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Integration of Customized Wheelchair Tracking and Durable Medical Equipment's Solutions for Hospitals: A Continuous Quality Improvement Project

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aim: The purpose of the project is to design a model that will reduce the number of missing wheelchairs in the National Institutes of Health (NIH) Clinical Center; this will be achieved by designing a process to improve the tracking of wheelchairs at the clinical center.
Study Design: Qualitative.
Place and Duration of Study: National Institutes of Health (NIH) Clinical Center between 2017 and 2018.
Methodology: A process flow diagram was designed to study the current process and identify areas of opportunities. Ten in-depth interviews were conducted with diverse staff, including nurses and patient escorts, to identify system inefficiencies and barriers. Stakeholders were chosen for

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their roles and experience, enriching the root cause analysis. A fishbone diagram was constructed to ascertain the flow and direction of the problem being investigated.

Results: The study found that investing in Stryker TC wheelchairs significantly reduced the rate of missing wheelchairs at the NIH Clinical Center from 50% to 20% monthly. This resulted in substantial operational cost savings. The hospital saved approximately $200,000 annually in 2017 alone by reducing the need to replace missing wheelchairs, which cost $5,000 per unit. It was a good management decision to invest in Stryker TC wheelchairs that reduced the rate of missing wheelchairs from an average of 50% to an average of 20% monthly.

Conclusion: The study shows that investing in Stryker TC wheelchairs significantly reduced missing wheelchairs from 50% to 20% monthly. This led to $200,000 in annual savings by decreasing the need for replacements. Although the initial cost is high, the long-term savings justify the investment. The findings suggest that healthcare administrators should consider similar investments to enhance care delivery and operational excellence. This research highlights the effectiveness of innovative solutions in addressing logistical challenges in healthcare settings, facilitating more efficient patient care industry-wide.

Keywords: Wheelchairs; missing; tracking; durable medical equipment.

1. INTRODUCTION

Operational inefficiencies in hospitals, such as those leading to extended lengths of stay and increased costs, underscore the critical need for effective management systems [1]. Improved tracking of durable medical equipment could address these inefficiencies. This project is borne out of the need to propose a solution to the incessant missing wheelchairs at the National Institutes of Health (NIH) Clinical Center. The purpose of the project is to design a model that will reduce the number of missing wheelchairs in the institution, which is meant to be achieved by designing a process to improve the tracking of wheelchairs at the clinical center.

1.1 Background

The wheelchair (WC) is a fundamental example of mobility-assistive equipment (MAE) [2], especially for sick patients. Every hospital has wheelchairs as regular equipment. They affect almost every aspect of the hospital's functioning. Wheelchairs can be a hassle, from the expenses involved to the delays resulting from their unavailability. Wheelchairs help some people recover more quickly, but many cannot be carried safely without assistance. It is crucial for these individuals to be able to access wheelchairs easily when needed. It could be essential in some situations. A staff member's time looking for an open wheelchair detracts from the quality of care provided to patients. The patient's health may suffer as a result of this. This then brings to the fore the need to solve the incessant missing wheelchairs in hospitals and clinical centers.

According to Z & Z Medicals, Inc., most hospital facilities estimate a 10 percent annual loss in their fleet of wheelchairs; this percentage can occasionally rise to 25 percent [3], and the staff wastes up to 20 minutes of their working time every day searching for a wheelchair [4]. When a wheelchair is not readily available, people other than patients are kept waiting. Getting patients where they need to go fast and effectively is essential to the healthcare workflow. Insufficient wheelchair availability or inadequate wheelchair tracking will lead to lines and delays that affect hospital operations and reduce efficiency [5].

According to an article in The Strait Times, hospitals' basement parking lots, specialized clinics, wards, and other common areas are usually the custodians for wheelchairs that were not in use [6]. To fully understand the relevance of this project, it is important to evaluate a system where wheelchair tracking is not fully functional and its effect on the healthcare center. In 2017, the NIH recorded about 40 – 60% of their wheelchairs were missing monthly, as shown in the Table 1.

This poses a severe challenge because operational inefficiencies related to missing wheelchairs and other Durable Medical Equipment (DME) could lead to a bad patient experience, a time delay in workflow, and increased business operations costs for healthcare centers. The introduction of an effective tracking system will improve workflow, patient experience, support time, and accountability.

Table 1. Percentage of missing wheelchairs at NIH Clinical Center

Month	Percentage of missing wheelchairs
January 2017	45.30%
February 2017	55.39%
March 2017	55.39%
April 2017	61.15%
May 2017	51.08%
June 2017	51.08%
July 17	54.67%
August 2017	45.32%
September 2017	45.32%
October 2017	59.71%
November 2017	49.64%

Even though there have been several studies for tracking wheelchairs and other DMEs within the hospital, there is no doubt that an effective tracking system can help hospital personnel locate wheelchairs and other DMEs within the hospital, thereby saving money and time. Tracking of DME, including wheelchairs, improves operations timeframe and workflow and promotes patient experience. Proper accountability is necessary for cost savings and reduction in redundancy. Over the years, significant advances have been made in technology for effective tracking mechanisms. Some innovative technologies available for tracking wheelchairs and other Durable Medical Equipment within the hospital include:

- **RFID:** Among various technologies employed for enhancing healthcare operations, RFID has demonstrated success. Thompson and Furness (2015) provide a detailed account of how RFID technology not only streamlined wheelchair tracking but also contributed to broader operational improvements in hospital settings [7]. The utilization of Radio Frequency Identification (RFID) is rapidly gaining traction due to its numerous extended applications. However, there aren't many instances where such a technology is used in the healthcare industry because of the investment concern [8]. Radiofrequency identification (RFID) technology uses electromagnetic fields in the radio frequency range to wirelessly capture and read the data stored in a tag for identification and tracking purposes [9]. RFID was discovered to be practical and helpful in the healthcare industry by several early adopters in areas like patient identification and asset tracking. Adoption however, is hampered mainly by technology limits, privacy concerns, interference issues, expensive pricing, and a lack of international standards. To improve RFID use in healthcare, more affordable, well-designed systems are required, along with privacy concerns being addressed [10]. RFID technology can also help medical professionals diagnose and treat patients more quickly and accurately. It can also facilitate the automatic streamlining of the patient identification process in health centers [11].

- **IR:** Infrared location tags transmit codes with light. They require ceiling-mounted readers and extensive infrastructure. The solution cannot pass through the wall because it uses light instead of radio waves. Hence, there is less possibility of false positives; radio-based systems can pick up other readers through walls.

- **GPS:** Global Positioning System (GPS) is based on satellites communicating with receivers. It tells the exact location and works with Wi-Fi. The satellites broadcast signals that contain information about their location and time. However, the tracking devices are quite big.

- Barcode technology requires proximity. The scanners or lasers used to read the barcodes measure the light reflected from the linear barcode. Hence, it is not efficient when an object is not in sight.

  However, since RFID waves do not need a line of sight to operate and come in varying read/tracking ranges, RFID technology is far superior and more practical compared to barcodes. RFID tags are used to tag objects and come with their unique serial number. A computerized system allows for quick and easy tracking of these objects. Some of these innovative technologies can also be used in combination. Some examples are:

- IR/RFID
- RFID + Barcode
- RFID + Barcode + GPS

In 2012, the Johns Hopkins Hospital adopted Midmark's Real Time Locating System (RTLS), Infrared (IR) technology for asset tracking and management. In 2016, the hospital improved surgical on-time cases by 25% by installing Venus RTLS in all 33 Operating Rooms. It was observed that most surgical delays were caused by missing equipment, particularly Intravenous (IV) pumps. Before the installation of the RTLS, a typical 8-hour shift was dedicated to finding and stocking 30 service carts, after the installation of the RTLS tags, the number of carts stocking during an 8 hours shift rose from 30 to 60 carts. In all, it is evident that tracking of DME and Wheelchairs within the hospital will improve operation efficiencies, reduce staff frustration, improve patient experience and save time and money. Simple low-cost techniques can enable efficient tracking of wheelchairs within the hospital. Interventions do not always have to be complex or sophisticated.

2. METHODOLOGY

The Capstone project was conducted at the National Institutes of Health (NIH) Clinical Center to address the challenges of missing wheelchairs. The NIH is the largest Biomedical Research Center in the world [12]. The clinical center is a hospital devoted to clinical research; it has over 1,600 clinical research studies in progress. In 2017, the hospital saw 9,700 new patients, had 92,000 outpatient visits, 4,500 inpatient admissions, 46,388 inpatient days, and an average length of stay of 8.8 days [12,13]. The Plan-Do-Study-Act (PDSA) cycle was employed as a framework for continuous quality improvement. The PDSA cycle is a proven approach to enhance operational efficiencies and patient care quality in healthcare settings [14,15]. First, a process flow diagram was designed to study the current process and identify areas of opportunities as shown in Fig. 1.

In this study, we conducted ten in-depth interviews with staff members at the NIH Clinical Center to comprehensively understand wheelchair management processes. The participants included a diverse group of nurses, patient escorts, and other essential personnel directly involved in the day-to-day management of wheelchair logistics. The selection of these stakeholders was strategically based on their roles and experience, ensuring a broad spectrum of insights into the operational challenges and opportunities. Each interview was structured to explore specific aspects of the current management system, barriers experienced by staff, and potential areas for improvement. This qualitative approach allowed us to capture detailed, context-rich information that informed our analysis and recommendations.

All of the stakeholders were interviewed to conduct a root cause analysis. In December of 2011, NIH purchased 100 new Stryker Wheelchairs. The Stryker Prime TC Transport Chairs have a rigid frame that helps prevent theft. Since the arrival of these chairs, the number of missing wheelchairs has decreased by about 50%. Cleaning is vital to preventing infection and Hospital-acquired infections. The Stryker TC is power-washable and makes cleaning easier. They feature a smoother design with obvious touch points, so there are fewer nooks and crannies for bacteria and viruses to get trapped in, and wiping the product down is simple and efficient. Using a color palette in the design makes it easier to see missed spots.

A fishbone diagram was used to systematically identify the root causes of wheelchair losses. Fig. 2. This tool is widely recommended for its effectiveness in unraveling complex operational challenges in healthcare. It facilities a thorough analysis by categorizing potential contributing factors into manageable domains [16]. A fishbone diagram, sometimes called an Ishikawa diagram or a cause-and-effect diagram, is a type of visual aid used in business to pinpoint and look into multiple potential reasons for a given problem, event, or result. It is organized like the skeleton of a fish, with the causes running to the left like the fish's bones and the problem statement at the head of the animal. The diagram can reduce complex issues to manageable parts, facilitating productive brainstorming and causal relationship analysis among teams. Fishbone diagrams are helpful for root cause analysis because they offer a systematic framework for investigating all possible sources of an issue, not just the most apparent one [17].

To better understand the process:

- There is no process in place to track where patient relatives drop the wheelchair after use
- There is no process in place to track the exact location of each wheelchair, though every wheelchair is assigned a number.

With this information, a process improvement plan was designed using the PDSA Cycle.

Using the PDSA Tool:

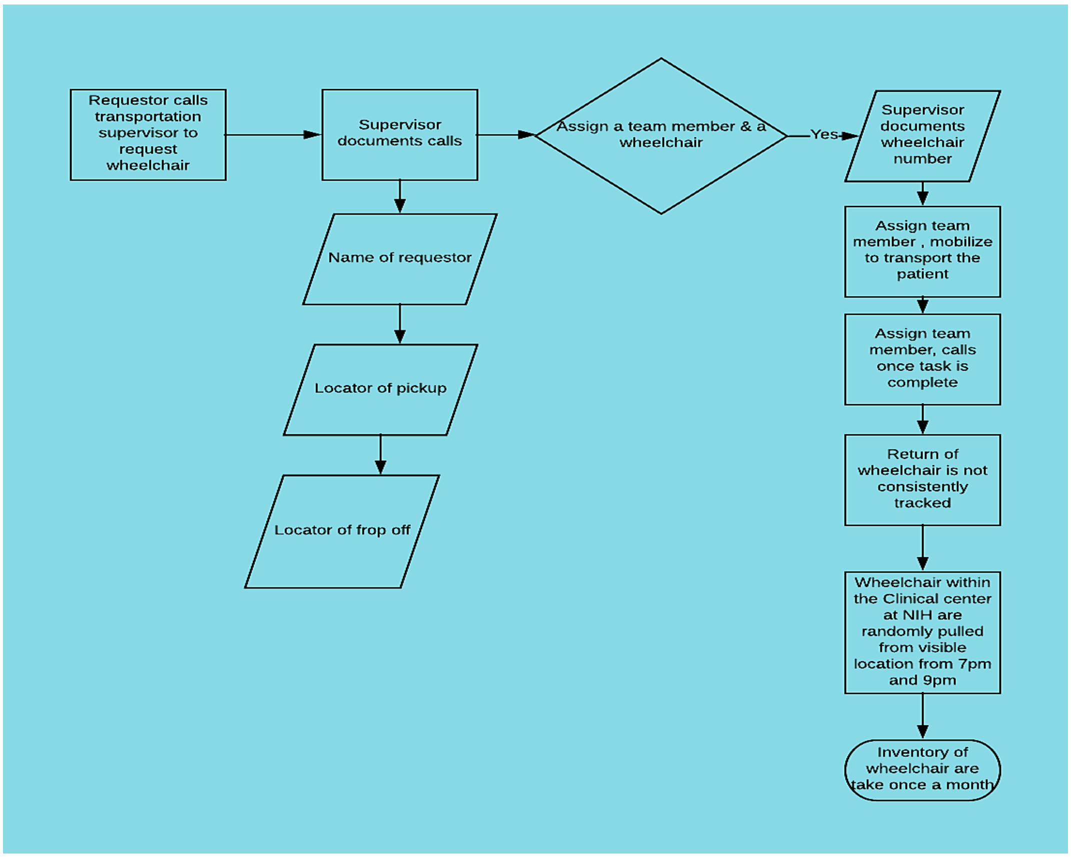

Fig. 1. The current process for accessing wheelchairs

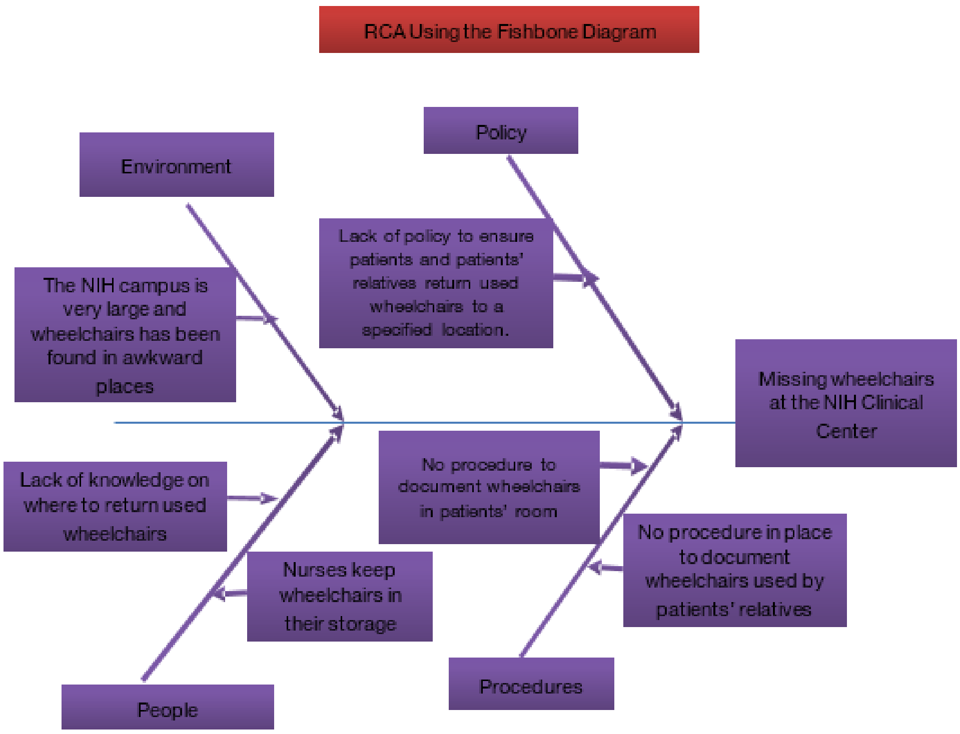

Fig. 2. The fishbone diagram for pinpointing the incidences of missing wheelchair

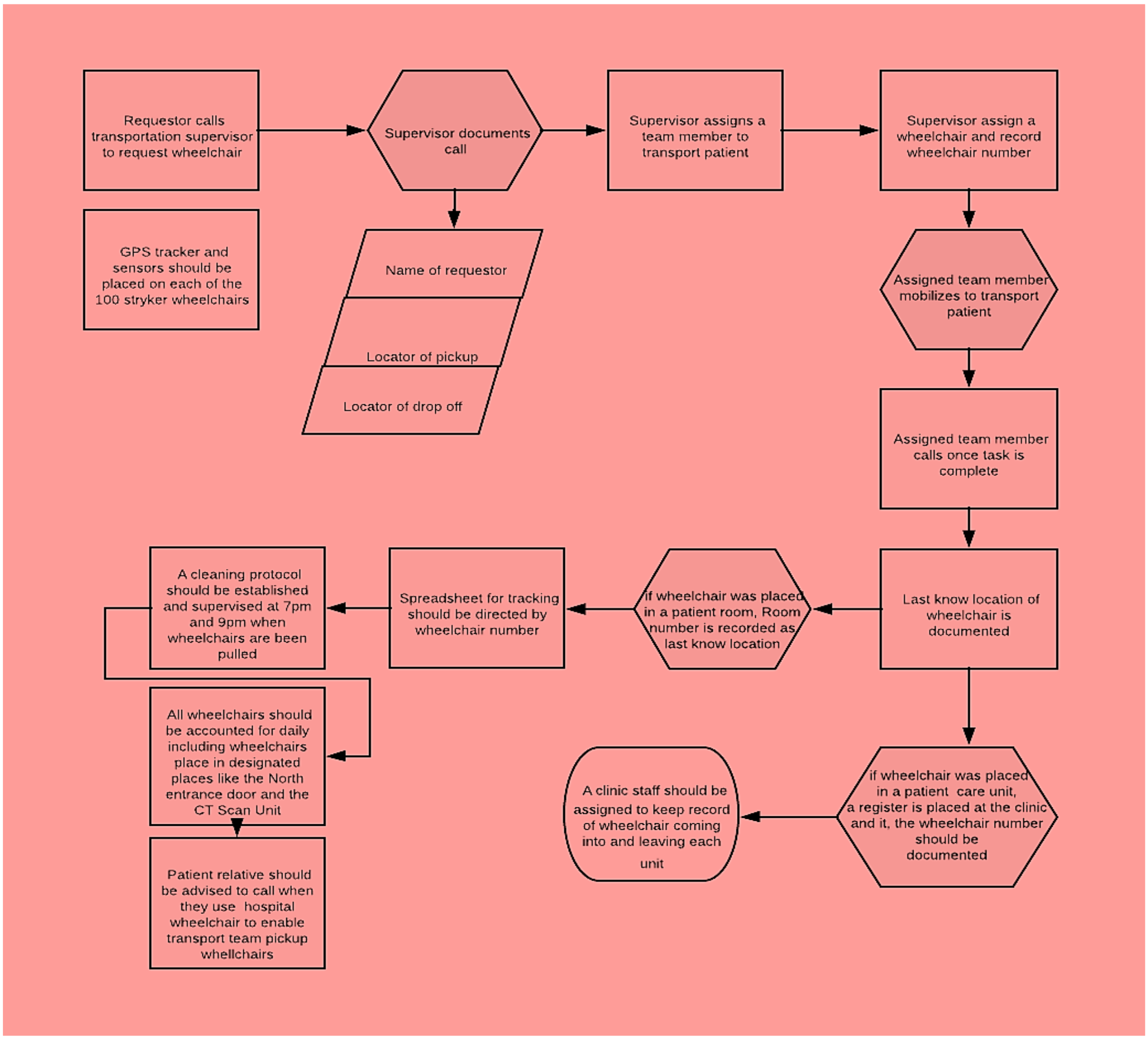

Fig. 3. The new process for tracking wheelchairs

Plan: Define the objective. Develop a plan.

Do: Put the plan into action (Keep 'plan' S.M.A.R.T)

- Specific
- Measurable
- Achievable
- Realistic
- Time Focused

Study: Collect data, Analyze data, Improve process, test process

Act: Implement solution, test solution

The objective is to reduce the rate of missing wheelchairs to 10% monthly over the next three months. This will be achieved by designing a new process flow to improve tracking on an Excel spreadsheet. The new Excel spreadsheet will track each wheelchair by its assigned serial number. Each wheelchair will be assigned a serial number, and each should be accounted for at the end of each day.

2.1 New Process

Do—The proposed system will undergo testing at a single Patient Care Unit to see if it reduces the number of missing wheelchairs.

Study: Data from the new process will be collected and analyzed, and the results will be recorded. For example, the number of missing wheelchairs at the end of each month will be recorded, and the number of patients calling messenger services after using a wheelchair will be analyzed to see if the policy is effective.

Table 2. New spreadsheet designed to track wheelchairs

Wheelchair Serial number	Name of Patient	Name of Requestor	Name of Escort	Location of Pickup	Location of Drop off	update location	Check if the wheelchair was pulled at the end of the day	Wheelchair cleaned
CH-0001	Pt 1	Michael S.	Yale N.	CC Lobby	Cardiology		Yes	Yes
CH-0002	Pt 2	Sarah P.	Parker C.	CC Lobby	Orthopedics		Yes	Yes
CH-0003	Pt 3	Jessica T.	Alex R.	CC Lobby	Phlebotomy		Yes	Yes
CH-0004	Pt 4	David B.	Vesper K.	CC Lobby	Parking lot		X	
CH-0005	Pt 5	Emily R.	Taylor I.	CC Lobby	Radiology		Yes	Yes

Act: If the percentage of missing wheelchairs is less than 10% at the end of each month, a recommendation will be made to management to expand the new process to the entire clinical center.

3. RESULTS AND DISCUSSION

3.1 Project Results

The study found that it was a good management decision to invest in Stryker TC wheelchairs that reduced the rate of missing wheelchairs from an average of 50% to an average of 20% monthly. However, it will be better to reduce this number to zero. Operational expenses associated with replacing missing wheelchairs are huge. In 2017, 100 new wheelchairs were purchased at $5,000 each. This expensive transport equipment saves the hospital about $200,000 annually if they don't have to replace missing wheelchairs.

3.2 Project Findings and Next Steps

The application of the fishbone diagram provided clear insights into the multifaceted nature of the wheelchair loss issue. By structuring the problem across various categories as suggested by Andersen, Fagerhaug, & Beltz (2010), we could pinpoint specific operational inefficiencies and procedural gaps that contributed to the losses, thereby guiding our development of targeted interventions [16]. Our findings from the interviews indicate that the investment in Stryker wheelchairs has significantly contributed to reducing the number of missing wheelchairs within the NIH Clinical Center. Staff members, including nurses and patient escorts, have reported a notable decrease in such incidents since introducing these new units. The unique design of the Stryker wheelchairs makes them easier to manage and retrieve, thus enhancing efficiency and availability. This investment not only improved wheelchair logistics but also reduced the time staff spent locating and retrieving wheelchairs, allowing them to focus more on patient care. The positive impact of this investment highlights the importance of considering high-quality, durable medical equipment in healthcare settings to improve operational efficiencies and patient services. These findings suggest that similar investments in other clinical settings could yield substantial benefits in managing resources more effectively and improving overall healthcare delivery. Designing a solution for tracking wheelchairs can ensure savings. The purchase of the new Stryker wheelchairs leads to a reduction in the percentage of missing wheelchairs.

Table 3. Reduction in the percentage of New Stryker Wheelchairs

Month	Percentage of missing wheelchairs
December 2017	0%
January 2018	19.40%
February 2018	32.10%
March 2018	20.10%
April 2018	19.41%
May 2018	17.20%

3.3 Challenge

One of the limitations of our approach was the application of the PDSA cycle, which can sometimes lead to insufficient recognition of the underlying complexities within healthcare systems [18]. Future projects could benefit from integrating additional systemic thinking approaches to address the gaps identified in this critique. In addition, meeting with all the relevant stakeholders at the same time was a challenge. Also, the compatibility and interoperability of new tracking and management systems with the hospital's current software infrastructure presented some technical difficulties. There were also concerns regarding the security and privacy of tracking systems that gather and retain patient data.

3.4 Recommendation

1. A policy should be in place to enforce the return of wheelchairs used by patients or patient relatives to the lobby or parking lot storage area.

2. The process for requesting wheelchairs should be automated—it may not be a significant cost, but it would make the process more accurate and manageable. The system can confirm the last known location of a wheelchair.

3. It may be worthwhile to contemplate investing in Stryker wheelchairs for our fleet. These chairs are known for their durability, robustness, ease of maintenance, and lower susceptibility to theft. By investing in these chairs, we can effectively lower operational costs and enhance the quality of patient care.

4. Table 2 outlines a tracking system that uses a comprehensive spreadsheet to monitor wheelchair movement and utilization. This spreadsheet is critical for documenting each wheelchair's location and status. Regular systematic collection and analysis of the data captured through the spreadsheet can evaluate the system's effectiveness and identify areas for improvement. Further research can provide valuable insights into the tracking system's impact and guide continuous improvement efforts.
5. Upgrading the current wheelchair tracking system to incorporate Radio Frequency Identification (RFID) technology is strongly recommended. This advanced system offers real-time tracking and management of wheelchairs, which significantly reduces the risk of asset loss or theft. The initial investment of approximately $50,000 is a wise decision when weighed against the $500,000 value of the wheelchair fleet. By adopting RFID technology, asset security and operational efficiency would be greatly enhanced, leading to substantial long-term savings and improved resource management.

Additional benefits of adopting RFID technology include:

- Non-Line-of-Sight Operation: RFID does not require visual contact to detect and track tags, facilitating more flexible and less intrusive asset monitoring.
- Extended Range Capabilities: RFID readers can detect tags from a significantly greater distance than other tracking technologies, enhancing asset management efficiency.
- Simultaneous Multi-Tag Reading: RFID systems can read multiple tags simultaneously during high-traffic periods, streamlining the tracking process.
- Data Storage on Tags: Essential data can be stored on the device using tags to track each asset and record its history.
- Enhanced Security: RFID tags can be secured with encryption and passwords to protect sensitive data from unauthorized access.
- Versatile Tag Design: RFID tags can be designed to fit various asset types and operational requirements and come in various sizes and shapes.
- Adjustable Read and Track Distances: The technology enables modifying reading ranges to suit the specific spatial requirements of various environments.
- Labor Efficiency: Once implemented, an RFID system requires minimal human intervention, reducing labor costs and human error while increasing operational efficiency. It does not require a direct line of sight to operate.

4. CONCLUSION

This study concludes that the decision made by NIH to invest in Stryker TC wheelchairs was not only wise but also proved to be highly beneficial. Introducing these wheelchairs resulted in a significant decrease in the incidence of missing wheelchairs, reducing from 50% to 20% monthly. This change resulted in substantial cost savings, conserving approximately $200,000 annually in operational expenses that would otherwise be spent on replacing lost equipment. Despite the initial high cost of these advanced transport solutions, the long-term savings and operational efficiencies they offer are undeniable.

Healthcare administrators should consider making similar strategic investments as a standard practice to ensure high-quality care delivery and operational excellence. This research provides a clear and compelling case for adopting innovative solutions that address common logistical challenges in healthcare settings, paving the way for more efficient and effective patient care across the industry.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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