Indonesian Journal of Global Health Research
Volume 8 Number 1, February 2026
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

OPTIMIZATION OF MEDICAL EQUIPMENT INVENTORY MANAGEMENT THROUGH BARCODE-BASED DIGITALIZATION

Maria Indah Septirini[1], Tuti Afriani[2], La Ode Abdul Rahman[2], Krisna Yetti[2], Dyah Fitri Wulandari[3]
[1]Master's Program in Nursing Science, Faculty of Nursing, Universitas Indonesia, Jl. Prof. DR. Sudjono D. Pusponegoro, Pondok Cina, Beji, Depok, Jawa Barat 16424, Indonesia
[2]Department of Basic and Fundamental Nursing, Faculty of Nursing, Universitas Indonesia, Jl. Prof. DR. Sudjono D. Pusponegoro, Pondok Cina, Beji, Depok, Jawa Barat 16424, Indonesia
[3]Khidmat Sehat Afiat General Hospital, Jl. Raya Muchtar No.99, Sawangan, Depok, Jawa Barat 16511, Indonesia
*maria.indah41@ui.ac.id

ABSTRACT
Digital transformation in medical equipment logistics is a vital part of healthcare reform, aiming to enhance efficiency, accuracy, and patient safety. One of the main challenges at hospital is the manual documentation system for borrowing and returning medical equipment, which results in low accountability, service delays, and a high risk of equipment loss. Case report area focused on the HCU/PICU unit. This study aims to describe the implementation process of a barcode-based digital medical inventory system through a managerial approach and planned change intervention based on Kurt Lewin's theory. A case report was conducted using Kurt Lewin's planned change approach (unfreezing, moving, and refreezing), data analysis through observation, questionnaires, interviews, and implementation evaluation. The Assessment of Medical Equipment Management (MEM) questionnaire administered to 103 nurses revealed that 87.4% of units still use manual recording and 50.98% reported suboptimal coordination in equipment returns, with reliability 0.86 and validity loading factor ±0.5; content validity 85%. The intervention involved developing Standard Operating Procedures (SOPs) and technical guidelines for the "MedScan-KISA" barcode system, conducting simulation trials using Google Forms and barcode scanners, and directly supervising the implementation process. The implementation of a barcode-based digital inventory system in the HCU/PICU unit of hospital was carried out through a gradual change process based on Kurt Lewin's theory. In the unfreezing phase, problems with the manual inventory system were identified through interviews, observations, and cross-unit discussions, leading to the design of a simple digital inventory system for the HCU/PICU unit. In the moving phase, an SOP was developed, simulations using barcodes and Google Forms were conducted, and intensive socialization and mentoring were provided to staff. Finally, in the refreezing phase, the new system was consistently practiced and integrated into daily routines in the HCU/PICU unit, thereby facilitating inventory recording and the return of medical equipment.

Keywords: barcode; inventory system; kurt lewin theory; logistics digitalization; medscan-KISA; nursing management; POSAC

How to cite (in APA style)
Septirini, M. I., Afriani, T., Rahman, L. O. A., Yetti, K., & Wulandari, D. F. (2025). Optimization of Medical Equipment Inventory Management Through Barcode-Based Digitalization. Indonesian Journal of Global Health Research, 8(1), 201–208. https://doi.org/10.37287/ijghr.v8i1.526.

INTRODUCTION

Health technology transformation is one of the six pillars of health transformation initiated by the Ministry of Health of the Republic of Indonesia to establish a resilient and integrated national health system. The World Health Organization (2022) stated that the adoption of digital technology in hospital healthcare services can accelerate and improve the accuracy of healthcare delivery, strengthen health governance and policy, and support cost efficiency in operational expenditures. The application of technologies such as barcodes, QR codes, and cloud-based systems has been proven to improve hospital logistics processes, particularly in tracking and recording medical equipment. The digitalization of medical equipment borrowing and return systems has emerged as a strategic solution increasingly adopted by healthcare facilities in achieving digital hospital transformation. By utilizing barcode-based systems and simple platforms such as Google Forms, documentation can be conducted automatically, accurately, and in real time. A study by Farras et al. (2025) demonstrated that the implementation of digital forms for medical equipment documentation

increased data accuracy by up to 90% and accelerated borrowing processes by 30% compared to manual systems. Google Forms is considered a suitable choice due to its flexibility, minimal infrastructure requirements, and accessibility via mobile devices.

The concept of Healthcare 4.0 further encourages the use of technologies such as the Internet of Things (IoT), Radio Frequency Identification (RFID), and Real-Time Location Systems (RTLS) in medical equipment management. According to Hasan et al. (2021), RFID technology enhances distribution efficiency, patient safety, and real-time tracking of equipment. However, despite its effectiveness, implementation often requires significant financial investment and sophisticated infrastructure. Effective inventory management of medical equipment should not only focus on recording additions or transfers but also include information related to usage status, location, borrowing history, calibration schedules, and the actual condition of the equipment. Volkov et al. (2021) emphasized that structured inventory systems improve utilization efficiency, prevent the use of damaged equipment, and facilitate hospital accreditation processes. Without digital record systems, equipment often becomes difficult to track, leading to service delays and even unnecessary procurement.

The transition from manual to digital systems in managing medical equipment borrowing and return can be analyzed using Kurt Lewin's three-step change theory: unfreezing, moving, and refreezing. The first stage, unfreezing, involves identifying problems in manual systems, such as high error rates in documentation, equipment loss, and service delays. At this stage, nurse managers must communicate the urgency of change to staff through educational and participatory approaches. The second stage, moving, occurs during the implementation of barcode systems and Google Forms, including pilot testing and providing technical support to ensure smooth transition. The third stage, refreezing, focuses on consolidating the new system, accompanied by regular evaluations and updated SOPs to ensure the change becomes embedded in the unit's culture of medical equipment management. This approach helps adaptation and minimizes resistance to digitalization.

The implementation of digital systems also has important implications for nursing management, particularly in supporting the functions of nurse managers through the POSAC principles (Planning, Organizing, Staffing, Actuating, and Controlling). In the planning stage, nurse managers analyze and calculate equipment needs based on previous inventory data. Organizing is carried out by arranging systematic distribution flows across shifts and units. Staffing involves assigning monitoring and reporting tasks to competent staff. Actuating is realized by motivating staff to comply with new technology-based procedures. Finally, controlling is strengthened with real-time data, enabling audits, delay monitoring, and periodic usage analysis. Musa Al-Hindi (2022) confirmed that digitalization of medical equipment logistics systems can increase time efficiency by 30% and reduce documentation errors by 45%. These findings indicate that transitioning from manual to digital systems provides tangible operational advantages for hospitals and allows more efficient workforce utilization.

The Special Inpatient Installation at Hospital is a vital service unit supporting nursing and medical procedures that require speed, accuracy, and precision. However, in practice, borrowing and returning medical equipment in this unit is still predominantly conducted manually or through verbal communication between staff. Such manual processes are prone to errors, including lost records, delays in documentation, data discrepancies, and even equipment loss. These issues not only delay healthcare delivery but also reduce nurse accountability and efficiency while increasing patient safety risks due to delayed availability of necessary equipment. The use of barcodes and Google Forms offers a practical, affordable, and user-friendly solution, while also strengthening the decision-making role of nurse managers through access to accurate data. Therefore, barcode-based systems provide a more practical and economical alternative for hospitals with limited resources, such as Hospital. Considering these aspects, the implementation of medical equipment inventory

digitalization at Hospital, has become an urgent necessity. This effort is not only aimed at administrative efficiency but also serves as a strategic measure to enhance service quality, patient safety, and governance in nursing units that are increasingly required to adapt to technological advancements.

METHOD

This study employed a case report method using Kurt Lewin's Planned Change Theory, which consists of three stages: unfreezing, moving, and refreezing. The unfreezing stage began with data collection through assessment, problem formulation, and brainstorming sessions involving the presentation of assessment findings and prioritization scoring in collaboration with the hospital management team. The moving stage involved developing problem-solving strategies in the form of a Plan of Action (POA), implementing the POA, and evaluating changes. The evaluation process was conducted to assess outcomes in terms of input, process, and output. The refreezing stage was carried out to stabilize the changes.

Problem assessment was conducted through interviews, questionnaires, and observation. Interviews were carried out with the head nurse and the nursing department to identify baseline data related to management functions from May 28–30, 2025, and continued on June 9, 10, 11, and 13, 2025. Problem formulation was then performed together with the head nurse, head of the nursing committee, and head of nursing services on June 16, 2025. Observations were conducted on healthcare services across all wards at Hospital. A questionnaire was distributed via Google Form to all staff nurses. The research instrument employed the Assessment of Medical Equipment Management (MEM) questionnaire, consisting of closed-ended positive statements representing five key indicators: *man, method, material, money,* and *environment.* The respondents included 103 nurses out of a total of 268 nurses at Hospital X, selected using a simple random sampling technique. Analysis of the questionnaire responses showed that 87.4% of service units still use manual recording, and 50.98% of staff reported suboptimal inter-unit coordination in equipment returns due to frequent delays in returning tools to their original units. The questionnaire instrument was tested for validity and reliability, yielding a Cronbach's alpha value of 0.86, indicating high reliability, and a loading factor of approximately 0.5, signifying adequate construct validity. Additionally, the content validity test conducted by two experts confirmed that the instrument was in accordance with the MEM evaluation guidelines, achieving an 85% level of agreement.

Data obtained from interviews, observations, and questionnaires were analyzed using the Ishikawa (fishbone) diagram, a method for root cause analysis that categorizes contributing factors into 5M: Man (human resources), Machine (equipment/tools), Material, Method, and Environment. Furthermore, a SWOT analysis was conducted to identify the organization's strengths, weaknesses, opportunities, and threats, with the aim of evaluating internal and external factors to maximize strengths, minimize weaknesses, optimize opportunities, and anticipate threats. The next step was determining problem priorities using the USG method (Urgency, Seriousness, Growth). This method classifies problems based on urgency (how immediately they must be addressed), seriousness (the impact of the problem), and growth (the likelihood of the problem worsening if left unresolved). After establishing the priority problem, the subsequent stage was to develop a Plan of Action (POA) as a structured solution. The POA was then evaluated to measure its effectiveness in addressing the identified problems.

RESULT

The study began with the unfreezing phase, in which problem identification was conducted through interviews, observations, and Ishikawa analysis to raise staff awareness of the weaknesses of the manual system. In the moving phase, Standard Operating Procedures (SOPs) were developed, barcode and Google Form simulations were conducted, and field supervision was carried out. In the refreezing phase, the changes became embedded in daily routines, facilitating documentation,

minimizing equipment loss, and supporting managerial decision-making through real-time data. The Ishikawa diagram revealed multiple factors contributing to suboptimal medical equipment management across the 5M categories. From the Man (Human Resources) aspect, 42% of respondents reported that socialization of equipment use was rarely conducted, while 29% admitted they were not proficient in operating certain tools, in addition to suboptimal equipment function and storage. In terms of Method, several tools lacked operational guidelines, and manual documentation made tracking difficult. The Machine factor reflected limitations of the manual system in facilitating tracking, while Material indicated that storage conditions for medical equipment did not meet required standards. The Money aspect highlighted inefficient budget utilization, delayed calibration, and high maintenance costs. Finally, the Environment factor pointed to delays in equipment returns and intense competition among hospitals, which further pressured the improvement of service efficiency.

These factors collectively contributed to suboptimal medical equipment inventory management, particularly in the borrowing and returning processes. Initial data collection for problem identification was carried out through questionnaires distributed to 103 nurses, from a population of 268. Based on USG analysis, the highest-priority problem was the manual and non–real-time documentation of medical equipment inventory, especially in borrowing and returning processes, with a total score of 15 (Urgency: 5, Seriousness: 5, Growth: 5). This issue was considered the top priority as it directly affected nursing service effectiveness and patient safety. Manual documentation posed high risks of recording errors, reporting delays, and data loss, which cumulatively reduced healthcare quality and led to resource wastage due to inaccurate information on equipment availability.

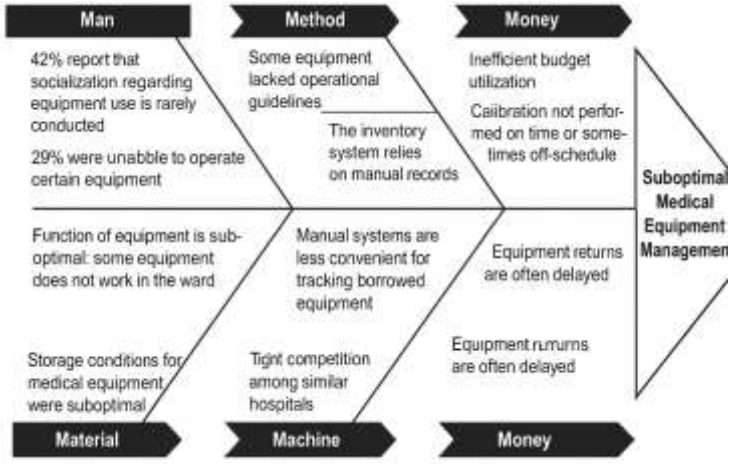

Figure 1. Ishikawa Diagram of Medical Equipment Inventory Management

Furthermore, the manual system made tracking borrowed and returned equipment difficult, increasing the risk of equipment loss or late returns. The subsequent step after identifying the priority problem was developing a Plan of Action (POA) as a structured intervention strategy. The POA systematically outlined the necessary steps, required resources, implementation timeline, and responsible personnel. By applying Kurt Lewin's Change Theory, the digitalization of the medical equipment inventory system at hospital was carried out in alignment with each of its stages. In the unfreezing phase, problems related to manual documentation were identified, and Standard Operating Procedures (SOPs) were developed as the foundation for change. The moving phase was marked by the simulation of a barcode system in the pilot unit (HCU/PICU) involving 20 nurses, intensive socialization, and the active involvement of nursing managers in supporting the transition from manual to real-time digital systems. Subsequently, in the refreezing phase, the change was reinforced through routine evaluations and staff compliance with the implemented activities. The implementation of barcode interventions facilitated the recording process, reduced the risk of equipment loss, and provided real-time medical equipment inventory data. This demonstrates that a structured implementation can transform change into a sustainable new culture.

DISCUSSION

The borrowing and return system of equipment between units was not systematically documented, often leading to delays, loss of equipment tracking, and difficulties in ensuring equipment condition upon return. Furthermore, no centralized database was available for cross-unit use, resulting in each unit working independently in managing medical equipment. This highlights the need for an integrated digital inventory system to improve efficiency, accuracy, and transparency in medical equipment management. With borrowing and return processes still being manual and not digitally integrated, there remains a high risk of data loss or delayed reporting. A questionnaire survey was conducted among all nurses at hospital regarding respondent characteristics. The instrument consisted of 27 closed-ended positive statements representing the indicators of Man, Method, Machine, Material, Money, and Environment. Respondents: The questionnaire was completed by 103 nurses from a population of 268.

Based on the analysis of the 5M aspects, the management of medical equipment logistics in the hospital was found to be suboptimal. From the Human Resources (Man) perspective, 29% of respondents reported not being proficient in operating certain medical devices, and 44.6% had not received guidance on equipment use from the head of the ward. Regarding Technology (Machine), documentation was still largely manual (87.4%), and only a minority (35.95%) felt that electronic systems facilitated equipment tracking. In terms of Material, 42.7% of respondents stated that equipment in their units was non-functional, which hindered nursing efficiency. In the Method aspect, 32% noted the absence of an SOP for borrowing and returning equipment, while 15% reported no inventory evaluation from the head of the ward. Only 38.6% stated that evaluations were conducted regularly. Regarding Budget (Money), 17% of respondents reported limited medical equipment availability, and 31% noted that equipment calibration was often delayed.

These findings highlight the need to improve staff competencies, digitalize documentation systems, refine operational procedures, and provide adequate facilities and budgetary support to ensure the safety and effectiveness of medical equipment services in hospitals. From the environmental aspect, 50.98% of respondents (n=103) stated that poor inter-unit coordination regarding the return of borrowed equipment—often delayed to its original unit—disrupted workflow, particularly when the equipment was urgently needed again. After conducting problem analysis using the Ishikawa diagram, the next step was to determine problem priorities using the USG approach (Urgency, Seriousness, Growth). The USG method is a technique used to set problem-handling priorities based on three main aspects: Urgency (how immediate the problem needs to be addressed), Seriousness (the impact of the problem on organizational performance), and Growth (the potential for the problem to worsen if left unresolved) (Utari & Wahyuni, 2020). Prioritization was carried out by assigning scores between 1 and 5 to each criterion, with higher total scores indicating greater urgency for prioritization.

The implementation process referred to the POSAC management functions (Planning, Organizing, Staffing, Actuating, and Controlling), which served as the foundation for executing the structured Plan of Action (POA). Evaluation was then conducted to assess the extent to which the objectives of the POA were achieved and to identify the effectiveness of the steps undertaken. This approach provided direct solutions for transitioning the inventory system for borrowing and returning medical equipment from manual to digital. Medical equipment logistics management involves a series of critical activities, including planning, procurement, storage, distribution, borrowing, maintenance, and returning of medical equipment used in healthcare services. This system plays a central role in ensuring the continuity of nursing and medical services in hospitals. At hospital, the logistics process was previously carried out manually but is now being transformed into a barcode- and Google Form–based digital system to improve efficiency and accuracy. The primary reason for this transformation is that the manual system has proven inadequate for meeting the demands of modern service efficiency. Internal evaluations revealed that 87.4% of hospital units still used manual

documentation, while 50.98% of staff reported suboptimal inter-unit coordination. Manual systems were also prone to recording errors, reporting delays, and difficulties in tracking borrowed equipment. Therefore, the adoption of a digital system is expected to overcome these issues by providing real-time automatic recording, accurate tracking, and enhanced accountability. This transformation is particularly important as the hospital strives to improve service quality toward achieving KJSU-KIA intermediate referral status while supporting the hospital's digitalization program and integration with the Hospital Management Information System (SIMRS). Implementation of the digital system began in the HCU/PICU unit. In this pilot unit, a barcode system was introduced for recording borrowing and returning of medical equipment, integrated with Google Forms and a logistics dashboard accessible to head nurses and logistics coordinators. Stakeholders involved in this system were diverse: staff nurses acted as direct users of the barcode system during borrowing transactions; head nurses and team leaders oversaw and validated data; logistics coordinators managed distribution and availability of equipment across units. Nursing managers played the most strategic role, bridging operational needs with hospital management policies. Students acted as innovators in developing and maintaining the digital system, while hospital management was responsible for strengthening regulations and evaluating the system.

The digital logistics process was carried out in a structured manner. Each borrowing transaction began with barcode scanning, automatically generating input in Google Forms that recorded details such as borrower's name, unit, borrowing time, type of equipment, and return status. All data were stored and monitored through a dashboard accessible to managers and unit coordinators. This system was supported by training, SOP socialization, and periodic monitoring, implemented following Kurt Lewin's Change Theory: unfreezing (raising awareness of the need for change), moving (system implementation), and refreezing (embedding the system as the new work standard). The planning stage began with problem identification and needs assessment through discussions held on June 17–20, 2025, with head nurses, staff nurses, and supporting medical staff still using manual systems. The goal was to identify weaknesses of the manual system and determine the features required for a digital system, resulting in a structured workflow for equipment borrowing and returning. Based on stakeholder input, Standard Operating Procedures (SOPs) and technical guidelines for the barcode- and Google Form–based digital inventory system were developed, with input from academic advisors and hospital mentors.

During the organizing stage, technical coordination was carried out with stakeholders such as head nurses, logistics coordinators, and staff nurses, through meetings and field supervision held from June 17–25, 2025. The pilot unit was established in the 4th Floor Ward (PICU/HCU), and simulations were conducted on June 23, 2025. At this stage, the implementation team organized task distribution and scheduled trial runs. The staffing stage involved engaging all stakeholders in the pilot unit (HCU/PICU), including head nurses, staff nurses, asset coordinators, and students implementing the change project. Head nurses assigned personnel responsible for data entry, equipment monitoring, and reporting. The project was supported by students as system innovators, while the Head of Nursing Department ensured the readiness of human resources for system implementation. The actuating stage included socialization and simulation of the barcode and Google Form system for staff in the pilot unit (HCU/PICU). Socialization was held on June 23, 2025, at 1:00 PM with the head nurse and four staff nurses. Trial results showed that both the head nurse and staff were able to follow the simulation successfully, practicing barcode scanning using mobile phones according to SOP steps. The simulation involved hands-on practice of recording borrowing and returning equipment, accompanied by discussions on form content and feature usage. Finally, the controlling stage was carried out through evaluation of simulation and system implementation from June 23–26, 2025. Supervision included monitoring barcode scan usage (MedScan-KISA) and assessing whether staff consistently applied the barcode system throughout the trial period.

CONCLUSION

The nursing management residency program at hospital, conducted over four weeks (May 28–30 and June 1–30, 2025), resulted in the development of the Scan Barcode MedScan-KISA digital system as a solution to the challenges of manual documentation in the borrowing and returning of medical equipment. This transformation was carried out systematically following Kurt Lewin's change model (unfreezing, moving, refreezing) and proved effective in the HCU/PICU unit, where most nurses understood its use and expressed readiness to implement it routinely. The evaluation recommended six follow-up strategies: strengthening socialization and simulation, expanding implementation to all care units, refining SOPs and technical guidelines, establishing regular monitoring and evaluation, integrating the system with the Hospital Management Information System (SIMRS), and proposing an internal hospital policy to provide a clear legal foundation for the sustainable adoption of the digital system.

REFERENCES

Akpor, O. A., Akingbade, T. O., & Olorunfemi, O. (2023). Lack of Adequate Equipment for Healthcare – The Agony of Patients and Nurses. *Indian Journal of Continuing Nursing Education*, *24*(1), 7–10. https://doi.org/10.4103/ijcn.ijcn_96_21

Alotaibi, N., Wilson, C. B., & Traynor, M. (2025). Enhancing digital readiness and capability in healthcare: a systematic review of interventions, barriers, and facilitators. In *BMC Health Services Research* (Vol. 25, Issue 1). BioMed Central Ltd. https: //doi.org/10.1186/s12913-025-12663-3

Ana, K., Yetti, K., Suhendri, A., & Maryunani, A. (2023). Budaya Pelaporan Insiden Keselamatan Pasien Terintegrasi Melalui SIMRS. *Journal of Telenursing (JOTING)*, *5*(1), 1083–1092. https://doi.org/10.31539/joting.v5i1.4905

Balkhi, B., Alshahrani, A., & Khan, A. (2022). Just-in-time approach in healthcare inventory management: Does it really work? In *Saudi Pharmaceutical Journal* (Vol. 30, Issue 12, pp. 1830–1835). Elsevier B.V. https://doi.org/10.1016/j.jsps.2022.10.013

Bocean, C. G., & Vărzaru, A. A. (2025). Health status in the era of digital transformation and sustainable economic development. *BMC Health Services Research*, *25*(1). https://doi.org/10.1186/s12913-025-12498-y

(Browning) Callis, A. M. (2020). Application of the Roy Adaptation Theory to a care program for nurses. *Applied Nursing Research*, *56*. https://doi.org/ 10.1016/ j.apnr.2020.151340

Chen, X., Xu, L., & Pan, Z. (2022). Design and Preliminary Realization of a Screening and Early Warning Health Management System for Populations at High Risk for Depression. *International Journal of Environmental Research and Public Health*, *19*(6). https://doi.org/10.3390/ijerph19063599

Chowdhuri, I. R., & Kiran Pal, A. (2022). Quantitative Assessment of Effectiveness and Utilization of Medical Equipment. In *IJIEM (Indonesian Journal of Industrial Engineering & Management)* (Vol. 3). http://publikasi.mercubuana.ac.id/index.php/ijiem

De Oliveira, E. M. C., Guimaraes, E. H. R., & Jeunon, E. E. (2017). Effectiveness of Medical-Care Equipment Management: Case Study in a Public Hospital in Belo Horizonte / Minas Gerais. *International Journal of Innovation*, *5*(2), 234–249. https://doi.org/10.5585/iji.v5i2.117

Dewi, A., Hariyati, Rr. T. S., & Dewi, L. (2021). Pengembangan Panduan Peran dan Fungsi Top Manajer Keperawatan di Rumah Sakit. *Journal of Telenursing (JOTING)*,*3*(1),8–19.https://doi.org/10.31539/joting.v3i1.2065

Eva, E., Hariyati, Rr. T. S., & Fitri, D. (2022). Efektivitas E-Logistik dan Tele-Logistik dalam Optimalisasi Pengelolaan Logistik Keperawatan di Ruang Rawat Inap: Suatu Program Inovasi. *Journal of Telenursing (JOTING)*, *4*(1), 47–58. https://doi.org/10.31539/joting.v4i1.3319

Holloway, S. (2024). *Impact of Digital Transformation on Inventory Management: An Exploration of Supply Chain Practices*. https://doi.org/10.20944/preprints202407.0714.v1

Kabeta, S. H., Chala, T. K., & Tafese, F. (2023). Medical Equipment Management in General Hospitals: Experience of Tulu Bolo General Hospital, South West Shoa Zone, Central

Ethiopia. *Medical Devices: Evidence and Research*, *16*, 57–70. https://doi.org/10.2147/MDER.S398933

Kehi, L. D., Yetti, K., Afriani, T., & Wulandari, D. F. (2025). Perancangan prototipe pendokumentasian keperawatan berbasis rekam medis elektronik di rumah sakit x dengan menggunakan teori perubahan Lewins. *Holistik Jurnal Kesehatan*, *18*(10), 1321–1330. https://doi.org/10.33024/hjk.v18i10.589

Kubáňová, J., Kubasáková, I., Čulík, K., & Štítik, L. (2022). Implementation of Barcode Technology to Logistics Processes of a Company. *Sustainability (Switzerland)*, *14*(2). https://doi.org/10.3390/su14020790

Li, C.-Y., Li, C.-Y., Huang, M.-H., Lin, Y. S., Chu, C.-M., & Pan, H. H. (2024). Effects of Implementing a Barcode Information Management System on Operating Room Staff: Comparative Study (Preprint). *Journal of Medical Internet Research*. https://doi.org/10.2196/56192

Marquis, B. L., & Huston, C. J. (2017). *Leadership Roles and Management Functions in Nursing : Theory and Aplication* (9th ed.). Lippincott Williams & Wilkins. https://lccn.loc.gov/2016046163

Milapastiniari, N. M., Suyasa, I. G. P. D., Adianta, I. K. A., & Sriasih, N. K. (2021). Pengembangan sistem pengelolaan alat kesehatan pada ruang perawatan berbasis teknologi informasi di RSUD Sanjiwani, Gianyar tahun 2021. *Intisari Sains Medis*, *12*(3), 735–741. https://doi.org/10.15562/ism.v12i3.1106

Mulac, A., Mathiesen, L., Taxis, K., & Gerd Granås, A. (2021). Barcode medication administration technology use in hospital practice: A mixed-methods observational study of policy deviations. *BMJ Quality and Safety*, *30*(12), 1021–1030. https://doi.org/10.1136/bmjqs-2021-013223

Neve, B. v., & Schmidt, C. P. (2022). Point-of-use hospital inventory management with inaccurate usage capture. *Health Care Management Science*, *25*(1), 126–145. https://doi.org/10.1007/s10729-021-09573-1

Noguerra Jr, C. P. (2023). Design and Evaluation of an Innovative Mobile Solution: QR Code-based Inventory Monitoring System. *International Journal of Advanced Engineering and Management Research*, *08*(03), 231–242. https://doi.org/10.51505/ijaemr.2023.8317

Núñez-Merino, M., Maqueira-Marín, J. M., Moyano-Fuentes, J., & Martínez-Jurado, P. J. (2020). Information and digital technologies of Industry 4.0 and Lean supply chain management: a systematic literature review. *International Journal of Production Research*, *58*(16), 5034–5061. https://doi.org/10.1080/00207543.2020.1743896

Profetto, L., Gherardelli, M., & Iadanza, E. (2022). Radio Frequency Identification (RFID) in health care: where are we? A scoping review. In *Health and Technology* (Vol. 12, Issue 5, pp. 879–891). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s12553-022-00696-1

Resty, D. E., Hariyati, Rr. T. S., Afriani, T., & Sudaryati, S. (2025). Digital Transformation of Borrowing System and Returning Medical Equipment. *Indonesian Journal of Global Health Research*, *7*(1), 1105–1116. https://doi.org/10.37287/ijghr.v7i1.5758

Turcu, C., & Cornel, T. (n.d.). *RFID-based Solutions for Smarter Healthcare*.

Utari, E., & Wahyuni, I. (2020). Analisis Matriks Usg (Urgency, Seriousness and Growth) Banten Mangrove Center Bagi Masyarakat Kelurahan Sawah Luhur Kecamatan Kasemen Kota Serang. *Biodidaktika: Jurnal Biologi Dan Pembelajarannya*, *15*(2). https://doi.org/10.30870/biodidaktika.v15i2.8720

Volkov, I. (2020). *Digital Twins, Internet of Things and Mobile Medicine: a Review of Current Platforms to Support Smart Healthcare*.

Wiraya, M., Yetti, K., & Maryunani, A. (2023). Optimalisasi Supervisi Kepala Ruangan dalam Pelaksanaan Edukasi Personal Hygiene untuk Keluarga dan Pasien. *Journal of Telenursing (JOTING)*, *5*(1), 1226–1233. https://doi.org/10.31539/joting.v5i1.5797.