Critical Success Factors to Control Nosocomial Infection by “Wireless Sensor Network” in Intensive Care Unit

Fahimeh Zerganipour1, Sima Ajami2*, Saede Ketabi3 and Ali Samimi2

1Health Information Technology, Medical Records Department, Golestan Hospital, Alley Golestan, Farvaridan Street, Ahvaz, Iran
2Department of Management & Health Information Technology, School of Medical Management and Information Sciences, Isfahan University of Medical Sciences, Isfahan, Iran
3Associate Professor, Department of Management, Faculty of Administrative Sciences and Economics, University of Isfahan, Isfahan, Iran

Abstract

New information technologies (IT) can be effective in the prevention, identification, and reduction of transmission of nosocomial infection and consequently decreasing time and additional costs in the hospital. Among these technologies, wireless sensor network (WSN) is able to simultaneously cover the activities of data management, infection source identification and tracking, warning, and preventing infection transmission. For acceptance and successful implementation of WSN-based project in the hospital, identifying and paying attention to the indexes and critical success factors by IT managers and officials of care organization and the hospital is required that acceptance and implementation of the technology does not face failure and paying high costs. Hence, the aim of this study was to identify critical success factors of accepting infection diagnosis by wireless sensor network in the hospital that helps healthcare managers and staff to adopt and facilitate the WSN technology acceptance process at health care centers. This study was narrative review, which search was conducted with the help of libraries, books, conference proceedings, through databases of Science Direct, PubMed, Proquest, Springer, and SID (Scientific Information Database). We employed the following keywords and their combinations; Wireless Sensor Networks, Critical Success Factors, Nosocomial, and Hospital. The preliminary search resulted in 150 articles, which were published between 2003 and 2015. After a careful analysis of the content of each paper, a total of 43 sources was selected based on their relevancy.

Keywords: Wireless sensor network; Critical success factors; Nosocomial; Hospital

Introduction

The word of “Nosocomial” has been derived from two Greek words “Nosos” meaning disease and “Komeion” meaning care; and refers to infections acquired in the hospital or other care centers that may occur inside the hospital or after hospital discharge. Infection means a phenomenon that due to invasion and growth and proliferation of infectious pathogen, the host is damaged; and meanwhile, nosocomial infection is an infection caused on a limited or released way and due to the pathogenic reactions related to the infectious agent or its toxins in the hospital provided:

1. Caused 48 to 72 hours after patient admission in the hospital;
2. At the time of admission, people shouldn't have obvious signs related to infection and the disease shouldn't be at its incubation period [1].

Investigations of World Health Organization around the world show that 5- 25% of hospitalized patients in the hospitals catch nosocomial infections that this rate in the intensive care unit (ICU) is 25% in developed countries and up to 50% in developing countries [2]. In Iran, the prevalence of nosocomial infections in special sections is high and up to 20%. The prevalence of these infections in intensive care infection (ICU) patients are 5 to 10 times general section patients [3]. Due to the nature of patients required hospitalization in ICU department and in terms of being weak, worsening the condition and being susceptible, they need more attention, monitoring and caring to prevent catching nosocomial infection.

Controlling nosocomial infection is necessary for patients and health care providers, both, that the planning needs use modern technology in health care. With further development of these technologies, the necessity of applying computers to meet the needs is felt more day after day in society. Recent development in reducing costs and miniaturizing the computing devices, and also using wireless communication technology and sensors simplifies human daily life. Sensor networks will be one of the critical technologies in future [4]. WSN is an appropriate option for places at which using wired receivers is expensive and difficult. These networks can be applied for the following purposes:

1. Controlling the region (for example existence of petrol or gas pipeline);
2. Controlling air pollution;
3. Forest fire detection;
4. Controlling greenhouse gases;
5. Landslide detection;
6. Controlling the health of the devices in the industrial sector;
7. Water and wastewater monitoring;
8. Microclimate assessment;
9. Monitoring animal populations;
10. Defense system;
11. Monitoring business and controlling work space;

*Corresponding author: Sima Ajami, Professor, Department of Management & Health Information Technology, School of Medical Management and Information Sciences, Isfahan University of Medical Sciences, Isfahan, Iran, Tel: +98-31-36884799; E-mail: ajami@mng.mui.ac.ir

Received March 01, 2016; Accepted March 03, 2016; Published March 25, 2016

Citation: Zerganipour F, Ajami S, Ketabi S, Samimi A (2016) Critical Success Factors to Control Nosocomial Infection by “Wireless Sensor Network” in Intensive Care Unit. J Inform Tech Softw Eng 6: 173. doi:10.4173/2165-7866.1000173

Copyright: © 2016 Zerganipour F, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
installing the sensors on patients’ body for controlling their vital signs, when patients are required to be controlled for a long time, and guiding patients for medicine consumption by sensors embedded in the drug package that when a patient takes the drug by mistake, the sensors will create warning messages. Among these networks’ applications for health care are systems of care for patients with disabilities who aren’t taken care of, smart environment for the elderly, communication network between physicians with each other and other hospital staff, and patients’ surveillance [5]. The ability of organizations for competition depends on their ability for applying smart technologies; therefore it is necessary that health system policy makers and managers are aware of issues relating to successful modern technology implementation so that they can equip their organizations to such technologies in this competitive world [6]. In order to prevent and control nosocomial infection, applying WSN can be helpful; since these networks are able to communicate with each other and with external networks via the internet or satellite, their application in health promotion like patient monitoring, diagnosis, prescribing and dispensing the drug in the hospitals, remote monitoring physiological data and particularly identifying and controlling nosocomial infection can be highly effective [7].

Health care providers should identify critical success factors (CSFs) of designing, implementing and developing these sensor networks in order to identify the same requirements of receiving and monitoring immediately. In order to manage sensor networks efficiently, several models have been presented and designed by organizations [8]. CSFs include necessary activities which should be formed well to achieve assignment and goals as well. There are significant issues that are considered at the time of implementing the projects with a focus on technology that while they center on real necessities, they cause to be possible members’ coordination in maintaining direction toward defining goals [9]. Lack of attention to CSFs in WSN can lead to unsuccessful implementation of this technology, waste of money and time, users’ resistance against acceptance and usage of this technology; therefore, the aim of this study was to identify critical success factors of accepting the technology of infection detection by wireless sensor network in the hospital that helps healthcare managers and staff to adopt and facilitate the WSN technology acceptance process at health care centers.

Methodology

This study was narrative review, which was conducted with the help of libraries, books, conference proceedings, and databases of Science Direct, PubMed, Proquest, Springer, and SID (Scientific Information Database). In our searches, we employed the following keywords and their combinations; Wireless Sensor Networks, Critical Success Factors, Nosocomial, and Hospital. The preliminary search resulted in 150 articles, which were published between 2003 and 2015. After a careful analysis of the content of each paper, a total of 43 sources were selected based on their relevancy.

Results

Revolution of network concepts and unprecedented interlacement of technical challenges cause wireless sensor networks to be one of the largest research interests of 21st century. Anyway, only recently such systems have emerged as the product in the market [10]. Critical success factors in implementing this technology, particularly depend on the assignment and strategic purposes of the project. While the assignment and goals focus on the general purpose and what should ultimately be achieved, critical success factors focus on the most important areas and address what should be achieved and how to achieve. Also, although there is no certain limitation, but confirming the number of these limiting factors is helpful. This helps to maintain those factors’ effectiveness and focus in providing the correct direction and prioritization than other components constituting project strategy [9]. Tables 1 and 2 compare the features of WSN technology with two other technologies of Radio Frequency Identification (RFID) and Mobile ad-hoc Network (MANET) [11,12]. Table 3 shows a summary of reports of different researches on critical success main factors and sub factors in the acceptance of WSN in the hospital [9,13–40].

Discussion

Effective criteria and sub criteria regarding prioritizing critical success factors of accepting WSN technology in hospitals in Iran into four main categories of organizational issues, technological factors, environmental factors and human factors along with 19 sub criteria of organizational process, needs assessment, top manager support, budget, cost- effectiveness, information volume and organization size, infrastructure, data, performance evaluation, cost, unique characters, stability, wearable, power management, vendors support, government support, competition, training, and technical knowledge were identified.

Ajami et al. in their study, identified effective criteria and sub criteria regarding prioritizing critical success factors of accepting RFID technology in hospitals in Iran into four main categories of

| Technology | Purpose | Component | Protocols | Communication | Mobility | Programmability | Price | Deployment |
|------------|---------|-----------|-----------|---------------|----------|-----------------|-------|------------|
| WSN | Sense interested parameters in environments and attached objects | Sensor nodes, relay nodes, sinks | Zigbee, Wi-Fi | Multi-hub | Sensor nodes are usually static | Programmable | Sensor node — medium | Random or fixed |
| RFID | Detect presence and location of tagged objects | Tags, readers | RFID standard | Single-hub | Tags move with attached objects | Usually closed systems | Reader-expensive Tag-cheap | Fixed |

Table 1: Comparison of WSN with RFID.
Table 2: WSN compared with Mobile ad-hoc Networks (MANET).

| Attribute | MANET | WSN |
|-----------|-------|-----|
| Single-hub | Portable Router | Normally No | Normally No |
| Multi-hub | Fixed | Yes | Commonly Yes |
| MANET | | Limited | Low |
| COST | | Low | Very High |

Table 3: Critical success main factors and sub factors of acceptance of WSN in the hospital.

organizational issues, technological factors, environmental factors and human factors along with 17 sub criteria of needs assessment, top manager support, budget, cost- effectiveness, information volume, infrastructure, comparative advantage, compatibility, cost, vendors support, government support, competition, state rules and standards, technical knowledge, training, readiness and acceptance, and trust that
is consistent with critical factors of this study [13].

Hussain- M in his study, obtained four main criteria like systematic field, organizational fields, individual field, and behavioral purpose of application with ten critical and sub criteria such as perceived usefulness, perceived ease of use, attitude, self-efficacy, training, management support, organized conditions, system reliability, information quality, and quality of providing services [24].

Ajami et al. in their study, stated that government support and staff readiness and acceptance can lead to acceptance of RFID technology, which are similar to the criteria identified in this study. Yan et al. in a study, considered a strategy to solve ETBGi problems that this strategy has proposed a combination of factors to select an analytic hierarchy process-based cluster head. This method not only uses the general weight of four criteria, including remaining energy, the number of adjacent nodes, mean distance to adjacent nodes, and distance to line slop center, but also optimizes mathematical method of determination of weight coefficients to reduce the effect of human factors, and causes that selected nodes are adequately optimized to be applied as cluster head. The results of simulation, in this study, have shown that selected cluster heads have scattered more correctly, so that the network lifetime becomes longer and the proposed pattern is more suitable for larger scale of sensor networks [28].

Nejad et al. in the study, have classified smart network advantages resulting from development in 6 critical areas such as: technical (with sub criteria of variable heterogeneous spectral characteristics in time and place, reliability and latency requirements, harsh environmental conditions and limitation of low power sensor nodes energy), economy (low cost, rapid deployment, flexibility, intelligence of collecting), efficiency, environment, security and safety [19].

Otero et al. in a research have provided the possibility of selecting the best kind of wireless sensor networks for decision makers through paired comparative matrix between selected criteria like: deployment cost, network connectivity, network coverage and network lifetime [22].

AL-Hawari et al. in their research have made a purposive selection of the best temperature sensor among alternative sensors in special industrial supplies. The underlying pattern of decision making has been based on AHP method that has graded temperature sensors in terms of various features, according to various levels obtained from independent assessment of four main criteria: static criteria (along with sub criteria: maximum operating temperature, minimum operating temperature, temperature curve, maximum sensitivity area, self- heating factors, long- term accuracy and stability, local temperature coefficient, wires development, setting up long wiring from the sensors, measurement factor and measuring the temperature), dynamic characteristics (along with sub criteria: electronic simulation requirement, local output levels in centigrade and quick time stability of local temperature), environmental criteria (along with sub criteria: small local size, sound safety, features of fragility- durability, environment with high temperature dip and resistance to erosion) and other criteria (along with sub criteria: measurement point or area, industrial variance, standards of Network Information Security and Technology(NIST) news, and cost). Paired comparisons were done based on specialized reviews in each area [27].

Na et al. in the research have prioritized WSN models presented by the different designers that among presents models, the model presented by Escenauer et al. about which the criteria of scalability, key connectivity, flexibility, excess storage, excess processing, and excess communication have been weighed, has had the highest priority [30].

Jang et al. in a study titled have stated issues and practical challenges which should be got noticed in designing and implementing WSNs in the building; these factors include: 1- cost, 2- reliability which is composed of elements such as accuracy, signal coverage throughout the building, user interface, secrecy, fault tolerance, Received Signal Strength Indication (RSSI), Link Quality Indication (LQI), and Packet Error Rate., 3- power management, 4- interoperability, 5- ease of use and maintenance, and 6- network security [23].

Christine et al. in a study have stated security, quality of service (QoS) and network configuration as challenges facing sensor nodes [17].

In the study conducted by Azimi et al. with the title of "A New Model to Identify and Evaluate Critical Success Factors in the IT Projects; Case Study: Using RFID Technology in Iranian Fuel Distribution System" in 2008 – 2009, critical success factors have been prioritized by the help of the AHP in 6 classes that the most important priority of these factors are in order: Support from senior management, Hardware infrastructure, Technology sanction, Pilot projects, beneficiary’s participation, and data management [9].

Neves et al. in their study have considered different matrices for WSNs evaluation like: network lifetime, coverage, cost and ease of deployment, response time, time precision, security, and effective sample rate, that many of these matrices are linked together [32].

Generally, criteria identified in mentioned studies have many similarities with the criteria identified in the present study, but criteria prioritization is significantly different in various studies, that in each country, in hospitals, these factors should be getting noticed based on priority importance in order to facilitate acceptance and implementation of the technology.

In various studies, different criteria were identified as critical success factors of WSN technology acceptance in the hospital. These criteria are generally subjective factors; in different studies, obvious differences are observed between prioritization and mentioned criteria weight that this makes clear the necessity of utilizing systematic and multi-criteria decision making patterns more than ever; methods by which decision makers can identify certain prioritization of factors by weighting various criteria [41]. AHP is one of multi- criteria the decision making processes which lead to consideration of subjective factors in the decision making process as objective factors [42].

Conclusion

Hospitals could reduce nosocomial infections by using new technology, such as WSN which alarms for patient’s wound or bed infected, schedules filter changes, reports observing in front of hand-washing areas to make sure employees spend enough time at the sink, monitors and warns staff to observe healthcare regulations. The technology can serve as an extra reminder, especially because even the most thorough infection-prevention guidelines are only as good as the people who are supposed to follow them. Successful acceptance and implementation of WSN technology- based projects in hospital, requires identification and paying attention to indicators and critical factors especially at the time of formulating relevant strategies by IT managers and officials of the care organization and target hospital so that deployment and acceptance of the technology do not face failure and high cost because the criteria, which have been considered as critical success factors in various studies, have obvious differences, that result from organizational, environmental and economic conditions.
Support and Source of Funds

This article resulted from part of research project number 393204 funded by the vice chancellor for research of the School of Medical Management and Information Sciences, Isfahan University of Medical Sciences, Iran as a master sciences thesis.

References

1. Alzahra hospital. Nosocomial Infection.
2. Ghorbani Birgani A, Asadpour S (2011) Nosocomial Infections in Intensive Care Unite of Ahwaz Arya Hospital (2008-2009). Modern Care J 8: 86-93.
3. Ghasvandian Sh (2012) Nosocomial infection in the Intensive Care Unit. J of HAYAT 8: 27-34.
4. Sadoughi F, Samadibeyk M, Eshtehadi A, Amin pour F, Rezaeihachchesop P (2011) Health Information Technology. Tehran: Jafar: 38: 90-93.
5. Ee CT, Krishnan NV, Kohli S (2003) Efficient Broadcasts in Sensor Networks. Unpublished Class Project Report, UCBerkeley, Berkeley, CA.
6. Sadoghi F, Sheikh-Taheri A, Meidani Z, Shahmorady I (2010) Management Information System. Tehran: Jafari 10-25.
7. Ajami S, Zerganipour (2016) Nosocomial Control by Wireless Sensor Network in Intensive Care Unit. Journal of Research in Medical Sciences.
8. Wu X, Cho J, d'Auriol BJ, Lee S (2007) Self-deployment of Mobile Nodes in Hybrid SensorNetworks by AHP. UIC, Springer Berlin Heidelberg.
9. Azimi A, Manesh FS (2012) A New Model to Identify and Evaluate Critical Success Factors in the IT Projects; Case Study: Using RFID Technology in Iranian Fuel Distribution System”. International Journal of Information Science and Management (IJISM) 99-112.
10. Lee Y, Kozar K, Larsen K (2003) The Technology Acceptance Model: Past, Present, and Future. Communications of the Association for Information Systems 12: 751-781.
11. Liu H, Bolic M, Nayak A,Stojmenovi I (2008) Integration of RFID and Wireless Sensor Networks. University of Ottawa, Canada.
12. Wireless Sensor Network, Pandemic computing infrastructure about the future of the market managerial review.
13. Ajami S, Karbalaei-eidi-shahabadi N, Ketabi S (2015) Critical Success Factors in Adoption Radio Frequency Identification (RFID) in Hospital. The National Medical Journal of India.
14. Dadashi A, Askari Moghadam R, Nazemi E, Vahidtd D, Pour Kiani F (2013) Ranking of factors that influence the adoption of e-procurement in the organization case study methodology and techniques AHP railway company IRI. Proceedings Journal technological development 9: 3-74.
15. Ehsani A, Moshabakhi A, Hadzadze M (2012) Identification of Key Capabilities for Effective Implementation of Knowledge Management in Hospitals with Structural Equation Modeling Approach. Health Management 15: 58-68.
16. Yaseen SG, Al Omoush KHS (2009) The Critical Success Factors of Web-based Supply Chain Collaboration Adoption: An Empirical Study. Al-Zaytoonh University of Jordan, Jordan, IGI.
17. Christin D, Reinhardt A, Mogre PS, Steinmetz R. Wireless Sensor Networks and the Internet of Things: Selected Challenges. Multimedia Communications Lab, Technische Universit at Darmstadt.
18. Finney Sh, Corbett M (2007) ERP Implementation: a compilation and analysis of critical success factors. Business Process Management Journal 13: 329-347.
19. Jafari nezhad A, Dorostan M, Mazini R (2013) Routing benefits of cognitive sensor networks for Smart grid communications infrastructure hierarchy. 28TH International power system conference 2013, Tehran, Iran: Faculty of Engineering, Department of Electrical Engineering International University of Imam Reza.
20. Gghazani SHHN, Lotf JJ (2012) Using Fuzzy Network Method to Analysis the Performance of Wireless Sensor Networks. J Basic Appl Sci Res 2: 396-405.
21. Atae A, Aghaei F (2011) Wearable Wireless Sensor Network Solutions and Implant for Health Monitoring. Paper presented at The First International Congress on Health Information Technology Application, Mazandaran, Iran: Mazandaran University of Medical Sciences.
22. Otero C, Kostanic I, Otero L, Meredith S, Whitt M (2011) Analysis of Wireless sensor networks deployments using vertical variance trimming and the Analytical Hierarchy Process. IJASUC 2: 169-190.
23. Jang WS, Healy WM (2009) Assessment of Performance Metrics for Use of WSNs in Buildings. 28th International Symposium on Automation and Robotics in Construction, Information and Computational Technology.
24. Hussain MN, Subramoniam S (2014) Ranking Critical Success Factors of Healthcare Management Information Systems using AHP. ISAHP 1-16.
25. Darwish A, Hassien AE (2011) Wearable and Implantable wireless sensor network solution for health care monitoring. Sensors 11: 5561-5595.
26. Sabbab E, Majeed A, Kang KD, Liu K, Abu-Ghazaleh N (2008) An Application-Driven Perspective on Wireless Sensor Network Security. ACMUSA: New York.
27. Al-Hawari T, Al-Boul S, Momani A (2011) Selection of Temperature Measuring Sensors Using the Analytic Hierarchy Process. JUMIE S: 451-459.
28. Yan XF, Zhang YK, Tang HL, Li SN (2013) An ETBG Optimization Algorithm Based on Analytic Hierarchy Process in WSN. Proceedings of the 2nd International Conference on Computer Science and Electronics Engineering (ICCSCE 2013); Zhengzhou, China.
29. Bastam M, Ramazanpourgyyduh A, Ramazannzechadhsz (2011) Providing intelligent health monitoring system based on wireless sensor network. Paper presented at The First International Congress on Health Information Technology Application, Iran.
30. Na R, Ren Y, Hori Y, Sakurui K (2011) Analytical Hierarchy Process aided Key Management Schemes Evaluation in Wireless Sensor Network: work in progress. Paper presented at fifth International Conference on Ubiquitous Information Management and communication (ICIUMC) Seoul, Korea.
31. Amanick SM, Ansarinejad A, Ansarinejad S, Mir Nargesi S (2010) A Group Decision Making Approach for Evaluation of ERP Critical Success Factors Using Fuzzy AHP. EMS 44: 195-212.
32. Neves P, Stachyra M, Rodrigues J (2008) Application of Wireless Sensor Networks to Healthcare Promotion. Journal of Communications Software and Systems 4: 181-190.
33. Ashraf MI, Harkonen M, Hamalainen M, Riekki J (2007) Health Care Process Management Supported by Wireless Technology.
34. Ajami S, Carter MW (2013) The Advantages and Disadvantages of Radio Frequency Identification (RFID) in Health-care Centers; Approach in Emergency Room (ER). Pak J Med Sci 29: 443-448.
35. Aggestam L, Durst S, Persson A (2015) Critical Success Factors in Capturing Knowledge for Retention in IT-Supported Repositories. Information S: 558-569.
36. Hung SY, Hung WH, Tkai CA, Jiang SC (2010) Critical factors of hospital adoption on CRM system: Organizational and information system perspectives. Decision Support Systems 48: 592-603.
37. Leimeister JM, Knebel U, Krcmar H (2007) RFID as enabler for the boundless real-time organisation: empirical insights from Germany. Int J Networking and Virtual Organisations 4.
38. Vanany I, Shaharoun ABM (2011) Barriers and critical success factors towards RFID technology adoption in South-East Asian Healthcare Industry. Proceedings of the 9th Asia Pacific Industrial Engineering & Management Systems Conference, Bali, Indonesia.
39. Lee K, Joki S, Bae M (2015) Identification of Critical Success Factors(CSF) and their Relative Importance for Web-based Information Systems Development. IGI.
40. Park G (2008) Suggesting an infection causes monitoring system based on wireless sensor network for hospital infection control [Thesis]. School of IT business information and communications: Univ. of Korea advanced institute of science and technology.
41. Ketabi S, Hagh-shenans A, Dalvi MR (2007) Performance evaluation using balanced scorecard through analytic hierarchy process. Management Knowledge 20: 21-46.
42. Ajami S, Ketabi S (2012) Performance evaluation of medical records departments by analytical hierarchy process (AHP) approach in the selected hospitals in Irfan: medical records dep. & AHP. Journal of Medical Systems 36: 1165-71.