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From Paper to Digital: Advancing Public Health Surveillance through ICT in Kathmandu Valley

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Abstract: ICT plays a critical role in healthcare, supporting patient records, decision-making, and public health monitoring, but its adoption in Nepal is hindered by challenges such as limited infrastructure, skilled personnel, and privacy concerns. Hence, this study aims to explore the role of IT in enhancing public health surveillance systems in Nepal, with a focus on identifying challenges, benefits, strategies, and the impact of IT to improve public health outcomes. This descriptive quantitative study involved 422 participants from healthcare professions in the Kathmandu Valley, selected using random sampling. Data was collected via paper-based questionnaires and Google Forms, followed by analysis using SPSS, with descriptive and inferential statistics to identify predictors of effective public health surveillance. Content validity was ensured through literature review and expert input, while reliability was confirmed through pretesting and a Cronbach's Alpha test. The findings reveal significant associations between socio-demographic factors and healthcare IT system-related perceptions, with all Chi-square values being highly significant (p-value = 0.0001). Key socio-demographic variables such as age, gender, educational level, profession, and years of experience influence participants' views on challenges, benefits, impacts, and strategies. Additionally, the correlation analysis shows significant positive relationships between the variables. Challenges are positively correlated with benefits, impacts, and strategies, while benefits strongly correlate with impact and strategies. In conclusion, addressing challenges in healthcare IT systems through strategies like training, collaboration, and user-friendly interfaces can enhance benefits, improve impacts, and ultimately lead to better healthcare outcomes.

Keywords: Benefits, challenges, ICT, healthcare outcomes, public health surveillance, strategies

Declaration: There is no conflict of interest, and the research was conducted as per the ethics of research conduct.

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Introduction

ICT is crucial in healthcare, supporting patient records, clinical decision-making, and evidence-based practices (Ammenwerth et al., 2004).Public health monitoring relies on ICT for evaluating health burdens and managing risks (Groseclose & Buckeridge, 2017). Despite its potential, many healthcare IT projects fail, costing significant resources (Beynon-Davies & Lloyd-Williams, 1999). Emerging technologies such as AI, big data, and IoT enhance healthcare systems, data collection, and pandemic management (Kuperman, 2011). However, in countries like Nepal, limited resources and infrastructure challenge public health surveillance, making ICT a promising solution (Shrestha, 2014). Nepal's e-government implementation faces challenges such as limited technology access, inadequate infrastructure, and a lack of skilled personnel, hindering citizen participation and transparency (Shao et al., 2023). Slow IT adoption is exacerbated by insufficient technical capacity, funding, and regulatory support (Kharel & Shakya, 2012). Data security and privacy concerns further undermine public trust, particularly in health systems. While IT holds potential to improve public health surveillance, its integration remains underexplored (Alenezi et al., 2018; Brous & Janssen, 2015; Wirtz et al., 2019). Tamilselvi et al., (2020) developed an IoT-based health surveillance system to monitor vital symptoms, but lacked detailed patient performance metrics. In Nepal, Drug Information Centers face financial challenges impacting efficiency (Shrestha et al., 2020). Acharya and Patil (2020) introduced an IoT monitoring kit but lacked data visualization features, data accuracy issues (Dhungana et al., 2019), limitations in integration and range (Trivedi & Cheeran, 2017). Kumar et al., (2017) and Gregoski et al., (2012) highlighted challenges in sensor management and continuous monitoring, indicating the need for more integrated and scalable healthcare IT solutions.

Therefore, further research is needed to assess Its role in enhancing Nepal's health surveillance systems. Research on health system frequently concentrates on the design and implementation of IT (Anderson, 1997; Jha et al., 2006; Lorenzi et al., 2008; Poon et al., 2006) but maybe not enough on the responses of clinician end users to IT that has already been put into place. Therefore, there is a critical need to investigate the role of IT in enhancing surveillance practices to effectively address public health challenges in Nepal. Hence, this study aims to explore the role of IT in enhancing public health surveillance systems in Nepal, focusing on identifying challenges, benefits, strategies, and the impact of IT on improving public health outcomes. This study offers valuable insights for public health policy and practice in Nepal. By exploring role of IT in enhancing public health surveillance, the findings can guide evidence-based decision-making and resource allocation. IT-enabled surveillance can improve disease detection, monitoring, and response, enhancing public health outcomes. Additionally, the research can aid in capacity building and inform the design and evaluation of IT solutions, contributing to a more resilient public health infrastructure in Nepal.

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Methodology

A descriptive cross-sectional quantitative study was conducted among 422 healthcare professionals working in various healthcare facilities within the Kathmandu Valley, including hospitals, clinics, and health posts. Participants were selected through random sampling method. Data collection was conducted using both paper-based and online (Google Forms) questionnaires. The research instrument exhibited strong content validity, established through a comprehensive literature review and expert evaluation, and high internal consistency, with Cronbach's alpha scores values of 0.859 for challenges items, 0.933 for benefits, 0.940 for impact, and 0.955 for strategies. Data were cleaned, coded, and analyzed in SPSS version 25. Analysis involved descriptive statistics to characterize the sample demographics and inferential statistics, including chi-square tests, correlation, and regression analyses, to identify predictors of effective public health surveillance. Ethical approval was obtained, and informed consent was secured from all participants prior to data collection.

Results

Table 1: Socio-Demographic Information

(N=422)

Socio-Demographic Characters		Frequency (N)	Percent (%)
Age (years	20-30	308	73.0
	31-40	68	16.1
	41 above	46	10.9
Gender	Male	297	70.4
	Female	125	29.6
Educational Level	Bachelor	274	64.9
	Masters	103	24.4
	PCL	45	10.7
Marital Status	Married	111	26.3
	Unmarried	311	73.7
Profession	Doctor	66	15.6
	Health Officer	106	25.1
	IT Officer	68	16.1
	Nurse	96	22.7
	Paramedics	86	20.4
Years of experience	1-5	220	52.1
	6-10	88	20.9
	11-15	81	19.2
	16 above	33	7.8

The majority of participants (73.0%) are aged 20-30 years, predominantly male (70.4%), and hold a bachelor's degree (64.9%). Most are unmarried (73.7%) and in healthcare professions, with health officers (25.1%), nurses (22.7%), and paramedics (20.4%) forming the largest groups. Over half (52.1%) have 1-5 years of experience, indicating a young, early-career, and highly educated workforce.

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Table 2: Benefits, Challenges, Impact, and Strategies for Integrating IT (N=422)

Items			SD	D	N	A	SA	Mean ± SD
Challenges	Limited access to healthcare facilities	N	38	87	141	119	37	3.07± 1.094
		%	9.0	20.6	33.4	28.2	8.8	
	Insufficient funding/ resources	N	47	29	143	143	60	3.33± 1.147
		%	11.1	6.9	33.9	33.9	14.2	
	Lack of trained personnel	N	29	55	102	187	49	3.41± 1.072
		%	6.9	13.0	24.2	44.3	11.6	
	Inadequate IT infrastructure	N	34	43	133	149	63	3.39± 1.107
		%	8.1	10.2	31.5	35.3	14.9	
	Poor data quality	N	29	57	139	86	111	3.46± 1.208
		%	6.9	13.5	32.9	20.4	26.3	
Benefits	Real-time data collection and analysis	N	39	38	120	106	119	3.54± 1.245
		%	9.2	9.0	28.4	25.1	28.2	
	Improved data accuracy and completeness	N	18	41	138	103	122	3.64± 1.123
		%	4.3	9.7	32.7	24.4	28.9	
	Enhanced disease detection and reporting	N	12	57	144	118	91	3.52± 1.060
		%	2.8	13.5	34.1	28.0	21.6	
	Faster response to public health emergencies	N	22	82	77	117	124	3.57± 1.240
		%	5.2	19.4	18.2	27.7	29.4	
	Better communication and coordination among healthcare professionals	N	22	37	131	96	136	3.68± 1.163
		%	5.2	8.8	31.0	22.7	32.2	
Impact	Improved early detection of diseases	N	37	38	165	118	64	3.32± 1.109
		%	8.8	9.0	39.1	28.0	15.2	
	Increased accuracy in disease diagnosis	N	15	56	147	151	53	3.4± 0.986
		%	3.6	13.3	34.8	35.8	12.6	
	Enhanced ability to track disease outbreaks	N	14	53	150	130	75	3.47± 1.028
		%	3.3	12.6	35.5	30.8	17.8	
	More timely reporting of diseases	N	13	52	162	135	60	3.42± 0.981
		%	3.1	12.3	38.4	32.0	14.2	
	More comprehensive reporting of diseases	N	24	35	155	154	54	3.42± 1.005
		%	5.7	8.3	36.7	36.5	12.8	
	More accurate reporting of diseases	N	14	39	182	118	69	3.45± 0.980
		%	3.3	9.2	43.1	28.0	16.4	
	Faster deployment of response measures	N	12	54	150	132	74	3.48± 1.015
		%	2.8	12.8	35.5	31.3	17.5	
	Improved coordination among healthcare agencies during emergencies	N	12	47	146	133	84	3.55± 1.021
		%	2.8	11.1	34.6	31.5	19.9	
	Enhanced ability to allocate resources effectively during emergencies	N	32	34	157	132	67	3.40± 1.084
		%	7.6	8.1	37.2	31.3	15.9	
	Increased efficiency in monitoring and evaluating public health interventions	N	25	50	150	114	83	3.43± 1.111
		%	5.9	11.8	35.5	27.0	19.7	

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Strategies	Providing training and capacity building for healthcare professionals on IT system.	N	31	24	81	87	199	3.95± 1.246
		%	7.3	5.7	19.2	20.6	47.2	
	Enhancing data security measures and ensuring compliance with privacy regulations.	N	30	23	92	151	126	3.76± 1.149
		%	7.1	5.5	21.8	35.8	29.9	
	Investing in upgrading IT infrastructure and software.	N	6	36	106	145	129	3.84± 1.002
		%	1.4	8.5	25.1	34.4	30.6	
	Encouraging collaboration and partnerships between healthcare institutions and IT companies.	N	12	18	79	159	154	4.01± 0.990
		%	2.8	4.3	18.7	37.7	36.5	
	Developing user-friendly IT interfaces and applications.	N	6	28	87	121	180	4.05± 1.013
		%	1.4	6.6	20.6	28.7	42.7	
	Establishing clear guidelines and protocols for data collection, storage, and sharing.	N	18	28	84	119	173	3.95± 1.122
		%	4.3	6.6	19.9	28.2	41.0	
	Implementing regular system audits and evaluations to ensure optimal performance.	N	15	37	100	138	132	3.79± 1.087
		%	3.6	8.8	23.7	32.7	31.3	
	Facilitating continuous feedback and communication between IT developers and end-users.	N	20	32	88	148	134	3.82± 1.107
		%	4.7	7.6	20.9	35.1	31.8	
	Promoting innovation and research in IT solutions for public health surveillance.	N	27	34	95	128	138	3.75± 1.179
		%	6.4	8.1	22.5	30.3	32.7	
	Ensuring scalability and adaptability of IT solutions to accommodate future needs and advancements.	N	20	31	96	138	137	3.81± 1.113
		%	4.7	7.3	22.7	32.7	32.5	

(Note: N=Number, %= Percent, SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree)

The data highlights key challenges, benefits, impacts, and strategies related to healthcare IT systems. **Challenges**: It include limited access to facilities (Mean = 3.07), insufficient resources (3.33), lack of trained personnel (3.41), and poor data quality (3.46). Benefits emphasize improved data accuracy (3.64) and better communication among professionals (3.68). Impacts focus on enhanced disease detection (3.47) and coordination during emergencies (3.55). Strategies such as developing user-friendly interfaces (4.05), encouraging collaboration with IT companies (4.01), and providing training (3.95) scored highly, reflecting their importance in strengthening healthcare IT systems.

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Table 3: Association between socio-demographic characteristic with benefits, challenges, impact and strategies for integrating IT

Cross Tab		Challenges	Benefits	Impact	Strategies
Age	Chi-square	258.818	175.834	297.633	320.412
	p-value	0.0001	0.0001	0.0001	0.0001
Gender	Chi-square	101.551	118.242	151.576	146.400
	p-value	0.0001	0.0001	0.0001	0.0001
Educational Level	Chi-square	147.642	155.821	237.301	275.903
	p-value	0.0001	0.0001	0.0001	0.0001
Marital Status	Chi-square	99.141	107.822	153.019	175.315
	p-value	0.0001	0.0001	0.0001	0.0001
Profession	Chi-square	389.892	435.702	462.505	550.248
	p-value	0.0001	0.0001	0.0001	0.0001
Years of Experience	Chi-square	284.874	299.085	347.106	498.898
	p-value	0.0001	0.0001	0.0001	0.0001

The cross-tabulation results reveal significant associations between socio-demographic factors and perceptions of healthcare IT challenges, benefits, impacts, and strategies. All chi-square values are highly significant (p-value = 0.0001), indicating a strong relationship between variables such as age, gender, educational level, marital status, profession, and years of experience. Notably, profession and years of experience show the highest chi-square values, suggesting they have the most substantial influence on participants' views regarding IT integration. These findings highlight the critical role that socio-demographic characteristics play in shaping attitudes towards healthcare IT systems.

Table 4: Correlation between benefits, challenges, impact and strategies for integrating IT

Correlations					
		Challenges	**Benefits**	**Impact**	**Strategies**
Challenges	Pearson Correlation	1			
	Sig. (2-tailed)				
Benefits	Pearson Correlation	0.305**	1		
	Sig. (2-tailed)	0.000			

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Impact	Pearson Correlation	0.233**	0.756**	1	
	Sig. (2-tailed)	0.000	0.000		
Strategies	Pearson Correlation	0.404**	0.712**	0.678**	1
	Sig. (2-tailed)	0.000	0.000	0.000	
**. Correlation is significant at the 0.01 level (2-tailed).					

The correlation analysis indicates significant relationships among challenges, benefits, impact, and strategies for IT integration. The Challenges variable is positively correlated with Benefits (r = 0.305), Impact (r = 0.233), and Strategies (r = 0.404), suggesting that as challenges increase, there are corresponding increases in perceived benefits, impacts, and strategies. The Benefits variable has strong positive correlations with Impact (r = 0.756) and Strategies (r = 0.712), indicating that greater benefits are closely linked to stronger impacts and more effective strategies. Similarly, Impact is positively correlated with Strategies (r = 0.678), highlighting the role of impact in shaping strategy decisions. All correlations are significant at the 0.01 level, implying a robust relationship between the variables.

Discussion

The present study identified significant obstacles such as limited access to healthcare facilities, insufficient funding, and lack of trained personnel, inadequate IT infrastructure, and poor data quality. These challenges are consistent with those reported in other studies, which highlight issues like unclear goals, poor management, inadequate skills, and insufficient training as common barriers to successful health information system implementation (Bagherian & Sattari, 2022). There are certain issues that are more unique to developing nations such as socioeconomic limitations (Sidek & Martins, 2017). Also, the shift from manual to electronic health information systems has increased burden, which has also made users reluctant to use these systems (Bagherian & Sattari, 2022; Ye, 2021).

The positive perceptions among healthcare professionals in current study regarding benefits such as real-time data collection, improved data accuracy, and enhanced communication are consistent with previous research (Aggrawal et al., 2020; Bieh et al., 2020). For instance, a study highlighted that enhancing traditional infectious disease surveillance systems with electronic tools improved the timeliness of report generation for public health personnel (Maddah et al., 2023). Participatory surveillance gives consumers all over the world complete access to a variety of data. Benefits include reduced costs, timely data collection, information gathering and exchange, platform scalability, and the potential to integrate public health services with the population being served (Neto et al., 2017).

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The present study showed that the participants recognized IT role in enhancing disease tracking and response, which is consistent with previous research highlighting the benefits of digital technologies in public health monitoring. For instance, the Centers for Disease Control and Prevention has emphasized the importance of informatics in improving public health surveillance, identifying both challenges and opportunities in this domain (Freifeld et al., 2010). However, the study also identified areas with lower consensus, such as early disease detection and resource allocation. These findings are echoed in other studies that discuss the limitations and challenges of digital surveillance, including issues related to data accuracy, infrastructure, and the need for clear legal frameworks (Donelle et al., 2023).

The findings of this study align with global research emphasizing the importance of training, collaboration, and user-friendly design in enhancing healthcare IT systems. For instance, a study on implementing medical information systems in developing countries highlights that using existing software validated in these regions can improve early results and facilitate growth, underscoring the need for adaptable and scalable IT solutions (Fraser & Blaya, 2010). Similarly, a review on digital health interventions in Nepal identifies challenges such as limited resources, inadequate infrastructure, and a lack of skilled personnel, which hinder the adoption of digital health solutions. The review suggests that addressing these challenges through strategic planning, capacity building, and policy formulation is essential for the successful implementation of digital health initiatives (Parajuli et al., 2022).

The findings underscore the significant role of socio-demographic factors in shaping perceptions of healthcare IT systems. Age, gender, educational level, profession, and years of experience all exhibit strong associations with views on challenges, benefits, impacts, and strategies related to healthcare IT. This aligns with existing literature indicating that factors such as age, income, education, and living situation can influence the use and perception of eHealth technologies (Reiners et al., 2019). The positive correlations observed between challenges, benefits, impacts, and strategies suggest an interconnectedness in how these elements are perceived. For instance, as challenges increase, there is a corresponding rise in perceived benefits, impacts, and strategies, indicating that addressing challenges may lead to enhanced benefits and more effective strategies. This interconnectedness aligns with findings from previous studies that found a need for addressing challenges to achieve successful implementation and realizing benefits (Scheibner et al., 2021). Similarly, the strong correlations between benefits, impacts, and strategies imply that improvements in one area are likely to positively influence the others. This support earlier findings that the digital divide can be classified into several stages or forms (van Deursen & Helsper, 2015).

These findings highlight the importance of considering socio-demographic characteristics when designing and implementing healthcare IT systems. Tailoring interventions to specific demographic

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groups can enhance the effectiveness and adoption of these technologies. Additionally, recognizing the interrelated nature of challenges, benefits, impacts, and strategies can inform a more holistic approach to healthcare IT development and implementation.

Conclusion

In conclusion, the findings underscore the critical role of healthcare IT systems in addressing challenges, realizing benefits, and maximizing impacts in healthcare delivery. While issues such as limited access to healthcare facilities, insufficient resources, and poor data quality remain significant challenges, the identified benefits, such as improved data accuracy and enhanced communication, highlight the potential of these systems to improve patient care. The positive impacts, including better disease detection and coordination during emergencies, further emphasize the importance of strengthening healthcare IT systems. To achieve these goals, strategies such as developing user-friendly interfaces, fostering collaboration with IT companies, and providing training are essential. Thus, addressing the challenges and implementing the proposed strategies will enhance the effectiveness and efficiency of healthcare IT systems, ultimately contributing to better healthcare outcomes.

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