Surgical Instrument Tracking and Maintenance System for the University Hospital KDU

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Abstract**:** *Lack of attention to the correct use of surgical instruments leads to errors in practice and especially difficult control losses. The present research aims to effectively use a surgical instrument tracking and maintenance system at University Hospital KDU in Sri Lanka. The features required to develop a system for the institution were identified by studying the existing literature about traceability systems. We decided to use QR code technology to detect and find the location of an individual surgical instrument. While securing the main purpose of the health and safety of patients, the system would increase labor efficiency and lessen worker responsibility, even though statistically significant data have not yet been discovered. The paper also demonstrates the benefits of using a surgical instrument tracking and maintenance system in a hospital's Central Sterile Supply Department. The outcomes of this study will be used for future implementation purposes of the system.*

Keywords: *QR code, instrument tracking system, medical equipment management system*

1. Introduction

University Hospital KDU (Kotelawala Defence University) is located in Werahara, Sri Lanka. The 814-bed hospital is equipped with cutting-edge technology and ultramodern facilities to offer round-the-clock emergency and trauma care as well as specialist treatment of diseases from all medical specialties, including surgery, pediatrics, obstetrics, and gynecology. The hospital contains twenty operating rooms, and the Hybrid Theatre stands out among them due to its new medical treatment approach and the fact that it is the first of its kind in Sri Lanka. Other theaters are likewise specialty theaters built to ISO level 5 specifications. The hospital's Intensive Care Unit is a sizable facility with 70 beds and private rooms for each patient.

Central Sterile Supply Department (CSSD) is the heart of the hospital, it is the place where they decontaminate, inspect, repair, recycle, and sterilize used instruments thereafter providing rapid, efficient, and low-cost maintenance and repacking of used instruments for reuse at the hospital. The records of the sterilization procedure and equipment maintenance must be monitored and controlled by a manual or automated information system at the CSSD.

Tracking is defined as the ability to track and identify surgical equipment and its usage based on previously recorded information. With the increase in surgical case volume, the hospital sees the need of implementing an automated tracking and maintenance system at the CSSD. By combining technology with quality procedures, the automated system would overcome any faulty or misplacement of instruments. Thereby allowing fast information retrieval and an increase in productivity.

An automated tracking and maintenance system would provide a multitude of functions and benefits, such as reducing human error, tracing instruments (identifying frequency of use, sterilization, repair, storage, product history, etc), identifying patients or procedures, and avoiding scheduling conflicts, identifying instruments that may or may not have been purchased, and having a streamlined workflow.

The CSSD's workflow consists of retrieving, sorting, washing/decontamination, assembling, sterilizing, supplying, and storage. These operations, which involve instruments moving back and forth between various units of the institution and CSSD, are ideal for implementing the system; data capture can offer the following information:

- To which unit the instruments were sent
- By whom the instruments were received and who handed over
- Which instruments are in each set
- Frequency of instrument usage
- Which instruments were broken
- Which instruments were lost

This paper is structured as follows: section two will discuss the existing literature on instrument tracking and maintenance systems; section three describes the methodology and development approaches; its results are given in section four. Discussion remarks are given in section five. Finally, the conclusion is in section six.

2. Literature Review

The review of this literature comes from many sources. This review will primarily focus on the various technologies used to identify medical instruments and the methods used in tracking and maintaining them throughout the sterilization process. The review will provide a good representation of the effective methods utilized by hospitals in handling medical equipment.

All the researchers considered in this literature used some sort of unique identification method for the surgical instruments. (Chu, Lee and Wu, 2012) and (Núñez and Castro, 2011) use QR does identify the instruments uniquely. In Goodali's invention Scanners at each checkpoint will scan the personalized code on each piece of surgical equipment. An alarm is raised if any of the equipment fails to go through the scanning process. (McCay et al., 2009) uses laser-embedded

optically scannable code to identify the instruments. (Fuchs, Hebestreit and Tummler, no date) and (Shipp, 1994) identify each piece of equipment, using a barcode, which consists of alphanumeric characters arranged in a 2-dimensional matrix. The authors' Chu, Nunez, and McCay emphasize the need for adopting mobile portable devices to boost the system's portability and eliminate the need for engineers to leave the repair site to look for information. Further, the authors go on to discuss safety, including how to use personal technologies safely in hospitals and how to handle information safely. The authors, Nunez and Castro also indicate that they use authorization mechanisms such as passwords to grant access to the system to relevant personnel.

There were many other special features found in the research. Goodali's invention entails having an alert system at several checkpoints, such as before surgery, from the nurse to the doctor, after surgery, from the sterilization facility back to surgery, inventory, and then back to the nurse, and so on. Fuch's invention contains several unique features. One is that the system keeps track of how long each piece of equipment is held at a particular transit station. If a station's time is exceeded, it is informed. In addition, the system has saved the production date of each unit so that it can track the unit's age and be notified when it needs to be serviced. The system would also keep track of the weight of the units as they passed through each station, ensuring that they were of the correct composition. Kost and Fry's invention allows searches to be performed based on this last touch criteria to identify instruments that may have been misplaced or need to be cycled. Each instrument's record includes a photograph of it. The technique also helps with comparing instrument counts before and after operation to ensure that all instruments are present. Shipp's invention has a unique characteristic in that it sends acknowledgment when a certain instrument reaches a specific transition. This makes it easier to locate the equipment.

3. Methodology

According to the study of existing literature, the features that need to be in the system were identified. The surgical instruments at UHKDU had already embedded QR codes. Thus, with the available features, the rest of the system was designed. The system will enable the traceability and control of all sterilization process stages using QR code technology.

Figure 1. An instrument having an embedded QR code

The creation of the product and CSSD staff database would require the longest time. Some instruments will be sent as a set and some will be sent as individual instruments. Figure 2 shows how the data will be stored when the instruments are stored as a set (Major basic set for general surgery, minor basic set for general surgery, hernia and appendix set, orthopedic major basic set, etc.). Each instrument will be stored in a container as shown in Figure 3, which could also have a unique QR code.

Name of the item	Amount	Item identification number
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Figure 2. Instrument Set Database

Figure 3. Instrument Sets stored in containers

The next stage would be to design the system. Figure 4 displays the schematic of the system. Using the information stored on the QR codes, the web application is used to generate services related to tracking and maintenance of surgical equipment.

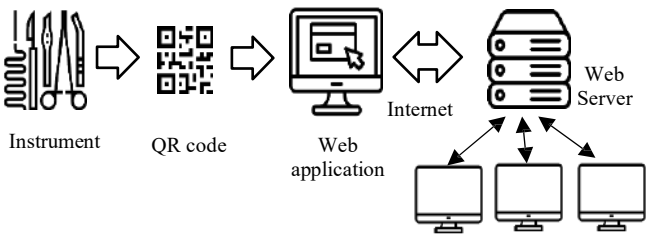

Figure 4. Schematic of the system

4. Results

CSSD is in charge of preparing instrumentation carts for surgeries according to the daily schedule. An authorized nurse at the CSSD can access the system. Some instruments will be sent as sets and some as individual pieces. Each barcode on a container (box carrying a set of instruments) must be scanned separately. Once the case's QR code is scanned, a list of the case's contents is displayed on the

computer screen. The nurse should then scan each instrument individually with a scanner. As a result, the nurse inspects and assembles it. Images and notifications already entered into the database now appear. If the count of instruments in that particular set is correct, the verification button is pressed. After that, a batch number is generated, and the cleaning cycle begins as usual. Then an automatic report is generated with the packing date, the nurse in charge at CSSD for assembly, the number of pieces, and the nurse receiving the package. The system generates a unique case number at this point, which is used to identify the instrument set and track the entire procedure in the administration module. The surgical instruments are then released for the surgical procedure. When the dirty equipment is returned to the CSSD, the case is closed. When a set is returned, again the same procedure is repeated to check the count of the individual pieces. Similarly, an automatic report is generated with the return date, the nurse in charge at CSSD for receiving dirty instruments, the number of pieces, and the nurse who handed over the package. The system implementation is explained in Figure 5.

5. Discussion

Nowadays, the benefits of using automatic identification technologies, such as QR codes, for improving patient safety have been established. However, the success of these technology projects depends on the understanding of thorough planning for the management of requirements, risks, and obstacles to implementation.

The present study demonstrates that, despite the fact that unique identifying codes are embedded into some surgical instruments, the technology has not been utilized at UHKDU. It is a major concern because there is no planning for restructuring and prioritizing these procedures. The majority of hospital employees oppose changes in workflow, which leads to a lack of awareness of new technologies.

A key difficulty in justifying and using technology in the institution is employee training. People can be trained to increase their awareness, acceptance, and proper use of technology, both in terms of benefits and utilization. As a result, training end-users can aid in the adoption of process modifications and lead to higher efficiency in the new processes. Users who have been properly trained can also help to eliminate errors.

Another critical consideration is the type of instrument identification. Various optically scannable identification methods (such as barcodes, QR codes, and so on) were discovered to be utilized in the existing literature. The identifying type must be carefully chosen. In our research, however, we preferred using QR codes because most equipment at UHKDU already had the code affixed.

6. Conclusion

We found that the most significant challenges to the successful implementation of the QR code system were a lack of expertise and understanding of the infrastructure, as well as insufficient staff training and funding for training.

Recommendations:

Managers and hospital directors should prioritize employing this technology more effectively by explaining the benefit of using QR codes and the return on investment or costs of this technology to them.

It is advised that all medical staff who work with QR codes be ready for its consumption. Employee training is necessary to ensure performance at a level that is acceptable and appropriate. Additionally, it is safer if the QR code system is thoroughly tested in a much smaller space, such as a single clinical department, before being introduced into all hospital processes.

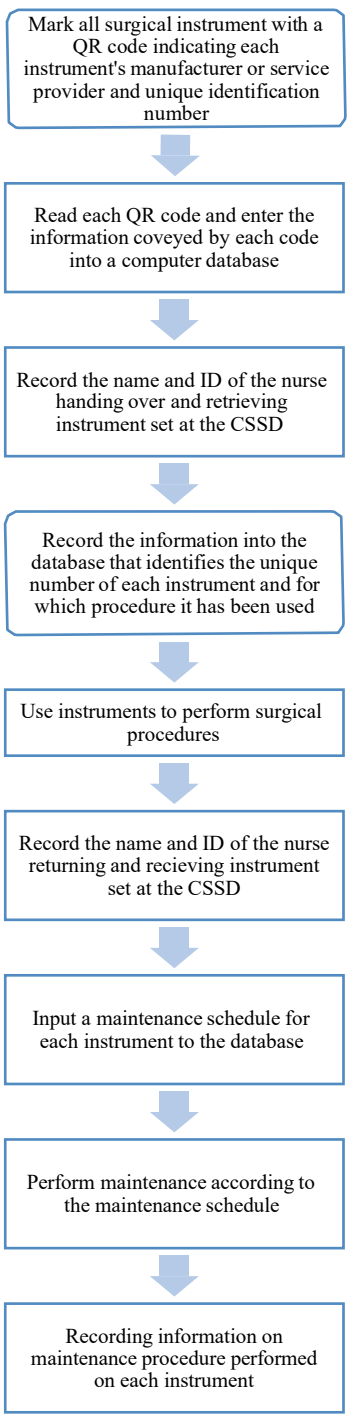

Figure 5. System implementation

7. Future Work

The benefits of having an automated tracking and maintenance system for the hospital's CSSD are presented in the study. It is a progressive and complete procedure that requires time and adjustment even after it has been implemented. The involvement of the CSSD nursing staff will be critical throughout future implementation. Based on the findings and design of this study, future work will entail the development of an efficient and effective web-based surgical instrument tracking and maintenance system. In the future, anyone with an interest in this topic can use the tools and procedures indicated as appropriate by this study.

References

C. Ochiai, "RFID and barcode based management of surgical instruments in a theatre sterile supply unit," *GS1 Healthc. Ref. B. 2009/2010*, pp. 32–35, 2009.

E. Keseler, "The hospital logistics of designing the central sterile processing department," no. June, 2019, [Online]. Available: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2623993.

A. Findik, O. Pinarer, and S. Turhan, "Laser Barcode-based Surgical Instrument Tracking System," 2020.

D. Mutia, J. Kihiu, and S. Maranga, "Maintenance Management of Medical Equipment in Hospitals," vol. 2, no. 3, 2012, [Online]. Available: www.iiste.org.

A. Goodali, "Safety surgical sterilization tool and system," 2003.

G. White, R. Kummerlen, C. Ray, R. Stavely, R. Hill, and M. Zakrewski, "Security Infusion Pump with Barcode Reader," *Mult. Scler.*, vol. 10, no. July, pp. 2002–2002, 2002.

J. I. Shipp, "Surgical instrument recycling and tracking system," 1994.

W. J. F. Karen L. Kost, "Back to results surgical instrument inventory database management system; Surgical instrument inventory database management system."

W. Fuchs, K. Hebestreit, and H.-P. Tummler, "Process and device for the monitoring and control of the flow of material in a hospital."

C. Núñez and D. Castro, "Management information system of medical equipment using mobile devices," in *Journal of Physics: Conference Series*, 2011, vol. 313, no. 1, doi: 10.1088/1742-6596/313/1/012003.

F. D. O. e S. Martins and M. L. L. Ribeiro, "Implantação e uso de sistema de rastreabilidade automatizado em central de materiais e esterilização," *Rev. SOBECC*, vol. 22, no. 1, pp. 52–58, 2017, doi: 10.5327/z1414-4425201700010009.

McCay, T.Dwayne, Hopkins, A John, Bible, John Brice, Schwartz, Frederick A Dahotre, Narendra B, and C. M. Sharp, "Method for marking, tracking, and managing hospital instruments."

M. Chakravarthy and K. Naagaraj, "Implementing QR Code Technology in Medical Device Pacakage," 2009.

L. C. Chu, C. L. Lee, and C. J. Wu, "Applying QR code technology to facilitate hospital medical equipment repair management," in *Proceedings - 2012 International Conference on Control Engineering and Communication Technology, ICCECT 2012*, 2012, pp. 856–859, doi: 10.1109/ICCECT.2012.31.

"Partners in traceability of instrument sets."

D. Swenson, "Designing and developing a Central Sterile Supply Department," *Biomed. Instrum. Technol.*, vol. 47, no. 3, pp. 259–265, 2013, doi: 10.2345/0899-8205-47.3.259.

Hachesu, P. R., Zyaei, L. and Hassankhani, H. (2016) 'Recommendations for using barcode in hospital process', *Acta Informatica Medica*, 24(3), pp. 206–210. doi: 10.5455/aim.2016.24.206-210.

Bimsara, Y. and Gunathilake, W. (2020) 'Review on Blockchain and Multi-Agent Technologies in Clinical Records Maintaining and Transferring', p. 54.

Insideaccess.lk. 2022. *Inside Access*. [online] Available at: <https://www.insideaccess.lk/detail/view/131/industry-insights/preventing-healthcare-associated-infections-with-central-sterile-supply-departments.>.

Elite Medical Australia. 2022. *The Rise of Technology for CSSD Identification*. [online] Available at: <https://www.elitemedical.com.au/blogs/news/the-rise-of-technology-for-cssd-identification>.

Healthcare Executive. 2022. *CSSD Workflow Automation: Need of the Hour — Healthcare Executive*. [online] Available at: <https://www.healthcareexecutive.in/blog/cssd-workflow-automation-need-of-the-hour>.

Klaic, M. *et al.* (2022) 'Implementability of healthcare interventions: an overview of reviews and development of a conceptual framework', *Implementation Science*, 17(1), pp. 1–20. doi: 10.1186/s13012-021-01171-7.

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