age Group 26-35 (40.00%):

Thus, the largest section of respondents, 40%, would be expected to be the most active cohort concerning healthcare, whether professional or personal. Apart from the interest that they have in improving healthcare and their acceptance of IoT-based monitoring systems, these persons are in the best position to appreciate the value of healthcare technology. This solidifies their importance in promoting and applying IoT technology within the health sector in Afghanistan.

Age Group 36-45 (20.00%):

This age group accounts for 20% of respondents with moderate attendance in the survey; although adults in this category may be somewhat less familiar with new technologies than the younger age groups, they tend to be decision-makers within households and healthcare systems. Perception and acceptance of IoT solutions by this group will therefore influence the success of healthcare monitoring systems.

Age Group 46+ (6.67%):

This is the smallest category of respondents, 46 years and above, amounting to only 6.67% of those surveyed. This means that they are less engaged with IoT technologies, accompanied by a view that technological familiarity and access may be limited. Age groups will need systems that are easy to operate, alongside supportive training and awareness programs to involve them and ensure the uptake of healthcare.

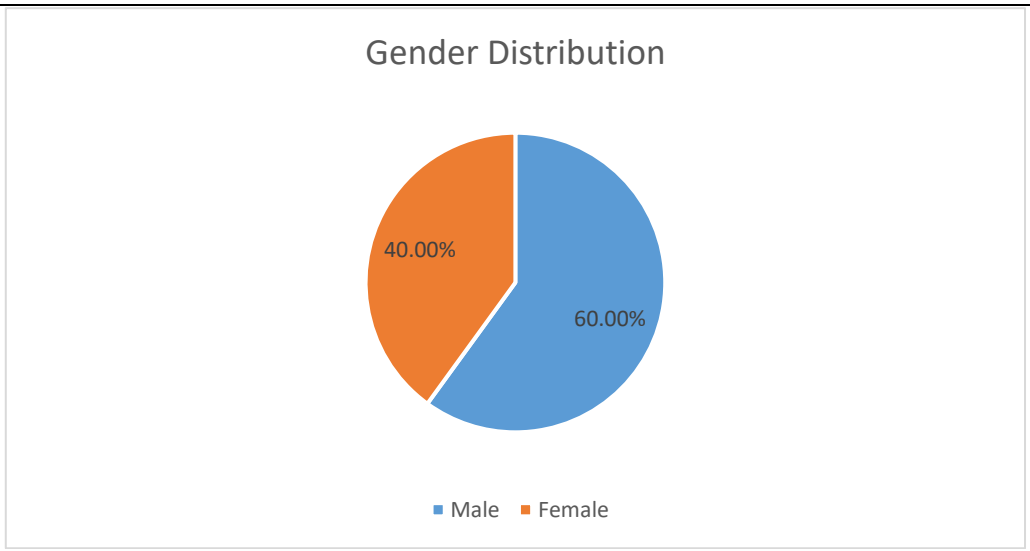

Figure 2. Gender Distribution

The graph depicts the division of gender within an IoT-enabled healthcare monitoring system operating in Afghanistan. Of the total surveyed, 60 percent constitute males and the remaining 40 percent are females.

An analysis of the distribution graph suggests a nearly equal gender ratio in the usage of IoT technology for healthcare monitoring by the Afghans. However, this would also alternatively signify that education and awareness-raising programs on IoT technology have effectively reached both men and women.

That means both genders have an equal understanding of the many benefits of this technology related to the health sector. Such successful programs show that the university has gone out on a limb in disseminating its education.

The analysis recommends sustaining and expanding educational programs around IoT technology to address areas of different needs and problems for both genders. This would further enhance their uptake and efficiency for IoT-enabled healthcare monitoring systems.

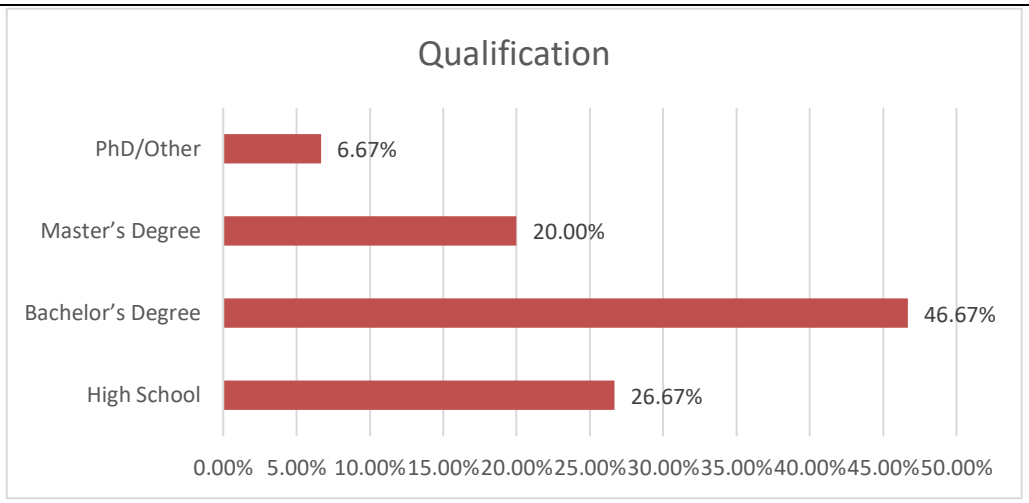

Figure 3. Qualification

The horizontal bar chart found at the entry "Qualification" displays the educational histories of the personnel involved in IoT technology involving healthcare monitoring systems in Afghanistan. It contains the following four qualifications: PhD/Other (6.67%), Master's Degree (20.00%), Bachelor's Degree (46.67%), and High School (26.67%). More than half of the individuals having a Bachelor's Degree are (46.67%) indicated as one belonging to the group followed by High School (26.67%), Master's Degree (20.00%), and a little portion have PhD or Other (6.67%).

The interpretation of the qualification chart indicates that a majority of the samples interviewed have a Bachelor's Degree, which also reflects significant higher education levels among people in IoT technology involving healthcare monitoring systems. Education-wise, the individual appears to be well established, and this could very well dovetail into executing and managing IoT technology in health care settings. Moreover, a significant proportion (perhaps even a quarter) of these individuals only hold a high school diploma, indicating that there is a need for continued education and training programs to enhance their technical skills about IoT systems.

This makes it abundantly clear from the above analysis that the educational outreach programs so far have managed to hit a wide cross-section of the population. Targeted education programs are then determined in this regard for graduates above the higher education level as well as those with lesser formal qualifications to ensure proper adoption and effectively use of IoT technology in healthcare monitoring systems. This may close the knowledge gap and empower all stakeholders in equipping the requisite skill in harnessing IoT technology efficiently in healthcare.

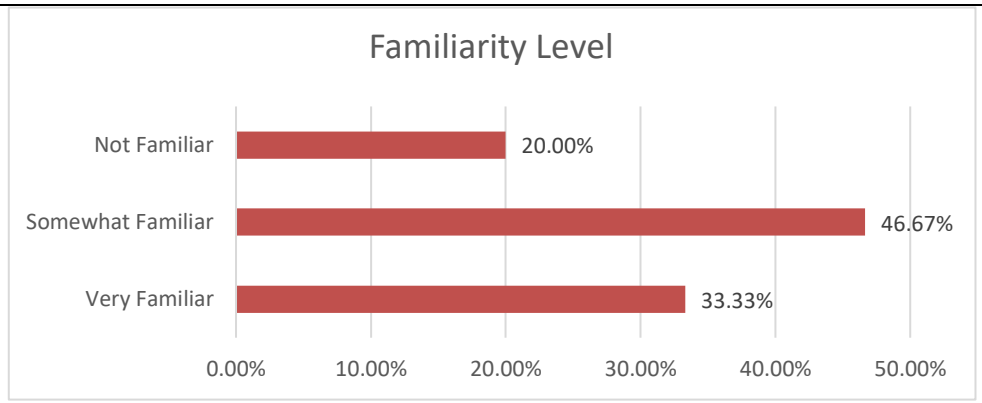

Figure 4, Familiarity Level

The horizontal bar chart titled "Familiarity Level" shows the distribution of respondents' familiarity with IoT technology concerning healthcare monitoring systems in Afghanistan. This chart has three categories: Not Familiar, Somewhat Familiar, and Very Familiar. The percentages are as follows:

Not Familiar: 20.00%

Somewhat Familiar: 46.67%

Very Familiar: 33.33%

From the analysis of the familiarity level chart, it is evident that a considerable number of respondents (46.67%) are somewhat familiar with IoT technology for healthcare monitoring systems, indicating a moderate level of awareness among the participants. In addition, respondents were reported to be very familiar with the technology in 33.33% of cases, indicating that a substantial number of people do have a high level of knowledge and cognizance of IoT applications in healthcare. However, 20.00% of the respondents are not familiar with IoT technology, which reveals a gap in awareness and a possible requirement for educational sessions.

Derived from the above analysis, it is apparent that while a good lot of it have some familiarity with IoT technology, it remains crucial to engage in educative and awareness-generating programs amongst those without such familiarity. These programs would enhance the understanding of IoT applications, advantages, and ways of implementation in healthcare monitoring systems.

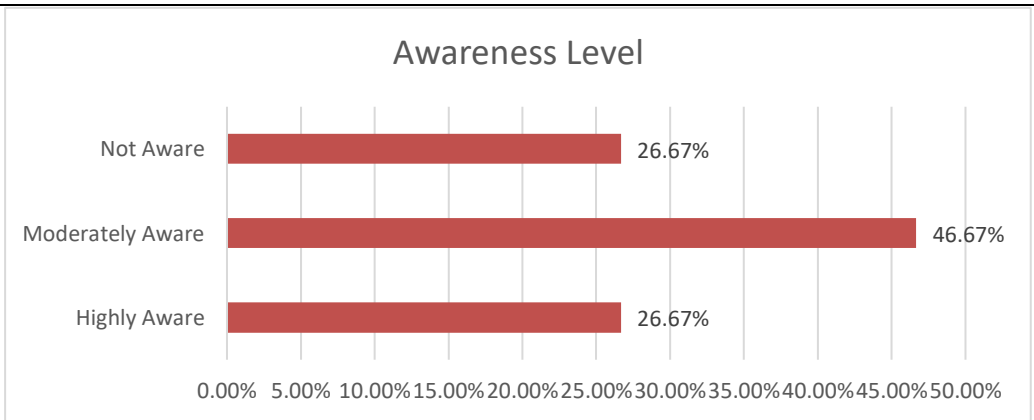

Figure 5. Awareness Level

The horizontal bar diagram titled "Awareness Level" depicts the distribution of awareness levels regarding IoT technology used in the healthcare monitoring systems for the people of Afghanistan. The chart gives three descriptions: "Not Aware," "Moderately Aware," and "Highly Aware." The percentages are: Not Aware-26.67%; Moderately Aware-46.67%; Highly Aware-26.67%.

The analysis of the awareness level chart indicates that a fairly good number of respondents (46.67%) are moderately aware of IoT in healthcare monitoring systems. This suggests that a fair number of people have a basic knowledge of IoT applications and the benefits that IoT can render to the healthcare sector. On the other hand, 26.67% of the respondents are either not aware or highly aware of IoT technology. This shows the area where more education can take place for the benefit of the health sector.

This data indicates that awareness and cognizance of IoT technology should be potentially raised among healthcare practitioners and the general public via well-targeted educational programs. With these, the gap in knowledge could be filled in and IoT solutions in healthcare monitoring systems would have wider reach and acceptance to fill an already urgent need. This would go a long way in upgrading healthcare services and the healthcare infrastructure in Afghanistan.

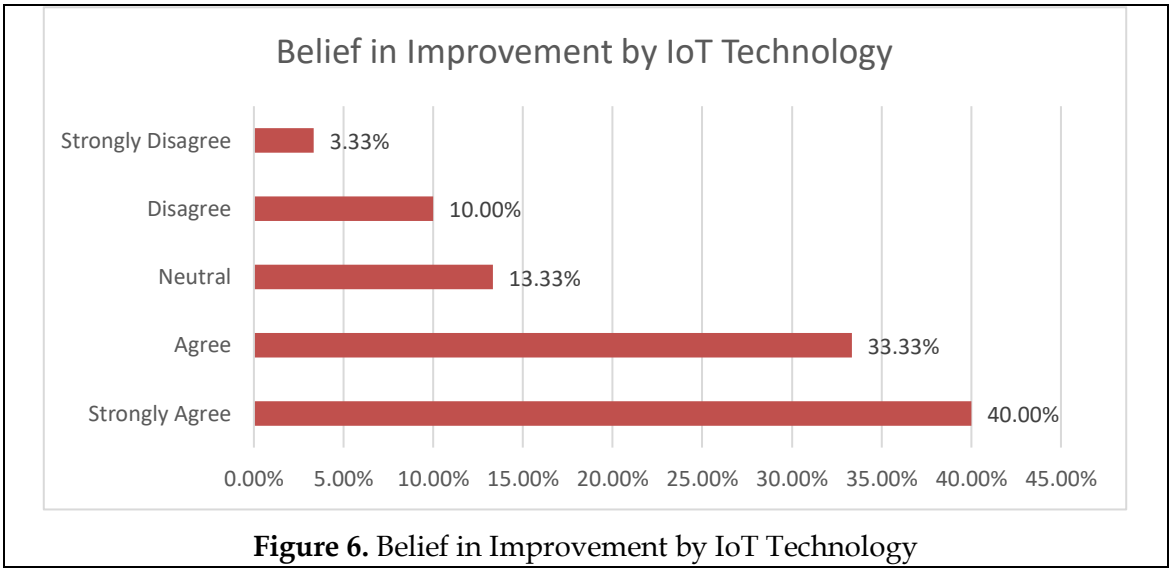

Figure 6. Belief in Improvement by IoT Technology

The chart showing "Belief in Improvement by IoT Technology" depicts the perception of the improvement IoT technology would bring to an area of healthcare monitoring systems. The responses are clustered into 5 categories: "Strongly Disagree" (3.33%), "Disagree" (10.00%), "Neutral" (13.33%), "Agree" (33.33%), and "Strongly Agree" (40.00%).

From the analysis of the belief in improvement chart, it can be seen that respondents had very positive perceptions about IoT technology applications in healthcare monitoring systems. With a 73.33% positivity towards IoT technology improvements (33.33% agreeing and 40.00% strongly agreeing), it really points out to a high degree of acceptance for IoT in the healthcare sector.

Such high acceptance reflects the chances for a good implementation and adoption of IoT technology into the healthcare monitoring system in Afghanistan. Respondents highly recognized the great advantages and improvements that IoT

technology could bring to healthcare services, such as better patient monitoring, efficient data management, and enhanced healthcare delivery.

Based on this analysis, it is recommended to keep marketing and investing in IoT technology for healthcare monitoring systems. Awareness and knowledge about the benefits of IoT technology and its applications should be enhanced through education and training programs. This will ensure broader acceptance of IoT solutions in healthcare, consequently leading to effective utilization.

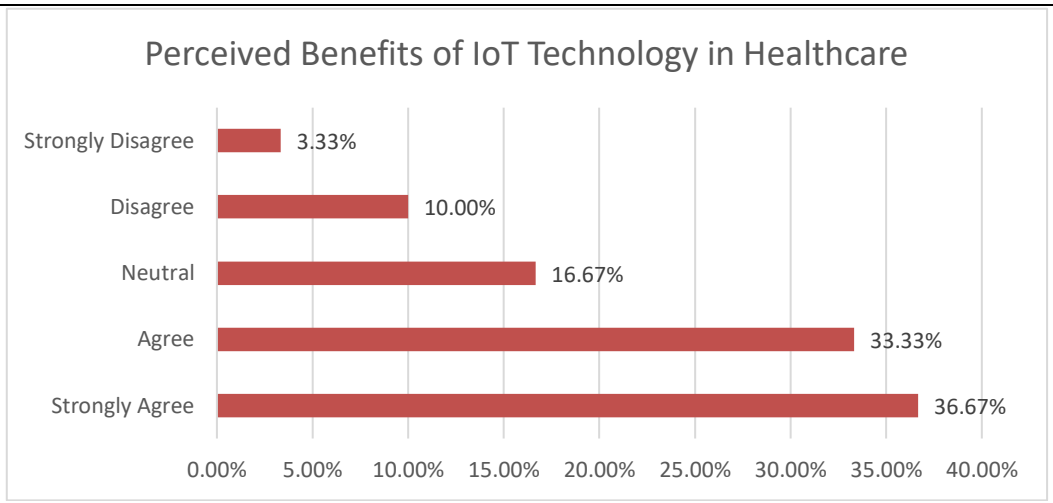

Figure 7. Perceived Benefits of IoT Technology in Healthcare

The bar chart which is entitled "Perceived Benefits of IoT Technology in Healthcare" displays levels of agreement by respondents towards the perceived benefits of the use of IoT technology in the healthcare setting. These responses were classified into five categories: "Strongly Disagree"(3.33%), "Disagree"(10.00%), "Neutral"(16.67%), "Agree"(33.33%) and "Strongly Agree"(36.67%).

An analysis of the perceived benefit chart discloses that a large majority viewed IoT technology positively in health. A total of 33.33% of respondents agree, while 36.67% strongly agree that IoT technology is an advantage in health. This index substantial acknowledgment of the benefits his technology brings. This overwhelming reception clearly indicates that there is an agreement in the possible improvements IoT could bring to healthcare monitoring systems like better patient tracking, real-time data collection, and improved delivery of healthcare.

Data indicate successful educational and promotional interventions put in place to raise awareness about the IoT technology benefits. The percentage, combining those who either agree or strongly agree totaling 70.00%, creates a good environment for adopting and expanding IoT-enabled health systems in Afghanistan. The fact that 13.33% either disagree or strongly disagree together with the 16.67% neutral indicates spheres that need further education and awareness programming to allay fears and bridge knowledge gaps.

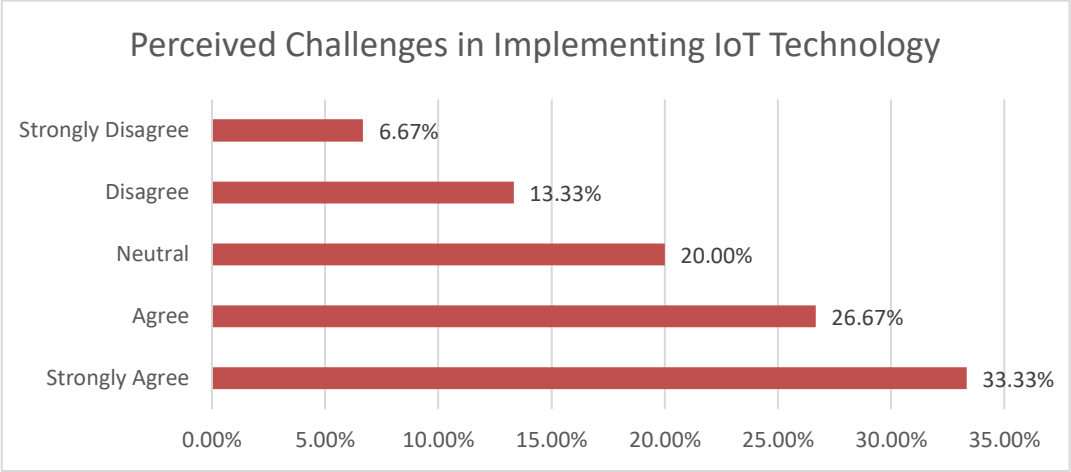

Figure 8. Perceived Challenges in Implementing IoT Technology

The bar chart entitled "Perceived Challenges in the Implementations of IoT Technology" shows the distribution of the levels of agreement set out by respondents concerning the challenges faced during the implementation of IoT technology. In this chart, responses are categorized into five levels: "Strongly Disagree" (6.67%), "Disagree" (13.33%), "Neutral" (20.00%), "Agree" (26.67%), and "Strongly Agree" (33.33%).

A view of the perceived challenges chart shows that a significant number of respondents acknowledge that there are considerable difficulties with the implementation of IoT technology in health monitoring systems. From which, 33.33% of respondents strongly agreed that there were serious challenges, and 26.67 agreed that serious challenges do exist. It goes without saying that there are triumphs and challenges of considerable concern needing attention. In contrast, 20.00% of respondents were neutral in answering, which means that they seem to be either unsure or indifferent to the challenges, while just small percentages disagreed (13.33%) and strongly disagreed (6.67%) concerning the presence of challenges.

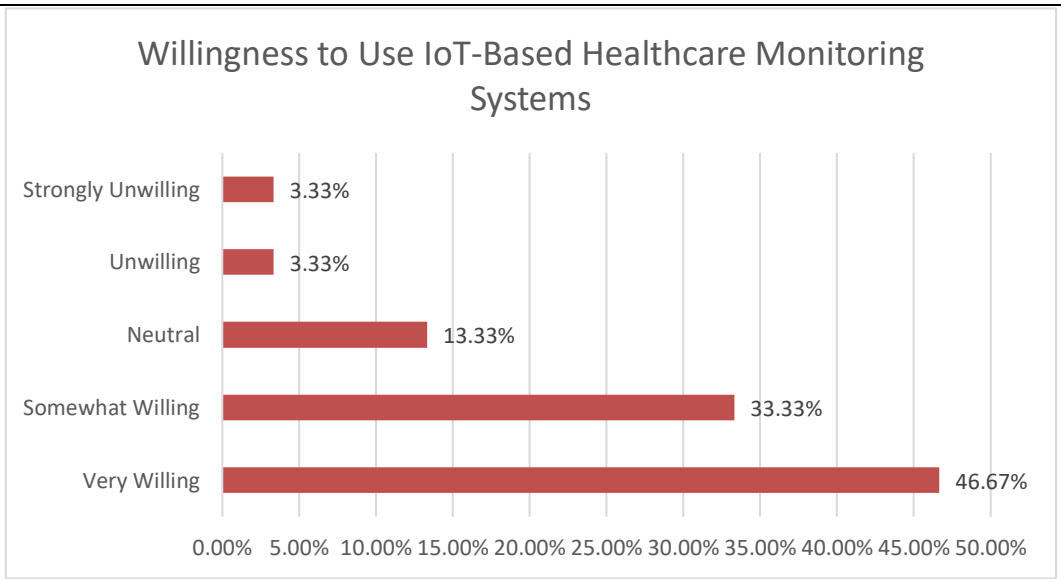

Figure 9. Willingness to Use IoT-Based Healthcare Monitoring Systems

The bar chart titled "Willingness to Use IoT-Based Healthcare Monitoring Systems" elaborates on the distribution of the respondents' willingness to adopt IoT in the healthcare monitoring systems in Afghanistan. The chart categorizes the responses under five levels: \"Strongly Unwilling\" (3.33%), \"Unwilling\" (3.33%), \"Neutral\" (13.33%), \"Somewhat Willing\" (33.33%), and \"Very Willing\" (46.67%).

The analysis of the willingness to use IoT technology chart indicates that there is a lot of backing to adopt IoT-based healthcare monitoring systems from those surveyed. With an 80% combined rating by the respondents being very willing (46.67%) or somewhat willing (33.33%), there is acceptance and indeed readiness to put in place IoT technology in healthcare tremendously.

Thus, this super enhanced willingness indicates people's positive perception and trust in the anticipated benefits of IoT technology for better healthcare service. This implies that a larger number of respondents are willing to accept any kind of technology that will improve patient monitoring with real-time data and healthcare delivery.

It is strongly recommended that this willingness be exploited by marketing and investing in IoT-based healthcare solutions. Establishing more awareness-creation and educational programs to inform the population about the actual benefits and concrete applications of IoT technology are essential. Trying to ensure that the few unwilling respondents, about 3% or so, and respondents that were neutral start to accept the applications of IoT in healthcare would also go a long way in propagating acceptance and, therefore, adoption.

From the foregoing, one could easily conclude that this chart of readiness to use IoT technology paints a good picture for the implementation of IoT-based healthcare monitoring systems in Afghanistan. If coupled with some appreciation of this good disposition and elevation of educational efforts, the result will be even better for enhancing the health infrastructure and services, improvement of health, and increased access to quality healthcare for all.

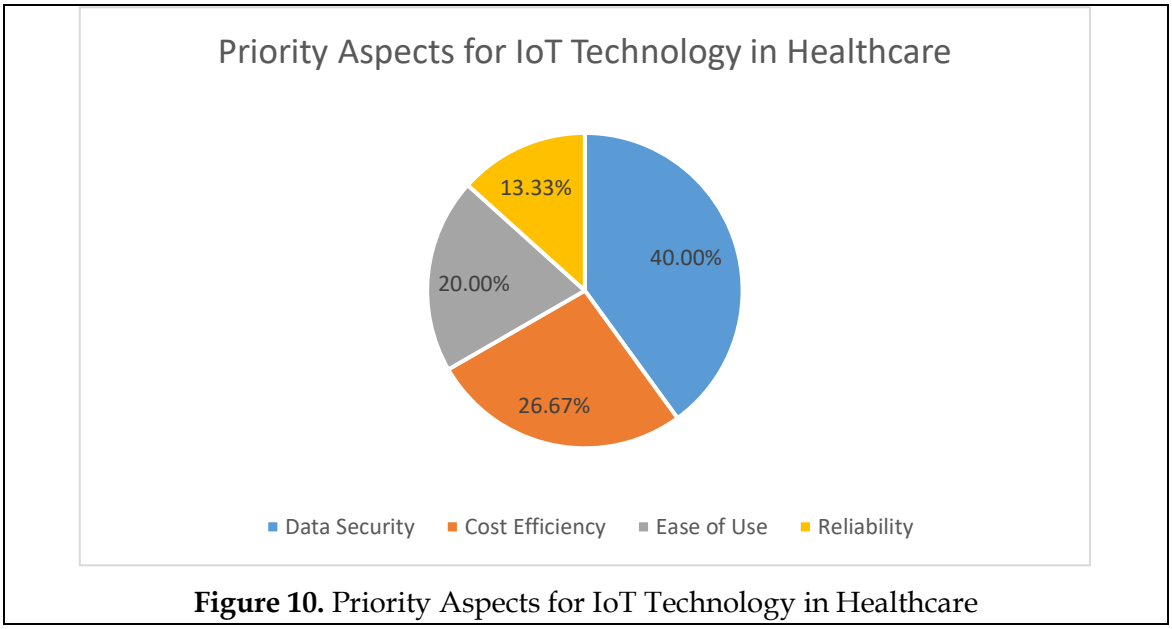

Figure 10. Priority Aspects for IoT Technology in Healthcare

The pie chart titled "Priority Aspects for IoT Technology in Healthcare" represents the priorities of the respondents relative to the introduction of IoT technology in healthcare monitoring systems in Afghanistan. The four segments represent various priority aspects: Data Security (40.00%), Cost Efficiency (26.67%), Ease of Use (20.00%), and Reliability (13.33%).

Analysis of the Priority Aspects chart shows that data security is the most crucial concern, with 40.00% of respondents indicating it as a priority. This reflects a strong emphasis upon the protection of sensitive health information and secure data transaction within IoT healthcare systems. An increased importance given to data security suggests that strong cybersecurity measures and protocols are needed to protect patient data against breaches.

The second-highest priority is cost efficiency, with 26.67%; thus, the respondents appear to be very sensitive to the financial implications of implementing IoT technology for harvesting health gain. For mass adoption to take place, it is imperative that IoT solutions are cost-effective, particularly in a resource-constrained environment such as Afghanistan. Hence, developing inexpensive IoT solutions with an active search for funding schemes is critical for the feasible rollout of these technologies.

Ease of use, with a score of 20.00%, is another important issue. This aspect places value on user-friendly interfaces and systems that healthcare practitioners and patients alike can easily operate. The simpler the interaction with IoT technology, the higher will be user acceptance and integration with existing healthcare routines.

Reliability, another important area albeit rated least at 13.33%, is still significant. Reliable IoT systems mean the capability of working consistently and dependably in healthcare settings. If IoT devices and systems are reliable, the level of trust and confidence amongst users will rise, thereby leading to better health care outcomes.

In conclusion, the priority aspects chart has pointed out critical areas to be addressed for implementing IoT technology in healthcare monitoring systems within Afghanistan successfully. By concentrating on data security, cost efficiency, ease of use, and reliability, stakeholders can develop IoT solutions aligned with the specific needs and priorities of the healthcare sector in Afghanistan. Combined together, these considerations contribute to the effectiveness and acceptance of IoT technology in the healthcare sector, thus improving healthcare services and outcomes for the consumers.

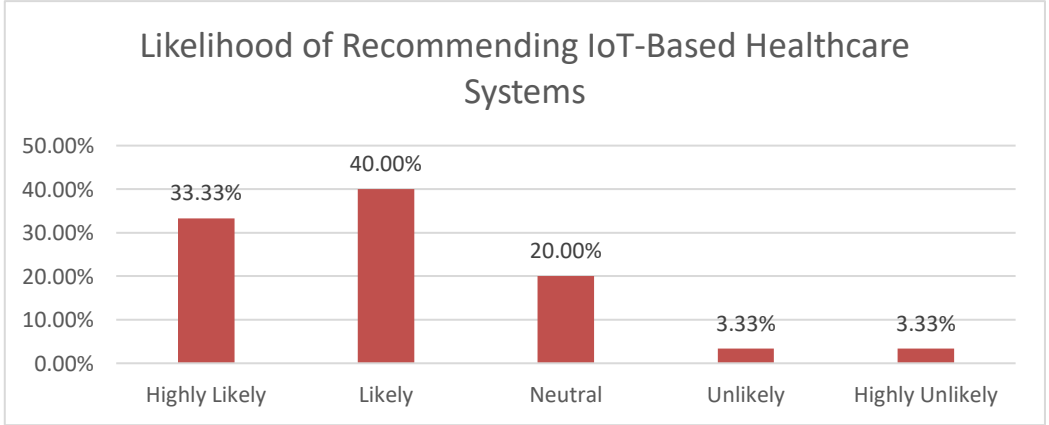

Figure 11. Likelihood of Recommending IoT-Based Healthcare Systems

The chart entitled "Likelihood of Recommending IoT-Based Healthcare Systems" indicates the spread of respondents with the likelihood of recommending IoT-based healthcare systems in Afghanistan. The responses have been categorized into five levels: "Highly Likely" (33.33%); "Likely" (40.00%); "Neutral" (20.00%); "Unlikely" (3.33%); and "Highly Unlikely" (3.33%).

The analysis of the chart for IoT-based healthcare systems in Afghanistan highlights a strong tendency among respondents in regard to recommending such systems. With a total of 73.33% of respondents being highly likely (33.33%) or likely (40.00%) to recommend IoT-based healthcare systems, it is clear that there is a strong amount of confidence in IoT technology in healthcare and its benefits and effectiveness.

Most feel positively that IoT-based healthcare systems do afford benefits, including better patient monitoring, real-time accessibility to patient data, and an improved delivery of healthcare service. The inclination to recommend these systems indicates a high level of satisfaction and trust in IoT technology, which truly needs to be seen for its further acceptance and implementation.

However, it is evident from the graph that at least 20.00% of the respondents felt neutral, while 6.66% said they would be unlikely or highly unlikely to recommend IoT-based healthcare systems. Thus, there is a great need for awareness and education that will begin to deal with the concerns or uncertainties that remain. By creating awareness about IoT systems and showing practical use cases beneficial to the users, it is possible to convert the neutral and skeptical people into advocates for the system.

DISCUSSION

Results of the present study provide reassurance concerning the potential of IoT-based healthcare remote monitoring systems (RHMS) in Afghanistan, along with respective gaps and opportunities of their implementation for a successful health-care system. The findings indicate that 73.33% of respondents believe that IoT technology has the ability to enhance healthcare systems by allowing for real-time data collection and monitoring of patients remotely (Hotak & Waqif, 2020). This is consistent with global trends, where IoThas been reported to improve health service provision by fostering efficiency, accessibility, and patient care (Al-Fuqaha et al., 2015). Yet, the study identifies infrastructural deficiencies, lack of finances, and low information on technology as a key barrier to the adoption of new technologies like geoinformation (Farooq et al., 2015), especially in developing countries such as Afghanistan.

One of the most noteworthy findings is the very high intention of the population to adopt IoT-based health care systems (80% would adopt). Such motivation is instigated by the multiple advantages of IoT, including enhanced patient observation, lower healthcare expenses, and better access to healthcare facilities (Abdulmalek et al., 2022). However, the study also highlights the need to address data security threats, ranked as the highest priority by 40% of respondents. This corresponds to the global literature which suggests that yet there should be no deficiency of cyber defense to ensure critical health data are protected in IoT networks (Shendge, 2021).

The consideration of another aspect of the study lies in how demographics affect the adoption of IoT. The 18- to 35-year-olds and higher-educated segments (Bachelor or Master) tend to support IoT integration because these cohorts are more technically

savvy and receptive to technological disruptions (Islam et al., 2020). This indicates that focused education and sensitization campaigns can play a significant role at bridging the knowledge divide and leading to the attained acceptance by the older and unschooled population (Bernhardt et al., 2014).

The second major finding is that IoT integration is feasible despite constraints in infrastructure. Even though 70% of respondents above claimed to be suffering from lagging infrastructure, like poor internet connection, and costly setup, they believed these issues could be solved with the right investment and well-planned policies (Lasi et al., 2014). This resonates with studies emphasizing public-private partnerships and state action undoing infrastructural gaps in developing economies (Sosunova & Porras, 2022).

Regression analysis from the study also affirms these findings, identifying perceived benefits, awareness, and familiarity as significant predictors for the uptake of IoT systems (R^2=0.82). This indicates that raising awareness and showcasing the real-world benefits of IoT technology may encourage its adoption in the healthcare sector of Afghanistan (Friha et al., 2021).

CONCLUSION

Using IoT-based healthcare monitoring systems in Afghanistan, the study aims to explore stakeholders' perceptions, challenges posed to the adoption of the technology, and willingness to adopt that technology in their settings. Almost everyone among the respondents has a strong belief that the application of IoT can vastly improve health service provision through data collection in real-time, remote patient follow-up, and increased accessibility. Approximately 73.33% of the respondents were confident that IoT could improve health service delivery; furthermore, 80% said that they would adopt such systems if they were cost-effective, easy to use, and culturally adapted.

However, the study also established some key barriers impeding the adoption of IoT systems, such as infrastructure limitations, issues related to data security, and low levels of technological literacy. However, concrete action plans must be put in place to remedy the situation, such as investment in Internet connectivity, establishment of efficient cybersecurity measures, and capacity-building programs to raise awareness and awareness about IoT technology. The influence of some demographic factors such as age and educational levels signals the importance of targeting interventions that will be able to narrow the knowledge gap and foster acceptance across various groups.

From all the above, it is evident that there is a possibility to introduce IoT into the health system of Afghanistan since 70% of the respondents believe that infrastructure-related challenges can be addressed with the right investments and strategies. Therefore, public-private partnerships and the support of the government would be key to overcoming these obstacles and ensuring the successful deployment of IO-based solutions.

Several recommendations must be taken into account to successfully implement an IoT-based healthcare monitoring system in Afghanistan. First, awareness-raising and education programs should be implemented to bring familiarity with IoT technologies among healthcare professionals and the general public. Such initiatives usually include workshop training sessions and information campaigns that

demonstrate the advantages and applicability of IoT in the healthcare sector. Infrastructure gaps must, therefore, be addressed with investments in improved internet connectivity and technical infrastructure, especially within rural and underserved communities. The better the connectivity, the more efficient the functioning of the IoT application. Third, data security measures should be made a priority to secure sensitive health-related information and establish trust amongst the users. Fourth, developing cost-efficient IoT solutions will indeed go a long way in ensuring that the technology avails itself to all population strata. This will cover low-cost devices and scalable systems that can integrate easily into the existing healthcare system. Lastly, public-private partnerships should be fostered for the adoption of IoT. The collaborative efforts between the government and private sectors and international organizations will ensure the provision of resources expertise and funding so that the implementation challenges will be overcome.

Social Implication of the Study

The introduction of IoT technology in healthcare systems may rewrite much of the healthcare provision story in developing countries like Afghanistan. While practical and infrastructural hurdles are ones to overcome, social and cultural aspects become a backdrop against which such innovations occur.

Some of the major social hindrances may consist of limited digital literacy among certain population groups like the professionals and the patients, which may hinder a proper application of IoT-based systems. This may be particularly potent in the rural areas, where cultural norms may balance acceptability against resistance due to the anticipated complexity of the devices or privacy issues accompanying the data-sharing aspect.

Other major hindrances will include engendering trust in technology. The other fact that Afghans may have some reservations against using new technology suggests that such trust can be built through transparent communication, awareness-creating mechanisms, and community engagement. Gender dynamics are factors that will also shape the adoption of the IoT; socio-cultural barriers to access to technology might be faced by women in many regions. Overcoming these layers of hindrances makes use of broad-minded strategies, such as accessibility-based training initiatives, increased input of female professionals in medical technologies, and designing IoT-based user-friendly solutions that can promote use of the tech.

Hence, the study calls for the need for specific educational initiatives that will aid in removing the malformations that lay in these social barriers and also further enhance the digital literacy and awareness on the usefulness of IoT among healthcare professionals and patients especially in rural and underserved areas. More so, health systems and policymakers should prioritize community engagement in developing inclusive, place-based solutions that engender trust, consider cultural factors, and ensure perceived security, accessibility, and compatibility of IoT-based systems with local values. Tackling these social and cultural hurdles alongside technical ones may lead to a higher probability of success in the integration of this IoT technology into Afghanistan's healthcare system.

Future Research

Future research should study how IoT-based healthcare systems in Afghanistan will impact patients in the long run, in terms of health outcomes, cost-effectiveness,

and operational efficiency. Other research could purposely investigate the role of cultural factors in IoT adoption and design strategies to address the older and less-educated populations' resistance. Researching the integration of IoT with other emerging technologies like artificial intelligence and blockchain could open gateways for developing secure and efficient healthcare systems. Moreover, comparative studies across different regions in Afghanistan would effectively identify region-specific challenges and opportunities for IoT implementation. This way, future research could help foster truly effective and inclusive IoT-based healthcare solutions.

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