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IoT Technology Applications and Healthcare System's Performance in the era of 4IR: Evidence from Bangladesh

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Abstract:- The Internet of Things (IoT) is the most fascinating concept in the fourth industrial revolution (4IR) era penetrating the advancement of wireless sensors andinternet networks. The application of IoT is wide-reaching and has branched out to almost every sector in the world contributing to an ample impact on the economy. The Internet of Things has a prevailing influence in the healthcare sector around the world for the distributed intelligence of smart devices achieving the highest results with limited resources. The application of IoT is improving the realm of the healthcare industry in Bangladesh. However, no significant research has been conducted in the given area. Therefore, this paper has been undertaken to learn about the substantial impact of IoT-based services in three areas-Healthcare Service Domain, Healthcare Transportation Domain and Healthcare Logistics Domainand their impact on the performance of the healthcare system. A survey coveringone hundred and fifteen respondents who belong to the healthcare profession has been analysed by SmartPLS3. The result shows a positive relationship between independent and dependent variables. The findings of this paper will aid policymakers, medical professionals, researchers, and others to learn about how IoT is shaping the healthcare industry and improving service performance.

Keywords:- *Internet of Things (IoT), Healthcare System, Healthcare Service, Smart Device, Transportation, Logistics and Fourth industrial revolution (4IR).*

I. INTRODUCTION

Internet of things (IoT) is the concept that put forward the advancement of smart devices interacting with one another, conceiving, and transferring data communication being self-empowered to take decisions by themselves when the devices get connected to the internet. The omnipresence of IoT on the internet-enabled environment where a variety of elements receive conscience to wellness and wired connections where a number of smart gadgets are intertwined to implement attached following a request of the users or create new service or application. The advancement of IoT is progressively infiltrating more and more industries and sectors and elevating the convergence of digital,virtual and real world to formulate a smart euphoria which is able to produce, process and deliver any product and servicein a more intelligent manner (Kaur & Singh, 2016). The Internet of things (IoT)is pervasive, and its usage is restructuring every aspect of the life of individuals as well as industries. Countless organisations are forgoing their traditional means of implementing internal and external functions and adopting IoT-based systems for gaining a competitive advantage in the industry. The healthcare sector has shown high dependency on IoT, and its gusty applications have facilitated quality of care, enhanced the accessibility to healthcare, reduced the cost of healthcare and alsoincreased the responsiveness of healthcare professionals and staff (Kodali et al., 2015). IoT-based smart devices are an integrated alternative to serve patientfast with quality and develop health care system. The Internet of things has the component to transfer any imperativeinformationinstantly to the medical centre and extract real-time feedback. And it contributes to effective emergency management which is highly functional compared to manual work (Ghosh et al., 2016). IoT-based healthcare offers responsiveness and efficacy in its monitoring and tracking service that augmented the resource managementsystem (Subramaniyaswamy et al., 2018).The Adoption of IoT-based devices has spread among organisations in the healthcare industry and extended its application to the functions such as utility service transportation and logistics which require higher time and effort to be fully implemented in Bangladesh. The success of a healthcare organisation is subject to offering the highest access in their service to the people and the rising adoption of IoT devices is supporting the industry to meet its goal. To maximise the competence of IoT-based health care systems organisations and researchers have been becoming more about it advancing this area concerning IoT-based technology that focuses on medical applications (Bui & Zorzi, 2011). Moreover, in the fourth industrial revolution (4IR) where automation through IoT is taking mentionable control over different industries, the health care sector must capitalise on smart systems to improve operational efficiency(Lee et al., 2018).This paper has therefore focused on unveiling the significance of IoT technology in healthcare and its impact on healthcare performance. The key objective of this research is to understand to what extent IoT in Healthcare Service Domain, Transportation Domain, andHealthcare Logistics Domain affected Healthcare System's Performance in Bangladesh.

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II. LITERATURE REVIEW CONCEPTUALISATION AND DEVELOPMENT OF HYPOTHESIS

According to Mohammeda & Ahmed, (2017)Internet of things is a novel technology built based onthe internet ecosystem. With IoT, different gadgets and elements become aware of their behaviour and achieve intelligence for making relevant decisions prior to communicating data among themselves. The author also added that the objects are connected for gaining excess data and information from other things or to transmit information. The author further elucidated that object connected to each other communicate through the internet in real-time within any geographical sphere and delivered services over the network. Through the concept of IoT, any object can be connected to network conducting data transmission among any things at any time and in any place over the network. On the other hand, Kaur & Singh, (2016) addeda new dimension to the concept explaining that with IoT more applications can be initiated involving smart homes and smart vehicles delivering additional services namely security automation, sensor computation, entertainment alerts and energy saving alert.Selvaraj &Sundaravaradhan, (2019) explained, that IoT is the progressive technology in the realm of the internet ecosystem that attaches different elements in real-time. The crucial particle of IoT is converting a simple business process into a smart one integrating several hardware, systems, networks through internet without much additional cost. The fact that the convergence of mundane items into technology infiltrated objects has brought acceptance in different industries,especially in the healthcare sector. IoT has a prolonged effect on healthcare service extending to health administration and therapeutic support to psychological assistance to the client. The inclusion of IoT in healthcare has enabled the trackingof patient'sdetails and all that data such as past medical history is incorporated into the control devices which are utilised and observed by the health monitoring unit. In many instances, the patient information is stored in a cloud platform which is controlled by the central healthcare unit of a particular organisation. While transmitting data from the sensor to the cloud platform security is a high concern for each of the parties as data could lose its confidentiality as intruders always can break into the system and use data for an ambiguous purpose. It is always a better option to store medical data in the cloud centre to process patients' data remotely by doctors. Moreover, the distributed environment of the cloud platform provides access to patients in their relevant information(CK & PK, 2016).

A. IoT in Healthcare Service Domain (IHSD) and Healthcare System's Performance (HSP)

Among all the potentials thrilled by the internet of things, the service domain of healthcare addresses the most progressive and technical benefits for all the relevant parties. Kaur & Singh, (2016) have identified tracking, identification and authentication and data collection as the most imperative application of IoT technology in healthcare. Whereas identification and authentication of individuals, data collection with automation have been underscored by Chaudhary et al., (2018) as the crucial application of IoT in the healthcare service domain. Bhuvaneswari &Porkod, (2014) has identified tracking, identification and authentication and real-time location system important factors in the IoT service domain. YIN, (2016) stated that tracking in real-time accommodates the lack of visibility in association with the patients, professionals, medical tools, and other resources. The author stressed that lack of visibility and timeliness create uncertainty impacting the standard service of the health care system.The author stated that among every other function the identification of the relevant information of individuals and other related parties in real-time is a key concern of tracking under IoT umbrella. According to YIN, (2016) identification and authentication are indispensable in the healthcare industry to maintain the standard of security procedure and ensure employee confidentiality. The author added that tracking of patients' information and staffs' treatment towards patient is an obligatory function imposed on healthcarefor reducing the chances of any harmful conduct that can affect patients and for improving the performance of healthcare service. In addition, the healthcare system based on the internet of things is dependent on data collection and data management originating from patients, hospitals community rehabilitation centres and household in real-time basis. While Kaur & Singh, (2016) confirmed that the internet of things has empowered the process of data managementautomated which has made data collection and processing highly efficient with reduced time. The author added that improved data processing involves automated processing of data and manage errors, automated procedure auditing and inventory management. Niyato et al., (2009) suggested that IoT has enabled the Medicare sector real-time provide reports to patience that helps analysing or diagnosing patients' conditions and enables them to see the results in online. Therefore, to learn the influence of the Healthcare Service Domain on the Healthcare System's Performance, the given hypothesis has been outlined.

H1 - IoT in Healthcare Service Domain (IHSD) has a positive impact on Healthcare System's Performance (HSP).

B. IoT in Healthcare Transportation Domain (IHTD) and Healthcare System's Performance (HSP)

According to the Internet of Things, Strategic Research Agenda (SRA), (2010) the application of IoT branches out to diversified channels specifically smart transportation identified as a crucial domain. Concurring with this statement Bhuvaneswari &Porkod, (2014)mentioned transportation as a significant application of IoT. According to Kaur & Singh, (2016) mobile ticketing and location mapping as the key elements of smart transportation. The author added that smart transportation allows professional healthcare staff or patients to obtain information about different ambulance options through mobile phone from registered website or apps of the particular organisation almost immediately following their request. The author also added that smart transportation let patient and drivers get information about the location they are heading towards, the best route to the locations and an accurate distance of the target destination from the website of the healthcare company in real-time. Wickramasinghe et al., (2017) signified location identification as an integral application of IoT devices in the healthcare sector. Considering IoT in the

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healthcare transportation domain location, mobile booking, real-time ambulance support, mapping and location tracking need to be prioritised as indispensable areas that need to be sustained to elevate service quality in the Medicare sector. Therefore, this is imperative to learn to what extent Healthcare Transportation Domain influences Healthcare System's Performance.

H2 - IoT in Healthcare Transportation Domain (IHTD) has a positive impact on Healthcare System's Performance (HSP)

C. IoT in Healthcare Logistics Domain (IHLD)and Healthcare System's Performance (HSP)

Internet of things has penetrated the domain of logistics in the healthcare sector with advanced system instruments like sensors and RFID and NFC along with processing power. Healthcare organisations are getting more responsive with real-time communication with suppliers, doctors and other healthcare staffs in order to minimise the waiting time of each patient to obtain proper treatment. Bhuvaneswari & Porkod, (2014) stated that the implementation of the internet of things benefits logistics with advantages like supply chain and product tracking and inventory monitoring. The author added that IoT-based services allow an organisation to conduct many logistics services like a first payment solution, control of rotation of products in the storage to automate restocking processes, fast check out using biometrics and others. Kaur & Singh, (2016) stated that IoT has an impending application in the logistics of an organisation. Yuan et al., (2007) detailed that IoT is enabling real-time information processing equipped with RFID and NFC controlling and monitoring every action of supply chains that stretch to purchase, transportation, and return of the materials. Karpis chek et al., (2009) has stressed that RFID technology allows an organisation to get real-time excess to the information of their supplies and directly send information to the suppliers of the necessary materials to be required immediately. That's how,It is important to learn about the dynamic application of IoT on the logistics of the medical centre and its influence on hospital performance for which the study proposed the given hypothesis.

H3 - IoT in Healthcare Logistics Domain (IHLD)positively impacts on Healthcare System

D. Healthcare System's Performance (HSP)

The application of IoT is highly diverse, and it is complicated to incorporate every element in a single paper. Therefore, based on the most crucial elements of IoT technology in the healthcare sector (IHSD IHTD & IHLD) have been taken into account which will be analysed to understand its effect on healthcare performance. Several studies have been undertaken to realise the indicators of healthcare system performance, some of those are discussed in this study. According to BANKAUSKAITE &DARGENT, (2007) Healthcare system includes all participants, organisations and resources that execute activities related to improving public health with a goal associated to be responsive, effective, and efficient. Hurst &Jee-Hughes, (2001) found out that effectiveness and responsiveness such as patient satisfaction and experience integral factors for improved healthcare performance. WHO has formed a framework for healthcare system performance that involves effectiveness and quality of healthcare. Palmers and Torgerson, (1999) have identified responsiveness,faster service, efficiency, quality of care as imperative determinants of performance. Perić et al., (2018) also foundthat,information efficiency and quality of care highly influence healthcare systems' performance. Following the literature review of IoT applications, no such complete work has been found concerning the contemporary scenario of the healthcare sector based on the healthcare service domain, transportation, and logistics. To fillthisvoid this paper has created a conceptual framework to analyse the IoT-based services in the medical field and their influence on Healthcare System's Performance in Bangladesh. This paper examines the impact of (IHSD, IHTD& IHLD) on Healthcare System Performance (HSP) and the findings would add value to this unexplored area.

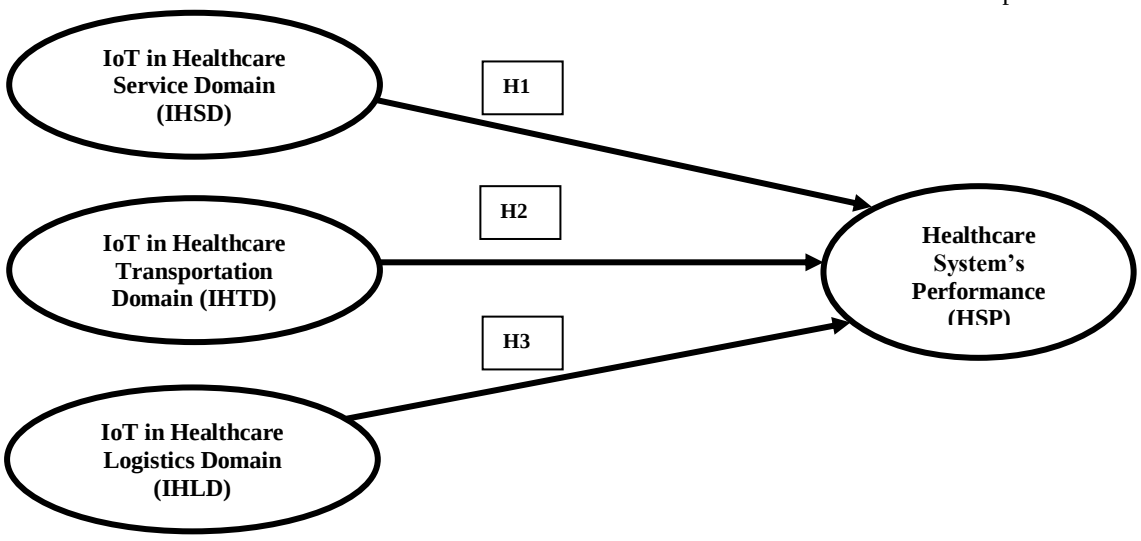

Fig. 1: Conceptual Framework

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III. RESEARCH METHODOLOGY

A. Data and Sampling

The paper has focused on a population that is directly engaged with the private healthcare service or profession and frequently uses IoT based technologies for healthcare service. The actual population size involved in the medical profession is still unidentified, therefore the existing medical professionals and staffs from private hospitals are chosen as a sample to execute the research. Non-probability purposive sampling has been applied as sampling technique. A total of 130 participants were selected for the online survey. Each of the questionnaires is distributed online to 130 respondents. The established questionnaire was sent to the respective respondents over email afterreceiving their approval. Among 130 respondents 15 responses have to be rejected as some data could not be retrieved from the questionnaire(Hair Jr et al., 2017). While some of the responses were not used for analysis due to data normality issues(Shan et al., 2013). Consequently, data were collected from 115 respondents and their data was analysed further through SmartPLS.

B. Measurement instrument

For undertaking credible research, the data collection has been executed based on multi-items measurement of constructs. A questionnaire was designed following 5 points Likert scale which ranges from strongly disagree to strongly agree. The questionnaire was constructed considering the valid items of previous research which is one of the reasons the items to be reliable for this study. The healthcare system performance as a dependent variable in the study has been instituted with 5 items measures as recommended by Li et al. (2021). Several items of the constructs have been modified in order to minimise confusion for the respondents.

C. Data Analysis Technique

For executing both descriptive statistics and production of measurement and structural model two kinds of statistical tools have been adopted in the study. First of all, Statistical Package for Social Sciences (SPSS25) has been utilised to construct descriptive statistics and carry forward the analysis. In addition, SmartPLS3 has been adopted to obtain results of measurement and structural model. partial least square structural equation modelling (PLS-SEM) has been employed to understand the significance of the mentioned hypothesis and to present the relationship between independent and dependent variables(Reisinger & Mavondo, 2007).

SEM is an essential element to elucidate the relation between selected variables. Whereas PLS-SEM is significant as a tool to formulate the applied multivariate analysis. Both the measurement model and structural model has been executed for the validity and reliability of this study (Hair et al., 2010).

IV. DATA ANALYSIS AND FINDINGS

A. Respondents profile

Following a survey, the results shown in table 1 have been collected from the respondents (N=115). Table 1 demonstrates a summary of the demographic analysis of this paper. Among the participants, females make up 53.91% and males 46.09%. While most of the respondents belong to the 25-34 age bracket, 29.57% was from 35-44 age bracket, 13.91% was from 45-54 age bracket, 13.04% was from 18-24 age bracket and rest of the respondents were from 55 to above according to age. Besides, it is visible that a higher portion of the respondents have post-graduation (42.61%) and post-graduation with other degrees (38.26%). It is further revealed that 41.74% of respondents are job holders and most of the participants (75.65%) regularly use IoT based automated healthcare system and rest of the respondents use it occasionally or rarely.

		Frequency N=115	Percent
Age Level	18-24	15	13.04%
	25-34	42	36.52%
	35-44	34	29.57%
	45-54	16	13.91%
	55 and above	8	6.96%
Gender	Female	62	53.91%
	Male	53	46.09%
Level of Education	Below graduation	9	7.83%
	Graduation	13	11.30%
	Post-Graduation	49	42.61%
	Post-Graduation with other degrees (Mphil/PhD/FCPS/MD/MS Others)	44	38.26%
Occupation	Business	7	6.09%
	Home Maker	9	7.83%
	Job Holder	48	41.74%
	Others	25	21.74%
	Retired	7	6.09%
	Student	19	16.52%
Frequency of Using IoT based Healthcare	Regularly	87	75.65%
	Rarely	18	6.96%
	Occasionally	10	8.70%

Table 1: Demographic profile of the Respondents

Constructs	Items	Loading Value	Cronbach Alpha (CA)	Composite Reliability (CR)	AVE
Healthcare Service Domain (IHSD)	IHSD1	0.742	0.668	0.825	0.529
	IHSD2	0.885			
	IHSD3	0.760			
	IHSD4	0.684			
	IHSD5	0.810			
	IHSD6	0.721			
Healthcare Transportation Domain (IHTD)	IHTD1	0.722	0.689	0.851	0.513
	IHTD2	0.749			
	IHTD3	0.692			
	IHTD4	0.743			
Healthcare Logistics Domain (IHLD)	IHLD1	0.635	0.749	0.731	0.501
	IHLD2	0.754			
	IHLD3	0.837			
	IHLD4	0.773			
	IHLD5	0.872			
Healthcare System's Performance (HSP)	HSP1	0.765	0.793	0.889	0.565
	HSP2	0.653			
	HSP4	0.847			
	HSP5	0.708			
	HSP6	0.757			

Table 2: Item loading, convergent validity, and reliability

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B. Measurement Model

a) Convergent validity

A convergent validity test has been carried forward to understand the degree to which each item has consistency with other items. Table 2 presents the convergent validity of IHSD, IHTD IHLD and HSPvariables in association with the loading value, Cronbach's Alpha (CA), Composite Reliability (CR) and the Average Variance Extracted (AVE) which extracted value of the variables in relation with their items. Following the assessment of the loading value of HSP, it has been established that the AVE value of the variable is less than the required 0.50, therefore as per the suggestion of Hair et al. (2010),that specific items were taken out of the table. The AVE score of each variable turned out to be higher than the required 0.50 following the removal of the item with a value lower than the expected 0.50. Consequently, the result shows that all the variables had adequate value that proves their convergent validity (Hair et al., 2019; Henseler et al., 2014). Whereas the variables had CA values ranging between 0.668 to 0.793 and the values are larger than the cut-off of 0.60, showing high-level reliability in the measurement model. Furthermore, the CR value of the variables varies between 0.731 and 0.889 which is over the demanded rate of 0.70 (Hair et al., 2019). This proves that the items of the variables had a positive reliability rate.

b) Discriminant Validity

The discriminant validity is measured to understand the discrete characteristics of each variable. Each of the variables must carry distinctive attributes devoid of mentionable similarity to other variables. In conjunction with the Heterotrait Monotrait (HTMT) ratio, discriminant validity of the variables has been measured (Henseler et al., 2014). The HTMT score needs to be below 0.85 which is suggested by (Hair et al., 2019; Kline, 2015). Gold et al., (2001); Hair et al., (2019) suggested that a 0.90 value is also acceptable. In table 3 it is shown that the HTMT ratio of these four variables has risen about the cut-off value of 0.85. The result indicates that the variables have sufficient discriminant validity which means each of the variables produces a discrete weight in this study. In bottom line, all the variables have both validity and reliability to carry out credible research. Therefore, the investigation of the structural model can be preceded.

C. Structural Model

In the structural model, the relationship between dependent and independent variables is measured. In table 4 the denominations of β, Standard Deviation, T and P values have been demonstrated (Memon et al., 2017). The β value designates the degree to which the independent variable changes as a response to the changes of the independent variable.

	IHSD	IHTD	IHLD	HSP
IHSD				
IHTD	0.686			
IHLD	0.588	0.559		
HSP	0.626	0.650	0.526	

Table 3: Heterotrait Monotrait (HTMT) Ratio

On the other hand, the P value estimates the hypothesised relationship between dependent and independent variables. The significance level of the P value is at 0.05 ($p < .05$).The table presents a clear picture that each of the variables has a positive significant impact on the dependent variable. IHSD (H1: IHSD → HSP, β=0.413, (SD)= 0.052, t=7.320and p=0.001) significantly affectsHSP as the outcome is significant at the level $p<0.01$. On the other hand, IHTD (H2: IHTD → HSP, β=0.148, (SD)= 0.062, t=2.937and p=0.015) has a significant impact onHSP as the outcome is significant at the required level $p<0.05$. Correspondingly, IHLD (H3: IHLD → HSP, β=0.172, (SD)= 0.061, t=2.873and p=0.004.) has positive significant impact on HSP.

While the R^2value determines the predictive power of structural model(Memon et al., 2017).The R^2value of 0.75, 0.50, and 0.25 indicates weighty, moderate, and weak predictive power of the independent variables to dependent variable (Hair et al. 2019; Henseler et al. 2009). The R^2value of the independent variable was 0.542denoting a moderate predictive power of the independent variable to describe or support dependant variable (HSP).

V. DISCUSSION ON FINDINGS

The paper has executed its objective by learning about the impact of the Healthcare Service Domain (HSD), Healthcare Transportation Domain (HTD), and Healthcare Logistics Domain (HLD) on the Healthcare System's Performance (HSP). The established hypothesis – H1, H2 and H3 show that IHTD,IHLD and IHSPhas a significant effect on the dependent variable HSP. These findings are quite akin to those (Kodali et al., 2015; Selvaraj & Sundaravaradhan, 2019), showing the quality of the healthcare system is enhanced by IoT-empowered systems. This result reflects the present state of the private Health care system in Bangladesh which suggests organizations for rapid adopting of IoT technologies. The health professionals and medical staff in private healthcare organisations frequently utilise IoT-based devices and the application lies in the service domain, transportation, and logistics. Private healthcare organisations in Bangladesh begin automating a number of practices such as tracking, data and sample collection, responsive customer helpline, location tracking, using RFID in tracking supply chain management of medical supplies and so on. Moreover, Health care professionals especially doctors are getting more involved in IoT-based smart devices by signing up through mobile apps which enlarges their contribution. However, application in

transportation is still not up to the mark due to a lackof smart vehicles, inchoate infrastructure, less educated drivers, inadequate IoT-based devices, and inflexibility (Sultana & Tamanna, 2021). Moreover, the private Health Care industry in Bangladesh has been able to sustain improved Healthcare System Performance (HSP) based on the application of IoT base technology in 3 areas -Healthcare Service Domain (HSD), Healthcare Transportation Domain (HTD) and Healthcare Logistics Domain(HLD).

	β	SD	T Value	P Value	Decision
IHSD →HSP	0.413	0.052	7.320	0.001	**Accepted**
IHTD →HSP	0.148	0.062	2.937	0.015	**Accepted**
IHLD→HSP	0.172	0.061	2.873	0.004	**Accepted**

Table 4: Results of Path analysis

VI. LIMITATIONS, FUTURERESEARCH DIRECTION AND IMPLICATIONS

This paper has several limitations. First of all, the target sample of this research paper belong to health care professionals and staff, which does not take into account customer-based data on the given subject. Therefore, the study is not able to present consumers' perception towards IoT base technology in healthcare. Therefore, future research in this area can include patients as respondents also. The paper focused mostly on the respondents of urban areas, which does not effectively represent the entire population. Further study can cover rural areas as well in future. Another dropped is the sample size which is not satisfactorily significant compared to the entire population. Hence for increasing the credibility of the research, researchers should engage more participants in researching this subject in future. Another limitation of this research is, that it is based on closed-ended questions for data collection. The problem with focusing only on close-ended questionnaires is that it provides limited scope for the respondent to share in-depth information on the related subject. Therefore, it is suggested that in the future researchers should integrate both closed-ended and open-ended questionnaires to extract crucial opinion suggestions and recommendations. The research shows the path for the researchers, healthcare professionals and governing bodies, and IT experts on the role of IoT-based services in influencing the Healthcare System's Performance (HSP). The benefit of IoT base services is quite limited inthe public healthcare sector. Policymakers should take account of this issue and formulate policies to initiate restructuring in the public healthcare industry. This paper disclosesthat IoT-based healthcare services, transportation and logistics are highly efficient in developing Healthcare System's Performance than manual system, and therefore policymakers can understand the significance of the issue and consider bringing automation into the services of the public healthcare sector.

VII. CONCLUSION

The study has found the efficiency of IoT-based technology and its applications which have a satisfying impact on Healthcare System Performance (HSP), especially in the private Health care sector. The dynamic impact ofIoT technology and IoT based system haveenthralled private healthcare organisations and healthcare professionals along with the staff working in this area. The private healthcare sector is representing Bangladesh in the fourth industrial revolution (4IR) by incorporating IoT-based technology where it is essential for every other sector to embrace the best technology to generate more output with less time and resources. The IoT technology is developing the service quality in private healthcare organisations nevertheless there are still some limitations in adopting fully fledged IoT based healthcare system for lack of resources. Insufficient infrastructure, rigid perception towards technology, lack of smart devices, limited knowledge of people etc.are a few of the chunks resisting the proliferation of IoT technologies. However, apart from these issues, the prospect of IoT-based technology in the healthcare sector is up to par. In conclusion, in the era of 4IR the implementation of IoT based technology will have an estimable impact on service performance in the diversified industries of Bangladesh.

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