Developing a Quick Isolation Bed Inquiry System During the COVID-19 Outbreak: User-Centered Design Approach Based on Toyota Production System

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Abstract

Background: During the COVID-19 outbreak in May 2021, our hospital, designated as a specialized facility for treating severely infected patients, faced critical staff and resource shortages. Efficient bed management and quick bed assignments were paramount to ensuring patient safety and treatment outcomes. Leveraging the Toyota Production System (TPS) mindset and Toyota Business Practice (TBP) problem-solving methodology, we aimed to develop a rapid solution to address this challenge.

Objective: To design a Quick Isolation Bed Inquiry System that provides real-time information on hospital bed availability, ensuring timely admissions without increasing manpower or costs.

Methods: We applied the eight-step problem-solving process of TBP, supported by TPS principles such as just-in-time and autonomation. The steps included clarifying the problem, breaking it down by constructing a value stream map, setting targets, analyzing root causes, and developing and implementing countermeasures. The system was built on the hospital's existing bed inquiry platform, utilizing Microsoft Excel's Visual Basic for Applications (VBA) to automate manual tasks. The process evolved through three cycles of problem-solving and iterative improvement.

Results: The Quick Isolation Bed Inquiry System, developed using VBA automation, significantly streamlined the bed inquiry process. It generated three outputs: a PDF for administrators, a large-screen view for bed control physicians, and a mobile-friendly version. Previously reliant on manual phone calls, the system reduced report generation time to 4 seconds, with PDF distribution via the hospital's LINE group (LY Corp) in 7 seconds. Later integrated into the hospital's virtual private network (VPN), it enabled authorized staff to check bed availability in real-time, from anywhere, supporting just-in-time practices. Even after the hospital's COVID-19 duties ended, the system continued to operate efficiently for general wards, with ongoing improvements.

Conclusions: The eight steps of TBP process, combined with the TPS thinking, enabled the rapid development of a Quick Isolation Bed Inquiry System. The system eliminated unnecessary steps, optimized processes, and could be operated by any authorized staff member. It facilitated the timely admission of COVID-19 patients, meeting authorities' expectations without additional manpower or costs. Continuous improvement opportunities remain, including further automation for report distribution, making the system adaptable for future needs.

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Abstract

Background:

During the COVID-19 outbreak in May 2021, our hospital, designated as a specialized facility for treating severely infected patients, faced critical staff and resource shortages. Efficient bed management and quick bed assignments were paramount to ensuring patient safety and treatment outcomes. Leveraging the Toyota Production System (TPS) mindset and Toyota Business Practice (TBP) problem-solving methodology, we aimed to develop a rapid solution to address this challenge.

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To design a Quick Isolation Bed Inquiry System that provides real-time information on hospital bed availability, ensuring timely admissions without increasing manpower or costs.

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Keywords: A3; autonomation; continuous improvement; COVID-19; just-in-time; problem solving; PDCA; Toyota Business Practice; Toyota Production System; value stream map

Introduction

In May 2021, our country experienced a severe COVID-19 outbreak. Our hospital was the first in the capital region designated by the government as a specialized COVID-19 treatment facility, tasked with accommodating 148 beds for severely ill patients. All COVID-19 patients in the capital region requiring hospitalization were prioritized for admission to our hospital. At the time, with the risks of caring for COVID-19 patients still unclear, some medical staff resigned or refused to participate in COVID-19 care. The remaining team not only managed inpatient care but also supported COVID-19 patients in the community and other institutions, creating a significant staffing challenge, especially for those treating severely ill patients.

The most pressing challenge was managing available beds and quickly assigning them to patients, as mandated by the National Disease Control Bureau and the Municipal Health Bureau. Under normal conditions, bed allocation was handled by the Medical Affairs Office, which assigned beds based on availability and patient needs. However, during the outbreak, we lacked both manpower and a clear system to provide real-time updates on bed availability to hospital management. In response, the hospital superintendent assigned the Vice Superintendent, the Head of Internal Medicine, and the Head of Surgery to oversee bed management and ensure swift allocation to COVID-19 patients.

Managing bed availability is a common challenge for hospitals, even under normal circumstances, as noted in existing literature [1-7]. However, during the COVID-19 outbreak, no literature was available on rapid bed allocation methods or platforms for real-time bed assignment. Without dedicated personnel or prior models to follow, senior physicians faced the unprecedented challenge of quickly determining all available beds in the hospital and allocating them rapidly to patients.

Our department has a long history of studying and implementing the Toyota Production System (TPS), also known as Lean management or Lean production. We recognize that TPS offers a systematic and efficient approach to problem-solving and overcoming challenges [8-9]. Previously, we successfully applied TPS principles to develop a user-centered surgical scheduling system [9]. In this case, our goal was to develop a Quick Isolation Bed Inquiry System within three days, utilizing existing resources. This system would be accessible to all authorized staff, not just doctors, and

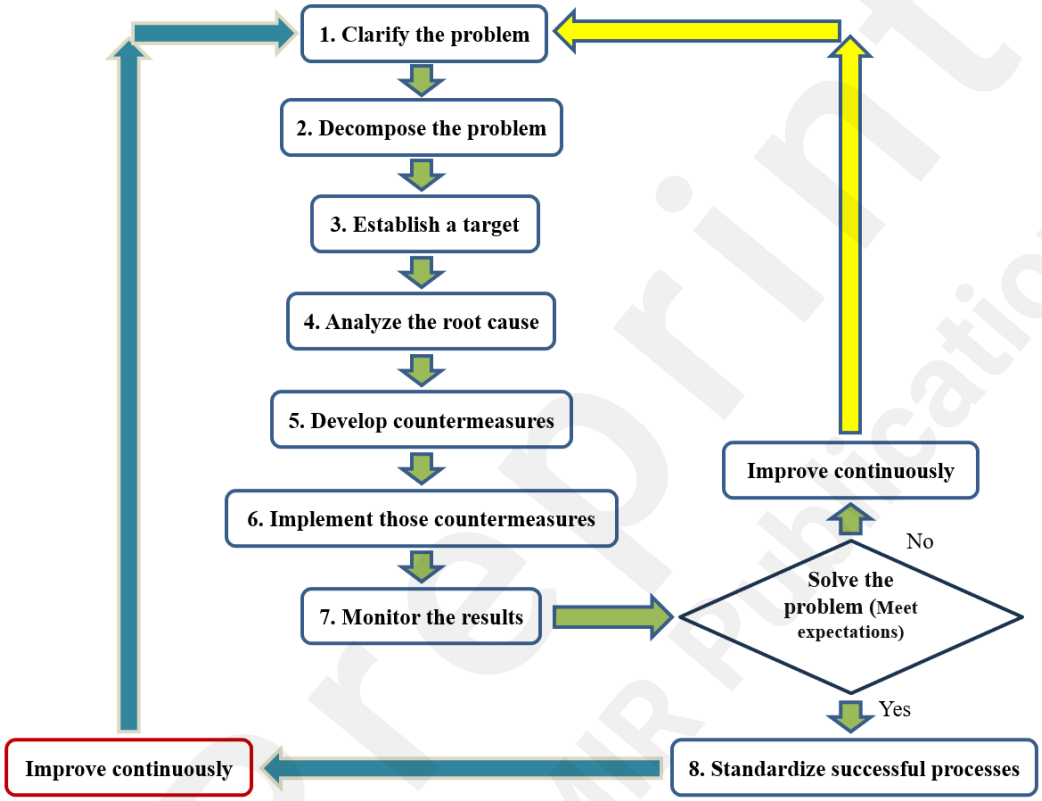
provide immediate bed availability information to hospital administrators and bed control physicians.

Materials and methods

Study Design

We followed the eight-step problem-solving framework of Toyota Business Practice (TBP), leveraging tools and methods from the TPS [10-12]. The TBP process involves the following steps: (1) clarify the problem, (2) break it down, (3) set a target, (4) analyze the root cause, (5) develop countermeasures, (6) implement those countermeasures, (7) evaluate results and processes, and (8) standardize and share the successful approach [8,10]. These steps are supported by TPS's core principle of continuous improvement, an essential mindset throughout the process [8-9,10-14], as shown in **Figure 1**.

Figure 1. The structured eight-step problem-solving framework of Toyota Business Practice.



The TPS thinking referenced here stems from key insights by Mr. Taiichi Ohno, the founder of the TPS, as outlined in his 1988 book Toyota Production System [11]. Additional concepts are derived from Lean Thinking by Womack and Jones [12], both of which provide essential frameworks for problem-solving and process improvement.

The first cycle of TBP

Step 1: Clarify the Problem

TPS Thinking 1: Problem identification begins with a need or expectation [11]. Once expectations are defined, direct observation and data collection at the workplace are essential to assess the current situation. A problem arises when there is a gap between expectations and the current situation [11-12].

Expectations: The hospital superintendent expected immediate and accurate information on bed availability to ensure the prompt admission of COVID-19 patients. Bed control physicians (including the Vice Superintendent, Head of Internal Medicine, and Head of Surgery) were responsible for posting available bed information in the Critical Care Bed Coordination Group via the LINE messaging app (LY Corp) and promptly assigning beds to patients.

Current situation: After clarifying leadership's expectations, we adhered to TPS principles by conducting on-site observations and collecting real data, rather than relying on secondhand

information or meetings. This direct assessment revealed that current hospital procedures and systems were unable to provide timely bed availability information, highlighting a clear gap between expectations and actual performance.

Impact: This issue of delayed bed availability information could compromise patient safety and treatment quality, making it a critical problem that must be addressed.

Step 2: Break down the problem

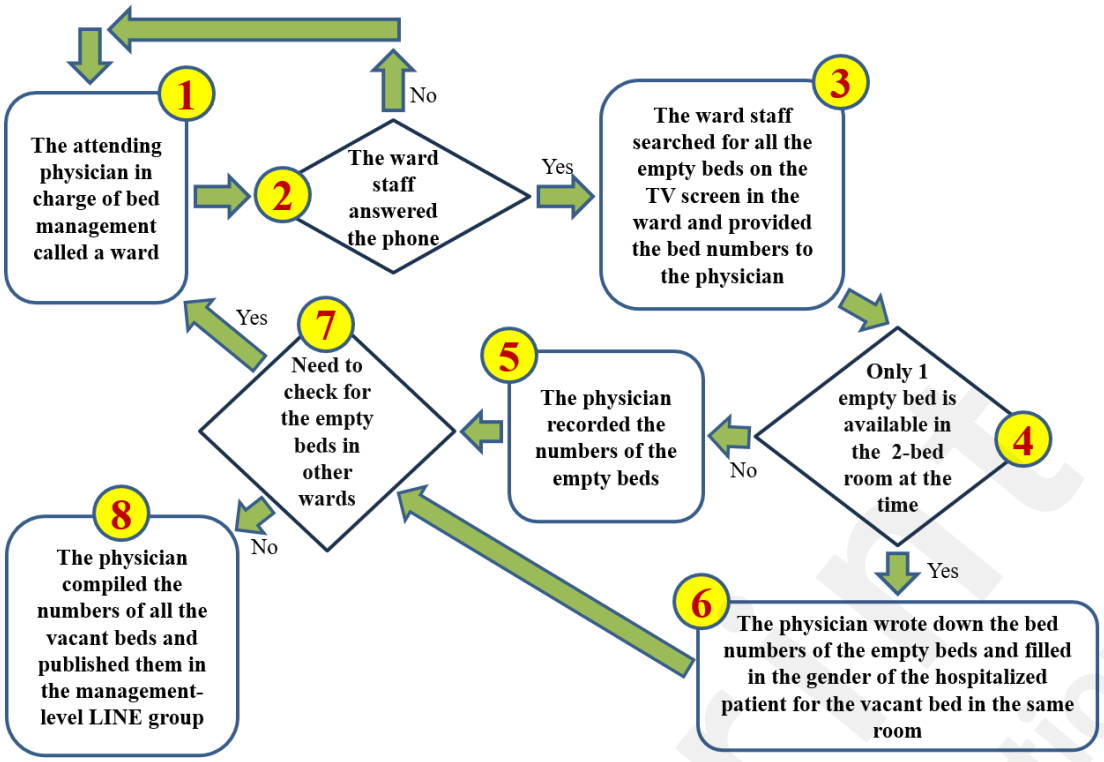
TPS Thinking 2: To break down the problem, it's essential to visit the workplace, either to perform tasks firsthand or observe directly, while gathering relevant numerical data. This information is then used to create a value stream map (VSM) to visualize the problem [11,12,15].

Initially, our hospital opened two wards (A9 and A8). Under emergency conditions, bed control physicians had to individually call each ward to check bed availability. As patient numbers increased, three wards (A9, A8, A7) were opened within a week, eventually expanding to four wards (A9, A8, A7, A6) with a total of 148 beds. The bed control physicians contacted nursing staff or clerks in each ward to count available beds, recorded the data, converted it into text, and posted it in the Critical Care Bed Coordination Group on the LINE messaging app.

It is important to note that hospital policy requires that only patients of the same gender (except couples) can share a double room in isolation wards. Therefore, when one bed in a double room is occupied, the gender of the patient must be identified and recorded to ensure compliance when displaying the remaining vacant bed.

Since we had no prior experience or information on querying bed availability, we conducted the search for bed availability ourselves. **Figure 2** illustrates that each step in the bed availability query process provided valuable insights for bed control physicians. Through hands-on operation and data collection, we gathered key numerical data, summarized in **Multimedia Appendix 1**. This table highlights the shortest time required to retrieve available bed information, as observed by one author acting as a bed control physician. To address the uncertainties in Step 2, such as unanswered calls, we excluded non-value-added activities like calls going unanswered, wait times exceeding 30 seconds, or the need to redial. Thus, the data collected only includes instances where ward staff answered the call within 30 seconds. We also recorded the time it took for the ward staff to locate available beds on the TV screen and for the surgeon to document vacant bed numbers.

Figure 2. Mapping the entire process of querying bed availability led to the creation of a value stream map.



Multimedia Appendix 1 shows that the average shortest query time was 454 seconds (7 minutes and 34 seconds), which did not meet management's expectations for immediate bed availability to expedite patient assignments. To improve bed management, the hospital superintendent mandated that bed control physicians report bed availability to the Critical Care Bed Coordination Group at 8 AM, 12 PM, 4 PM, and 8 PM daily. To comply with this directive, physicians must start checking available beds 20 to 30 minutes before each reporting time.

Step 3: Establish a target

TPS Thinking 3: All problems arise due to the existence of waste. Prioritize eliminating the most significant and impactful waste identified in the VSM, with a defined deadline for achieving the target [11,12].

As shown in Step 2 of **Figure 2**, the main issue stems from ward staff being too busy to answer calls, leading to significant delays and inefficiencies. The goal is to reduce the instances of phone calls taking more than 30 seconds to be answered by 50% within 3 days.

Step 4: Analyze the root cause

TPS Thinking 4: The root cause of any problem lies in the presence of waste. To identify this waste, TPS employs the "Five Whys" technique, which helps drill down to the root cause by repeatedly asking "why" [11-12].

In order to identify the root causes based on the set target and the contents of the VSM, **Multimedia Appendix 2** illustrates how we applied the “Five Whys” method to identify the root cause of the issue: “Why aren't calls answered promptly?”. Different ways of asking may lead to different root causes.

After asking the "Five Whys," it became clear that the root cause of the ward's inability to answer phone calls was a shortage of staff. Furthermore, with the priority placed on patient care, the head nurse could not guarantee that someone in the ward would be available to answer the phone immediately.

Step 5: Develop Countermeasures and Step 6: Implement Countermeasures

TPS Thinking 5: Countermeasures should be developed based on the root cause and goals, prioritizing those that address major issues or are simple to implement. Ideally, the problem solver should take direct action on-site [11,12].

To address the root cause and achieve our goals, we developed two countermeasures. First, assign ward staff to regularly check and report bed availability at four scheduled intervals or proactively notify available beds. Second, if no staff is available, the bed control physician should personally check bed availability at the nursing station. If the first countermeasure is successful, it will reduce the time physicians spend making follow-up calls and meet the hospital superintendent's expectations. However, during emergencies or when ward staff are unresponsive, the second countermeasure ensures immediate access to bed availability information. While implementing countermeasure 1, we observed the actual situation and collected relevant numerical data simultaneously.

Step 7: Evaluate the pilot results and the process

TPS Thinking 6: To verify the results, it is necessary to return to the workplace where the problem originated, observe the implementation in practice, and collect numerical data [11,12].

Although the head nurse indicated that they aim to ensure someone is available at the nursing station to answer calls during these specific times, during the implementation of the first countermeasures, we observed that a key issue identified in the VSM was the frequent delay or failure of nursing and administrative staff in isolation wards to answer calls (**Figures 2**, step 2), especially during evening shifts (data not shown). This forced bed control physicians to repeatedly call or contact other wards and redial unanswered ones, creating a potential loop in Steps 1 and 2. The delays were primarily due to reduced staffing during the evening shift (starting at 4:00 p.m.) and the absence of administrative personnel. Given these constraints, assigning staff specifically for bed availability checks was not feasible.

When the ward cannot answer the phone, the second countermeasure effectively locates available beds but has notable drawbacks. First, bed control physicians moving between nursing stations violates infection control protocols. Second, real-time updates on bed availability cannot be provided to administrators when changes occur. To address these issues, TPS principles were applied to optimize existing resources without increasing staff.

TPS Thinking 7: Prioritize process improvement and equipment optimization before considering increasing manpower. Adding staff should be the last resort. [11,12]

To address bed management efficiency, we conducted a detailed review of the VSM again (**Figure 2**). We found that the primary method for checking bed availability involved ward staff searching for empty beds on the ward's TV screen (step 3). This indicated that the hospital's bed management was already digitized, suggesting the presence of a database tracking bed occupancy and patient information.

Following this valuable discovery, we consulted with the Medical Affairs Office, which is responsible for admissions and discharges. They confirmed that the hospital's information system (HIS) includes a bed inquiry platform that contains essential inpatient data.

The second cycle of TBP

Step 1: Clarifying the Problem

*Expectations***:** Bed control physicians expect the hospital bed inquiry platform to provide all the necessary information required by authorities.

Current Situation: The hospital bed inquiry platform displays a menu (see **Multimedia Appendix 3**) and returns 761 bed records upon accessing the system. Each record includes 28 fields, such as bed number, patient name, medical record number, gender, admission date, discharge date, and attending physician. Of the 761 beds, 399 are for acute care, while the remaining beds consist of deactivated beds (215), post-op recovery beds (6), dialysis beds (36), emergency/virtual observation beds, long-term respiratory care beds, psychiatric day care beds, and nursing home beds.

When reviewing available beds using the platform's built-in menu, 488 active beds are displayed, each with 28 fields. However, we only needed information for 148 beds, with only 3 relevant fields: bed number, medical record number (for occupancy), and gender. This demonstrates that the system provides unnecessary information.

The platform has a query function that allows bed availability checks by ward (see **Multimedia Appendix 4**). All combinations of the inquiry functions were tested. Currently, identifying double occupancy rooms requires consulting a reference table. To find gender-specific beds, users must manually scan the 488 active beds, visually tracking the relevant data, which involves moving the mouse pointer across the screen.

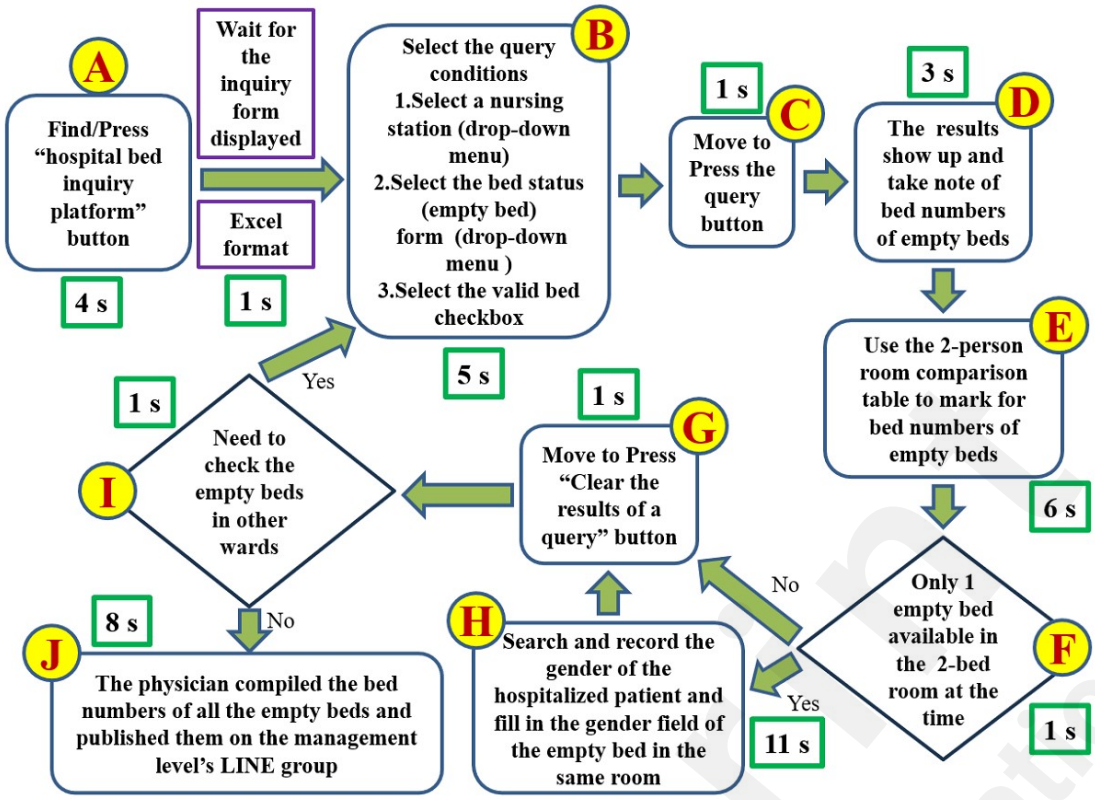
This inefficiency reveals that the current system does not meet physicians' expectations, highlighting a significant issue that needs to be addressed.

Impact: Delays in determining bed availability jeopardize patient safety and the quality of future care.

Step 2: Break down the problem

Figure 3 illustrates the VSM, showcasing the most efficient method we identified for querying available beds hospital-wide. The times, measured in seconds, reflect the minimum duration needed for a proficient physician to locate one available bed. Steps E and H were found to be the most time-consuming, taking 17 seconds to identify a single bed. If more beds are available (e.g., 10), the time needed for steps E and H increases significantly.

Figure 3. The value stream map illustrates the built-in query function of the hospital bed inquiry platform, used to check all available beds across the hospital. The times shown in seconds reflect the fastest possible query duration for a physician proficient in computer operations, assuming only one available bed is found. These represent the minimum time required for the query process. s: seconds.



Step 3: Establish a target

Our goal is to reduce the time spent on steps E and H by 50% within 3 days.

Step 4: Analyze the root cause

To identify double-occupancy rooms, we currently rely on a comparison table (**Figure 3**, step E). In collaboration with the Medical Affairs Office, we applied the "Five Whys" method to pinpoint the root cause (see **Multimedia Appendix 5**). The challenge stems from the fact that double-room designations depend on real-time factors, such as available equipment and ward conditions, preventing the establishment of a standardized guideline. As a result, identifying double-occupancy rooms still requires using the double room comparison table for reference.

We ask "Five Whys" to determine the root cause of the step H (data not shown). The root cause is that the hospital's information system is unable to automatically identify the gender of the patient in the adjacent bed in double rooms.

Step 5: Develop Countermeasures and Step 6: Implement Countermeasures

Based on the root cause analysis and established targets, two countermeasures were proposed. First, for step E, bed control physicians were tasked with memorizing the comparison table to expedite data comparison, potentially reducing processing time. For step H, Medical Affairs Office staff were instructed to input the patient's gender into the bed management system during admission, resolving the gender mismatch issue for double-occupancy rooms. The second countermeasure involved enhancing physicians' proficiency in quickly searching bed numbers and gender in the

system, further decreasing task completion time. During implementation, we continuously monitored the process and collected relevant data to evaluate the effectiveness of these measures.

Step 6: Evaluate the pilot results and the process

After actual operation, the bed control physicians found the process excessively complicated. Checking the availability of a single isolation room required at least 8 steps, involving multiple mouse clicks and selections, leading to eye and wrist strain. The method still relied on manually using the comparison table to determine and record gender, missing opportunities to leverage the computer system's advantages, such as speed, real-time processing, and automation. Even for experienced physicians, memorizing the double-room comparison table proved difficult. As a result, no one opted to use these built-in functions for checking hospital-wide bed availability, highlighting the need for alternative solutions or areas for improvement.

TPS Thinking 8: Problems occur in the workplace, and the solutions to these problems must also be found in the workplace [11].

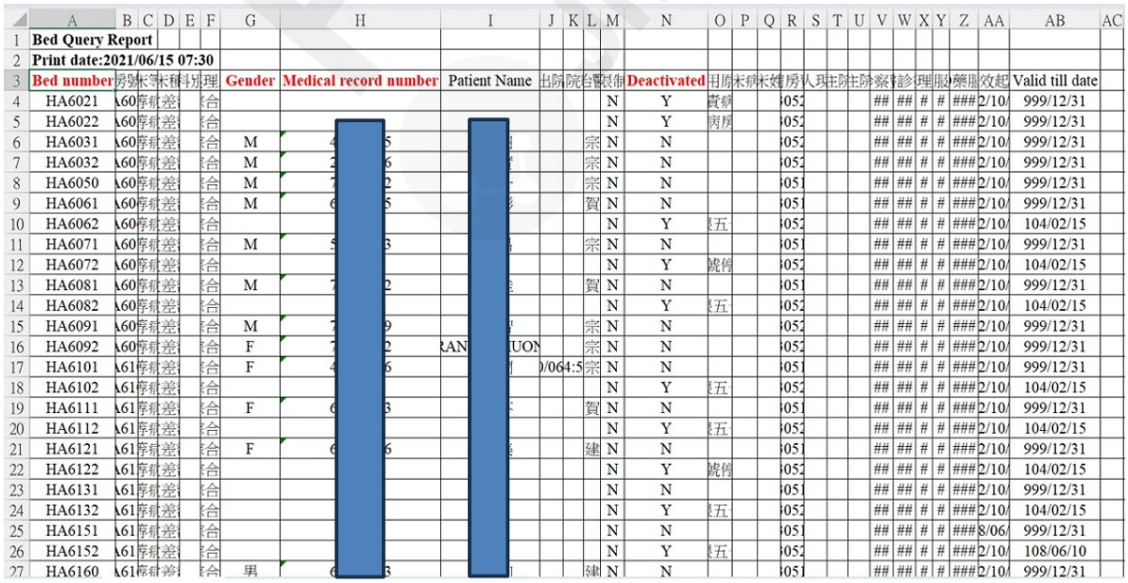
The third cycle of TBP

Step 1: Clarify the Problem with the Hospital Bed Inquiry Platform's built-in features

Expectation: We expected to leverage the hospital's computer information system for faster, repeatable, and more immediate bed availability inquiries, addressing staff shortages and the urgent need for quick bed assignments.

Current Situation: The hospital bed inquiry platform lacked real-time bed availability features and administrative access, limiting its functionality to meet our needs. However, upon further examination, we discovered an export function (**Multimedia Appendix 3**) that generates an Excel (.xls) file with 761 entries across 28 columns, referred to as the "Exported Raw Data .xls," as shown in **Figure 4**.

Figure 4: A simplified version of the Exported Raw Data .xls file. From the 28 available columns, only 3, highlighted in red, are necessary for use.

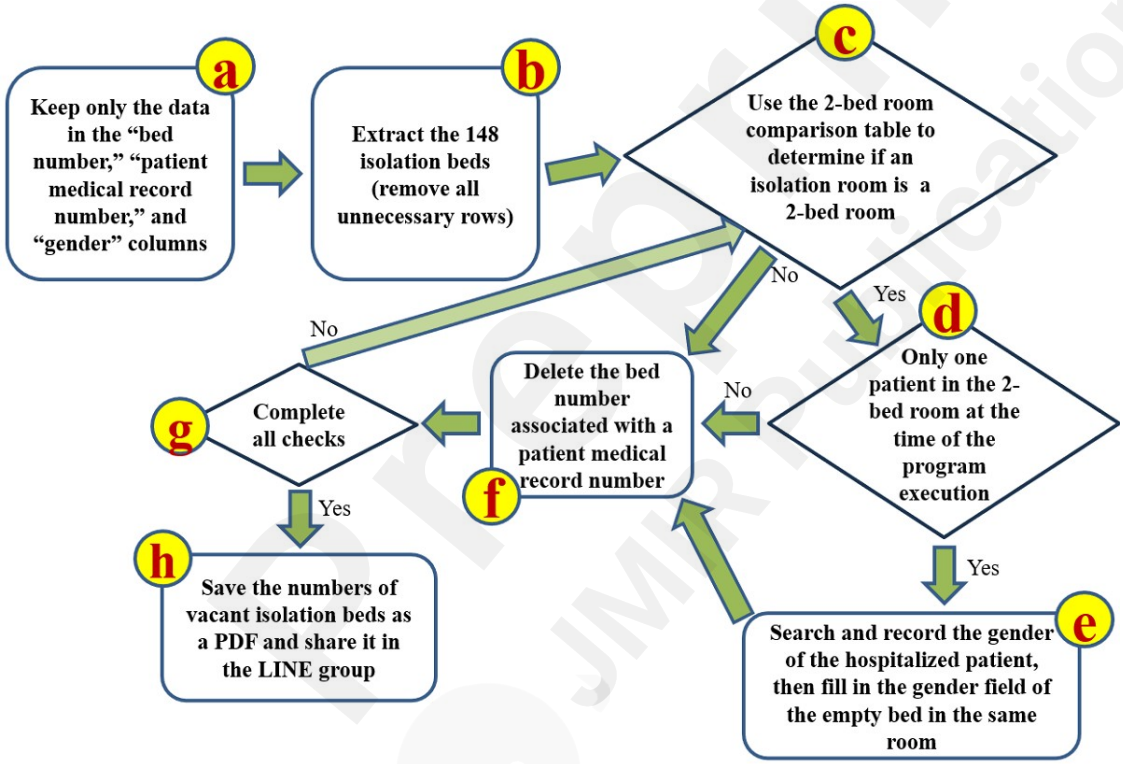


	A	G	H	I	M	N	AB
1	Bed Query Report						
2	Print date:2021/06/15 07:30						
3	Bed number	Gender	Medical record number	Patient Name	退制	Deactivated	Valid till date
4	HA6021				N	Y	999/12/31
5	HA6022				N	Y	999/12/31
6	HA6031	M			N	N	999/12/31
7	HA6032	M			N	N	999/12/31
8	HA6050	M			N	N	999/12/31
9	HA6061	M			N	N	999/12/31
10	HA6062				N	Y	104/02/15
11	HA6071	M			N	N	999/12/31
12	HA6072				N	Y	104/02/15
13	HA6081	M			N	N	999/12/31
14	HA6082				N	Y	104/02/15
15	HA6091	M			N	N	999/12/31
16	HA6092	F			N	N	999/12/31
17	HA6101	F			N	N	999/12/31
18	HA6102				N	Y	104/02/15
19	HA6111	F			N	N	999/12/31
20	HA6112				N	Y	104/02/15
21	HA6121	F			N	N	999/12/31
22	HA6122				N	Y	104/02/15
23	HA6131				N	N	999/12/31
24	HA6132				N	Y	104/02/15
25	HA6151				N	N	999/12/31
26	HA6152				N	Y	108/06/10
27	HA6160	男			N	N	999/12/31

Step 2: Break Down the Problems in the Exported Raw Data .xls

Upon reviewing the exported data, we identified that most of the information was unnecessary. Out of 761 total entries, only 148 active bed numbers, provided by the Medical Affairs Office, were relevant. Similarly, from the 28 columns per entry, only 3 were relevant: bed number, patient medical record number, and gender. The process to identify vacant beds involved filtering the data down to these 148 entries and focusing on the 3 key columns. A bed is considered available if there is no associated medical record number. For two-bed rooms, the gender of the admitted patient must be considered, as only patients of the same gender can share a room. **Figure 5** illustrates the VSM used to identify vacant beds from the Exported Raw Data (.xls) across the hospital

Figure 5. Value stream map for identifying vacant beds from the Exported Raw Data .xls across the hospital. The strategy focuses on filtering out unnecessary information, retaining only the bed numbers of the 148 isolation beds, along with the patient medical record numbers and gender. For double-occupancy rooms, if only one patient is present at the time of execution, the gender of the admitted patient must be considered when displaying the vacant bed number.



Step 3: Establish a target

The goal is to develop a user-friendly Quick Isolation Bed Inquiry System within 3 days, leveraging data from the Exported Raw Data (.xls) file. The system should allow anyone, not just physicians, to access real-time bed availability, enabling bed control physicians to quickly relay this information to hospital administrators.

Step 4: Analyze the root cause of Exported Raw Data .xls

The excess of irrelevant data in the exported file significantly hinders the efficient identification of available beds. Only the bed number, patient medical record number, and gender are deemed essential and valuable for this process.

Step 5: Develop Countermeasures and Step 6: Implementing Countermeasures

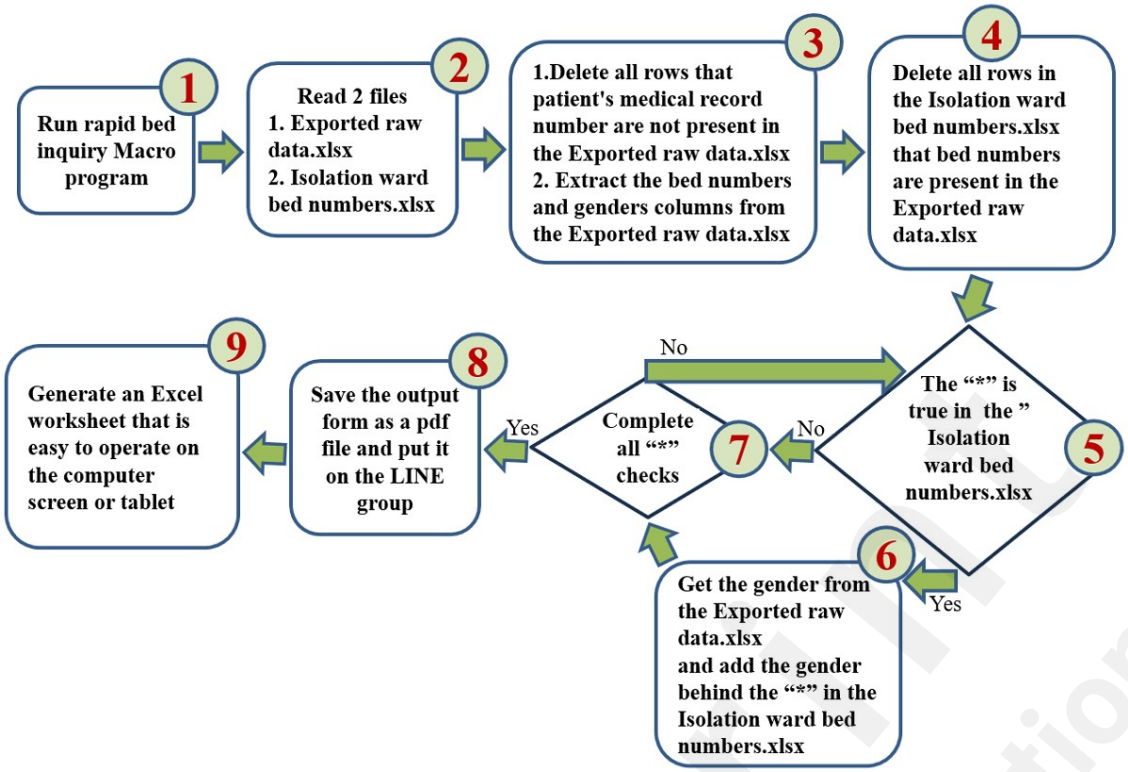
Based on the identified root cause and established targets, our countermeasure was clear: we needed to use the computer information system to eliminate unnecessary information. We explored two countermeasures: manual processing in Excel and automation using Visual Basic for Applications (VBA) to implement this plan through actionable steps.

The first countermeasure (manual process in Excel) involved having the bed control physician manually process the exported data file in Excel. The steps were as follows:

1. Delete the first two rows and unnecessary columns, retaining only the bed number, patient medical record number, and gender.
2. Use the "Deactivated" column (cell N1) as a sorting header, then sort and remove all rows marked "Yes (Y)," leaving 488 usable beds.
3. Filter these beds to retain only those from the A9, A8, A7, and A6 wards.
4. Use the double-room comparison table to mark the gender of patients in double-occupancy rooms. If a room is partially occupied, the gender of the patient must be noted when displaying the vacant bed.
5. Finally, sort by the medical record number column (cell I1) and remove all occupied beds. The remaining vacant beds are then recorded and shared in the LINE group.

The second countermeasure (automated process using VBA) utilized Excel's VBA to automate the manual process. With prior experience developing a surgical scheduling system using VBA, we recognized the potential to streamline this task by creating a macro [9,16]. Before coding, we drafted an algorithm using the technique of constructing a VSM, converting the manual steps into a computer-executable workflow [16,17]. The algorithm in **Figure 6** served as the blueprint for the VBA macro, automating the sorting, deletion, and comparison tasks in the first countermeasure.

Figure 6. An algorithm based on value stream map construction techniques was used to develop an Excel's Visual Basic for Applications (VBA) macro that automates the manual processes of sorting, deleting, and comparing data.



During program development, we anticipated fluctuations in the number of isolation ward beds due to changes in patient numbers or nursing staff availability. To manage this, we stored the current 148 bed numbers in a separate file, Isolation Ward Bed Numbers.xlsx. Any future updates to bed numbers would require changes only to this file. An adjacent "Notes" column was used to provide key details about each bed. Double-occupancy rooms were marked with an asterisk (*), while beds equipped for dialysis were labeled "HD" (hemodialysis), as illustrated in **Figure 7**.

Figure 7: A simplified version of the Isolation Ward Bed Numbers.xlsx format. When the program runs, columns DE, GH, JK, and MN are merged into column AB. Column A lists the available bed numbers, while column B (the Notes column) records bed characteristics. For example, a "*" signifies a two-bed room, "HD" indicates a dialysis-ready bed, and "INS" marks that the patient in the adjacent bed has mental instability.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Bed number	Notes		Bed number	Notes		Bed number	Notes		Bed number	Notes		Bed number	Notes
2	HA9010	/HD		HA8111	/INS*		HA7020			HA6031	*		HICU17	
3	HA9020	/HD		HA8112	/INS*		HA7101	*		HA6032	*			
4	HA9030	/HD		HA8121	*		HA7102	*		HA6050				
5	HA9050	/HD		HA8122	*		HA7131	/HD*		HA6091	*			
6	HA9060			HA8131	/HD*		HA7132	/HD*		HA6092	*			
7	HA9070			HA8132	/HD*		HA7210	/HD		HA6101				
8	HA9080			HA8210			HA7221	*		HA6111				
9	HA9090			HA8320			HA7222	*		HA6121				

The Excel macro was fully operational within 3 days after being written and debugged.

Ethical Considerations

According to local legislation and institutional requirements, ethical review and approval were not required for this type of project, which involves analyzing operational procedures without direct intervention on human participants. Please refer to the Personal Data Protection Act [18], Chapter I (General Provisions), Article 6, which outlines exceptions for data collection in the contexts of healthcare, public health, or crime prevention research, provided such data cannot lead to the identification of specific individuals.

Consistent with national legislation and institutional requirements, written informed consent was not required for this study [19]. For more details, please refer to **Multimedia Appendix 6**. This document includes an official administrative document released by the government and its English translation. All data were de-identified to ensure privacy and confidentiality. No compensation was provided to participants, as the study did not involve any direct participation. It is also ensured that no individual participants/users can be identified in any images in the manuscript or supplementary materials.

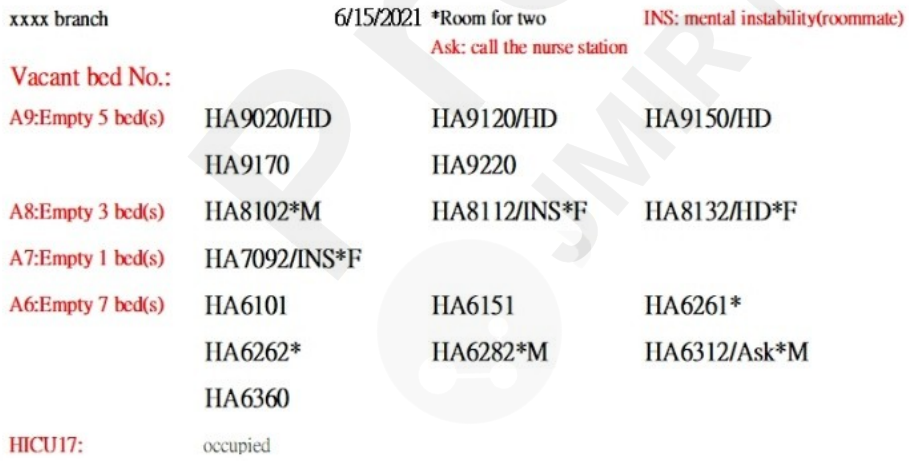
Results

Step 7: Evaluate the Results and the Process

The Excel macro is highly user-friendly. By simply pressing a large button in the worksheet, users can generate three forms within 4 seconds:

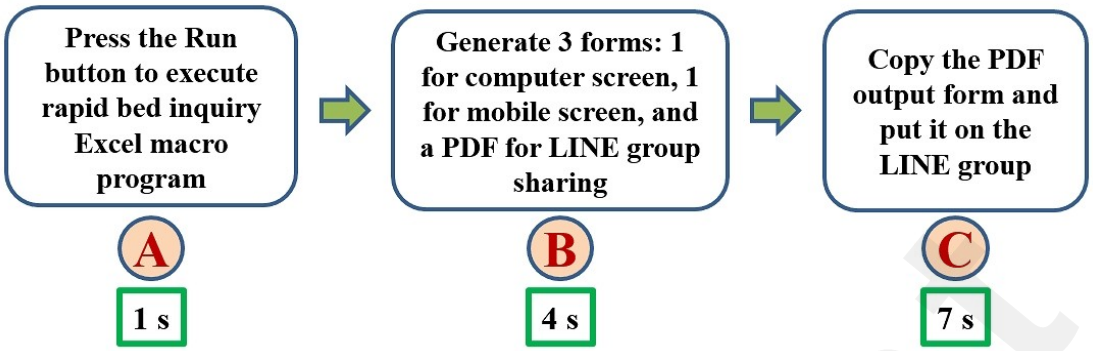
1. PDF Form: Designed for upper management, this form is automatically exported in PDF format and shared via the LINE group for quick reference (**Figure 8**).
2. Large-Screen Form: Tailored for bed control physicians, this version is optimized for viewing on large screens such as computer monitors or tablets (**Multimedia Appendix 7**). The space below the bed numbers in the worksheet allows users to input and store basic patient information and diagnoses for future reference.
3. Smartphone Form: This mobile-friendly version is created for bed control physicians to use on smartphones (**Multimedia Appendix 8**).

Figure 8. PDF form exported for upper management reference. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.



The completion of the isolation ward bed inquiry Excel macro has greatly improved the efficiency of bed control physicians in querying available beds, resulting in an updated VSM showing the enhanced workflow (**Figure 9**). After downloading the Exported Raw Data.xls, the macro generates 3 output forms in as little as 4 seconds (step B), and the fastest PDF report is sent to the LINE group in 7 seconds (step C). The macro also prevents duplicate filenames by incorporating the execution date and time (down to seconds) into each file name.

Figure 9. The completion of the isolation ward bed inquiry Excel macro has significantly streamlined the process for bed control physicians to quickly query available beds, leading to an updated value stream map that reflects the improved workflow.



Step 8: Standardize and Share the Successful Process

The Excel macro generates a PDF and two bed availability forms with a single click, offering an efficient solution that meets the needs of bed control physicians while fulfilling hospital management's expectations for quick and accurate information. The program was stored in a designated hospital system folder, enabling authorized personnel to run it remotely via Virtual Private Network (VPN) at any time. It has also been adapted for Microsoft Office 365 and is publicly accessible (**Multimedia Appendix 9**).

Improve continuously

The Excel macro can be adapted for various applications with minor modifications or added functions. For example, incorporating ward codes allowed us to track availability and occupancy in each ward, and adding an attending physician’s list enabled us to monitor how many patients each physician was responsible for in different wards (see **Multimedia Appendix 10**). This demonstrates how small adjustments can extend the macro's functionality, reflecting the principle of continuous improvement.

Discussion

Principal Findings:

The TBP problem-solving process and TPS mindset facilitated the rapid creation of a Quick Isolation Bed Inquiry System, significantly improving bed allocation for COVID-19 patients. This system ensured timely admissions while fulfilling hospital requirements without additional staff or expenses. By applying various TPS principles, when we were unable to eliminate the root waste identified in the VSM **(Figures 2** and **3**), we instead focused on the value within the VSM and leveraged it, turning it into a foundational value. This approach led to the creation of a new VSM (**Figure 9**) to address our problem. Continuous improvement opportunities remain, including further automation through VBA integration and merging manual steps, allowing for even greater time savings and resource optimization within the hospital’s infrastructure.

The TPS serves as the foundation for the eight-step problem-solving process. This methodology was formalized by Toyota Motor Corporation in 2004 as the TBP [20]. TBP is known by various names across different fields, including the A3 problem-solving process, A3 document, A3 report,

and A3 methodology [21-23]. For those familiar with the PDCA (Plan-Do-Check-Act) cycle, widely used for problem-solving, efficiency improvement, and quality assurance, the TBP aligns closely with this framework. The "Plan" phase in PDCA is represented by the first five steps of TBP, while "Do" corresponds to TBP's sixth step, "Check" aligns with the seventh step, and "Act" with the eighth step [14,22]. TBP's focus on continuous improvement mirrors the cyclical nature of PDCA, as shown in **Multimedia Appendix 11**. This alignment highlights the importance of the planning phase, which is emphasized as the most crucial stage in problem-solving, reinforcing TBP as a powerful tool for effective issue resolution.

Verify problem resolution

To evaluate whether a problem has been effectively resolved according to TPS standards, both subjective and objective criteria are applied. Subjectively, from a user or customer perspective, a problem is considered solved when the product or service meets their needs and expectations. However, the provider must ensure the solution also aligns with the core TPS principles: just-in-time and autonomation, the two pillars of TPS [11,24]. For a solution to be fully resolved by TPS standards, it must comply with these foundational principles.

In healthcare, a problem is deemed resolved when patient care is safe, effective, timely, affordable, and of high quality. From a patient-centered view, success is measured by patient satisfaction with outcomes, costs, and waiting times. To meet these expectations, hospitals must implement management strategies that reduce costs, increase efficiency, and improve care quality, mirroring the TPS approach to customer satisfaction in manufacturing.

The needs of healthcare patients are similar to those of car buyers, making Toyota's management methods highly applicable in healthcare. Toyota developed the just-in-time and autonomation principles to address customer needs in production and management. As emphasized by Taiichi Ohno, these two pillars are crucial for achieving sustainable, effective solutions in any context, including healthcare [11].

Autonomation refers to machines imbued with human-like intelligence or automation with a human touch, designed to automatically stop when defective products or abnormal events are detected. By adhering to autonomation principles, we minimize abnormal events, ensuring the safety of products and services for customers. During the programming process, we continuously debugged and validated the accuracy of both the macro program and data output. Proper programming effectively prevents human errors, aligning with the core principles of autonomation. In the Isolation Ward Bed Numbers.xlsx file, we flagged abnormal situations and displayed them in the output forms. This allowed bed control physicians to quickly and accurately assess the status of vacant beds, enabling prompt and precise bed assignments, further reinforcing the autonomation approach.

Just-in-time refers to producing the right product in the right quantity at the right time. Mr. Ohno emphasized in his writings that achieving this standard requires the application of three key methods [11]: pull, leveling, and Kanban (visual management). By consistently applying these methods, we were able to rapidly develop the Quick Isolation Bed Inquiry System.

The pull method ensures that production responds directly to immediate demand, meaning products and services are created based on actual needs rather than forecasts, thus preventing overproduction [11,12]. In our case, all problem-solving efforts were focused on meeting the authorities' and bed control physicians' expectations, fully aligning with the pull method.

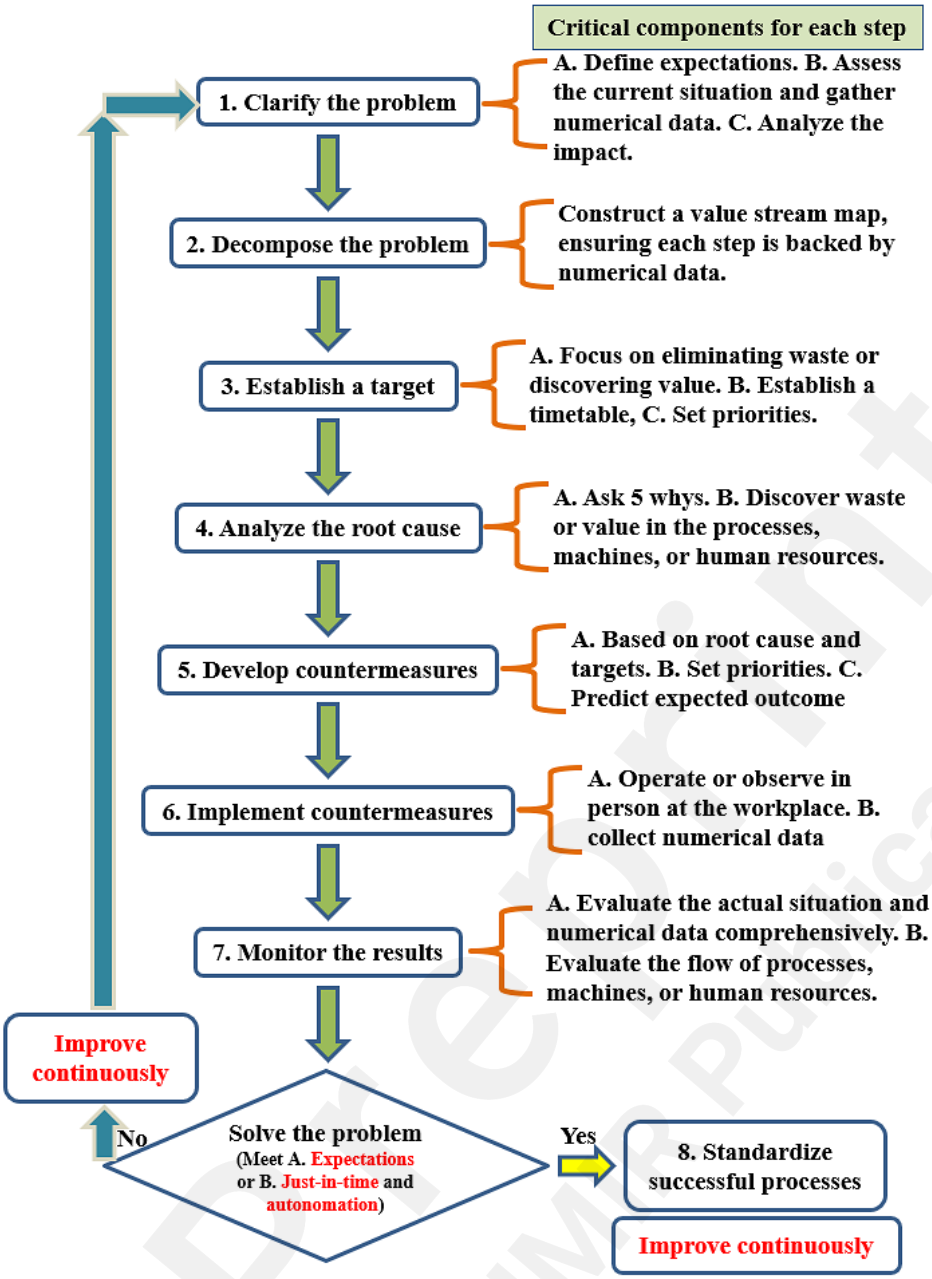
Leveling method involves evenly distributing workload and work intensity over time to reduce variations, which minimizes wait times and resource waste, such as equipment and labor [11,12]. By utilizing the developed Excel macro, we were able to distribute the workload of the bed control physicians, who were heavily burdened with querying bed availability. This allowed them to prioritize patient care and arrange admissions more efficiently. Additionally, the macro can be used by any authorized staff member, further sharing the workload of the bed control physicians, in line with the leveling method.

The Excel macro generates three types of electronic forms that quickly display bed availability and other relevant information, which aligns with the *Kanban method*. The program produces the necessary reports with the right information in a right amount of time when needed, effectively meeting the just-in-time and autonomation principles.

Highlight the key concepts of the TBP methodology

Figure 10 outlines the TBP problem-solving process, emphasizing the essential elements at each stage.

Figure 10. Overview of the Toyota Business Practice problem-solving process, detailing the critical components of each step.



Ohno consistently emphasized his strong belief in the concept of “gemba” (on-site work). Even after joining Toyota’s top management, he continued to spend most of his time at the workplace [11]. Therefore, it is no exaggeration to say that TPS is fundamentally about on-site management (*TPS Thinking 8*) [11-14]. According to Ohno’s statements, work activities are classified based on their contribution to value into three categories: waste, non-value-added work (necessary but non-value-adding activities), and value-added work [11-12]. Waste refers to the use of resources without creating value. Non-value-added work, while necessary under current circumstances, does not generate value and is still considered a form of waste. Value-added work refers to activities that directly enhance the original value [11-12]. TPS thinking asserts that a product or service is valuable only if it meets the needs and expectations of the user or customer [11-14]. It is essential to observe the workplace carefully to clearly distinguish between value-adding activities and wasteful actions.

In the "Clarify the Problem" step, the current situation should be described using objectively observed facts, avoiding emotional responses or personal value judgments as much as possible. The numerical data collected throughout each step of the workflow should be based on objective and

accurate measurements, in line with *TPS Thinking 1* [11,12]. This raises the question: which is more important, factual observations or numerical data? While Ohno valued numerical data, he believed that facts observed in the workplace were often more significant than the numbers alone [11]. From our experience, when numerical data and observed facts do not align, we take extra care to re-observe and verify the data.

From this study, it is clear that the data collected at the beginning allowed us to calculate averages or medians (see **Multimedia Appendix 1**). However, this data did not provide meaningful value in solving our problem. Since our goal was to quickly and immediately obtain available bed information, in the later stages of data collection, we focused solely on gathering information that would help us achieve this goal as efficiently as possible, as shown by the seconds recorded in **Figures 3** and **9**. This data cannot be analyzed for statistical significance as in typical scientific experiments. Our research emphasizes factual events, with numerical data playing only a minor role. This approach aligns with Ohno's belief that directly observing events in the workplace and ensuring smooth processes is far more important than focusing exclusively on data analysis [11].

A VSM is constructed using accurate and objective facts about the current situation. This map is created by chronologically sequencing all valuable components of the work or process, following *TPS Thinking 2* [8-9,12,15]. In theory, every activity within the value stream should add value. However, in practice, even value-added activities may contain elements of waste or non-value-added work. Developing a detailed VSM to break down the problem is a critical step [11-12,14]. This article presents three levels of VSMs. The VSM for problem breakdown in **Figure 2** leads to the VSM in **Figure 3**, and the problem breakdown in **Figure 3** leads to the VSM in **Figure 5**. This step-by-step process of extracting value and eliminating waste is an ideal demonstration of problem decomposition.

When establishing a target, two approaches can be considered. The first approach involves eliminating all waste in the VSM, which is the most fundamental concept of TPS, as outlined in *TPS Thinking 3* [11,12]. The second approach focuses on directly extracting value from the VSM and using this to create a new VSM [12]. We were able to develop the Quick Isolation Bed Inquiry System only after adopting the second approach, following the failure of the first approach during the first and second cycles. It is crucial to emphasize that when setting a target, a strict deadline for completion must be enforced.

In the "analyzing root causes" step, the primary task is to use the "Five Whys" technique, asking "why" five times to uncover the root cause of the problem, with reference to *TPS Thinking 4* [11]. Commonly, asking "why" 2 to 3 times reveals the main cause, but it often requires 4 to 5 iterations to identify the true root cause. If the root cause is not addressed, the problem is likely to recur. Only by eliminating the root cause can the issue be fully resolved [8,11-14]. A cause can be considered the root cause if it consistently leads back to the observed problem and aligns with the collected facts and data. The inferred root causes in our case align with these principles.

According to *TPS Thinking 5* and *TPS Thinking 7*, the "Develop Countermeasures" step should prioritize solving process-related issues first, then machinery-related problems, and finally human-related concerns. Each countermeasure must clearly define the expected outcomes before implementation. During the "Implement Countermeasures" step, it is critical to return to the workplace to observe the actual conditions and simultaneously collect relevant numerical data. We have always adhered to this principle.

Additionally, it is important to note that our success in meeting hospital superintendent's requirements and completing the task was largely due to our ability to write VBA programs [9]. We acknowledge that our programming skills are only at a moderate level, and we believe that if a professional programmer were to refine our VBA code, it would become more concise, and the program's execution efficiency would improve. Ohno repeatedly emphasized that "teamwork is everything" [11], and we believe that having a VBA programming expert on our team would enhance the execution efficiency and quality of our Quick Isolation Bed Inquiry System. This also underscores the significance of cross-team collaboration.

Meeting the expectations of users and customers can be considered as having achieved the goal, but only by fully attaining just-in-time and autonomation can it be called perfection [11,12].

Improve continuously

Continuous improvement is a core mindset in TPS, often regarded as the ultimate action within the system. Even when you're satisfied with progress and unsure of what else could be improved, it's important to always remember the final step, continuous improvement [11,12]. Since developing the Excel macro, we have successfully addressed the needs of both bed control physicians and hospital authorities, while meeting the just-in-time and autonomation principles. Although this suggests the problem is solved, the spirit of continuous improvement in TPS encourages us to explore further enhancements.

Looking ahead, there are at least two areas for potential improvement. First, by learning how to use VBA to send PDF files directly to the LINE group, we could merge Step C of **Figure 9** into Step B, further reducing operational time and conserving human resources. Additionally, if the hospital's information technology department integrates the Excel macro into the hospital's system, enabling the Exported Raw Data.xls to be downloaded and the macro to be executed with a single click, we would achieve true automation, aligning even more closely with the just-in-time principle.

In August 2022, the surgical department no longer had to manage COVID-19 patients. The hospital allocated 39 general ward beds to the department for regular surgical patients. To ensure fairness, surgeons agreed that each doctor would be assigned one bed for their patients, with the remaining beds distributed among subspecialties based on previous patient admission data. Minor adjustments were made to the Quick Isolation Bed Inquiry System's Excel macro to enhance transparency in bed allocation, as shown in **Multimedia Appendix 12**. This fair and transparent system allowed each doctor to manage their patients without conflicts. Adhering to hospital discharge policies, which required patients to be prepared for discharge the day before and discharged by noon, we were able to maximize bed utilization and efficiency.

Reflecting on the challenges of the COVID-19 pandemic, we remain committed to continuous improvement, embracing the principles of TPS and its problem-solving methodologies.

Limitations

This paper has some limitations. First, many hackers use macro programs to transmit viruses, which poses information security risks for computers. Therefore, enabling the Microsoft Excel macro function increases the risk of computer virus infection. To address information security concerns, the hospital information technology staff only allows authorized personnel to use approved computers (including those capable of using VPN). Second, Microsoft Office frequently updates, and if there are future version updates, it is possible that the Excel macro may no longer work. For example, our

Excel macro was developed using the 2016 version of VBA, but recently, when running it on Microsoft Office 365, syntax errors have occurred. After making a few minor modifications, **Multimedia Appendix 9** is now able to run on Microsoft Office 365.

Conclusion

The eight steps of the TBP problem-solving process, along with the TPS mindset, allowed us to systematically and rapidly develop a Quick Isolation Bed Inquiry System. The system eliminated unnecessary steps, optimized processes, and can be operated by any authorized staff member. This system enabled the timely admission of COVID-19 patients, meeting the expectations of the authorities without requiring additional manpower or costs. Continuous improvement opportunities remain, including further automation of report distribution. The system has proven effective in managing hospital bed availability, offering a sustainable solution adaptable to future needs.

Data Availability

The data sets analyzed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

C-CL, J-HS, S-LC, H-LH, C-YPL and H-MH: protocol and project development. C-CL, J-HS, H-LH, and H-MH: implementation of the protocol. J-HS, S-LC and C-CL: data acquisition and interpretation. C-CL, J-HS, S-LC, H-LH, C-YPL and H-MH: manuscript preparation. J-HS, S-LC and C-CL: define the algorithm and program coding. C-CL, J-HS, S-LC, H-LH, C-YPL and H-MH: manuscript revision and accountable for all aspects of the work. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Calculate the time spent (measured in seconds) on querying the availability of vacant beds in ward A9, A8, A7 and A6 based on the value stream map in Figure 2.

Multimedia Appendix 2

The “Five Whys” technique was used to identify the root cause of the problem: “Why aren't calls answered promptly?”

Multimedia Appendix 3

This is the menu screen of the hospital bed inquiry platform. When you press the “Query” button, the computer displays 761 bed records, with each record containing 28 fields.

Multimedia Appendix 4

The built-in query function of the hospital bed inquiry platform enables users to check bed availability across different wards in the hospital.

Multimedia Appendix 5

In collaboration with the Medical Affairs Office, we applied the “Five Whys” method to identify the root cause of the problem: “Why do we need to use the double room comparison table to identify double occupancy rooms?”

Multimedia Appendix 6

Scope of human research cases exempt from review by the ethics committee.

Multimedia Appendix 7

Large-screen form for use by bed control physicians on computers or tablets. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.

Multimedia Appendix 8

Smartphone form designed for mobile use by bed control physicians. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.

Multimedia Appendix 9

The original Excel macro code developed for the Quick Isolation Bed Inquiry System has been adapted for compatibility with Microsoft Office 365.

Multimedia Appendix 10

The Excel macro, with minor adjustments, offers versatility for various applications. For instance, integrating ward codes enabled us to efficiently monitor bed availability and occupancy across different wards, while adding an attending physician's list facilitated the tracking of patient loads for each physician across various wards. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.

Multimedia Appendix 11

The Toyota Business Practice (TBP) closely aligns with the Plan-Do-Check-Act (PDCA) cycle, a proven framework for problem-solving and continuous improvement. TBP's eight steps correspond to PDCA's four stages: the "Plan" phase includes the first five TBP steps, "Do" corresponds to the sixth step, "Check" to the seventh, and "Act" to the eighth. This alignment underscores the critical role of thorough planning in problem-solving and highlights TBP as a comprehensive tool for resolving issues effectively.

Multimedia Appendix 12

The Quick Isolation Bed Inquiry System's Excel macro can be easily adapted for a variety of applications with minor modifications or additional functions. By incorporating ward or department codes, we were able to track bed availability and occupancy in specific wards or departments. Adding an attending physician’s list also enabled us to monitor the number of patients each physician was responsible for across different wards. Additionally, the system can provide statistics on how many patients in each ward are expected to be discharged the following day. ENT: Otorhinolaryngology. CVS: Cardiovascular surgery. Obs/Gyn: Obstetrics and Gynecology.

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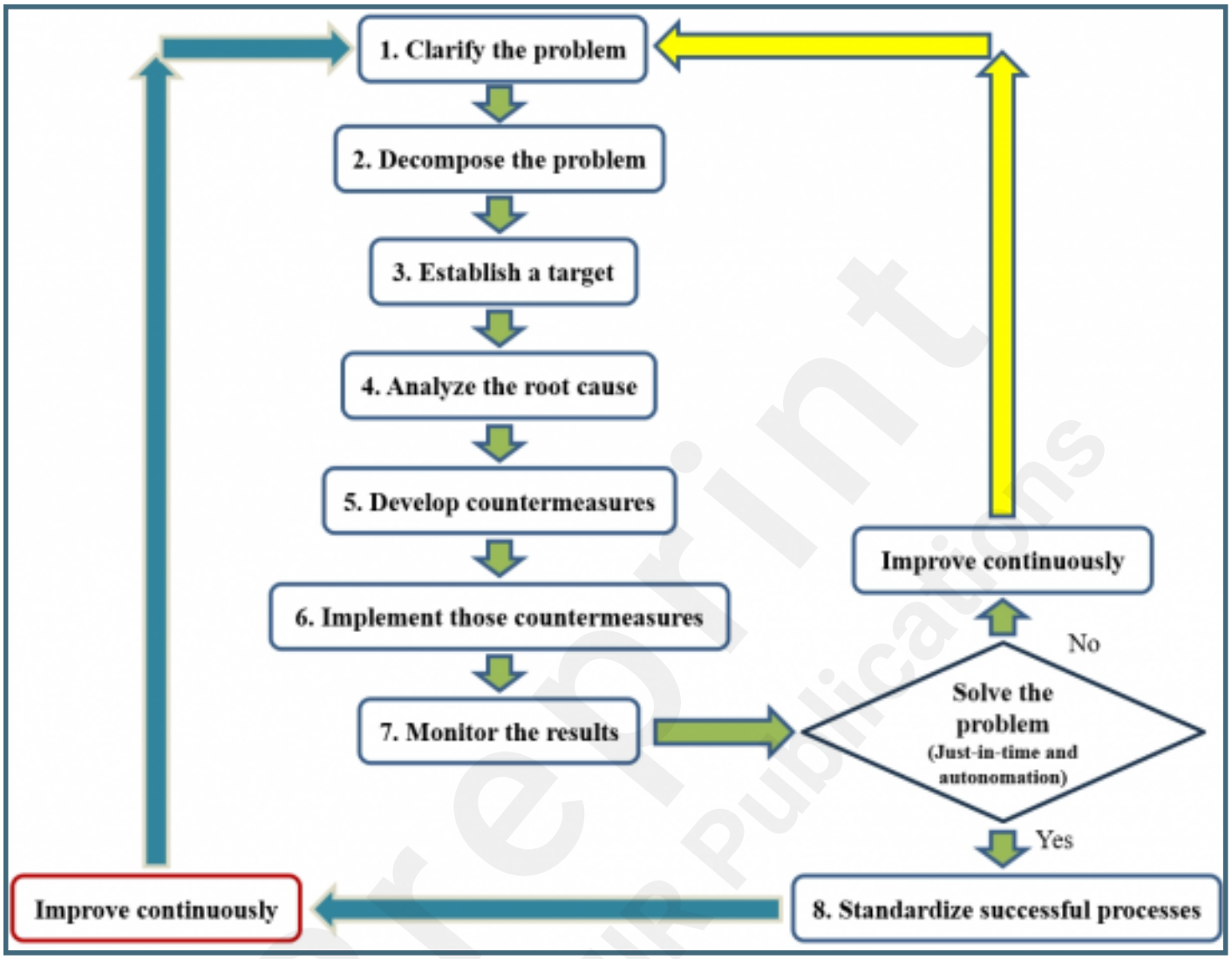
Abbreviations

TBP: Toyota Business Practice
TPS: Toyota Production System
VBA: Visual Basic for Applications
VSM: value stream map

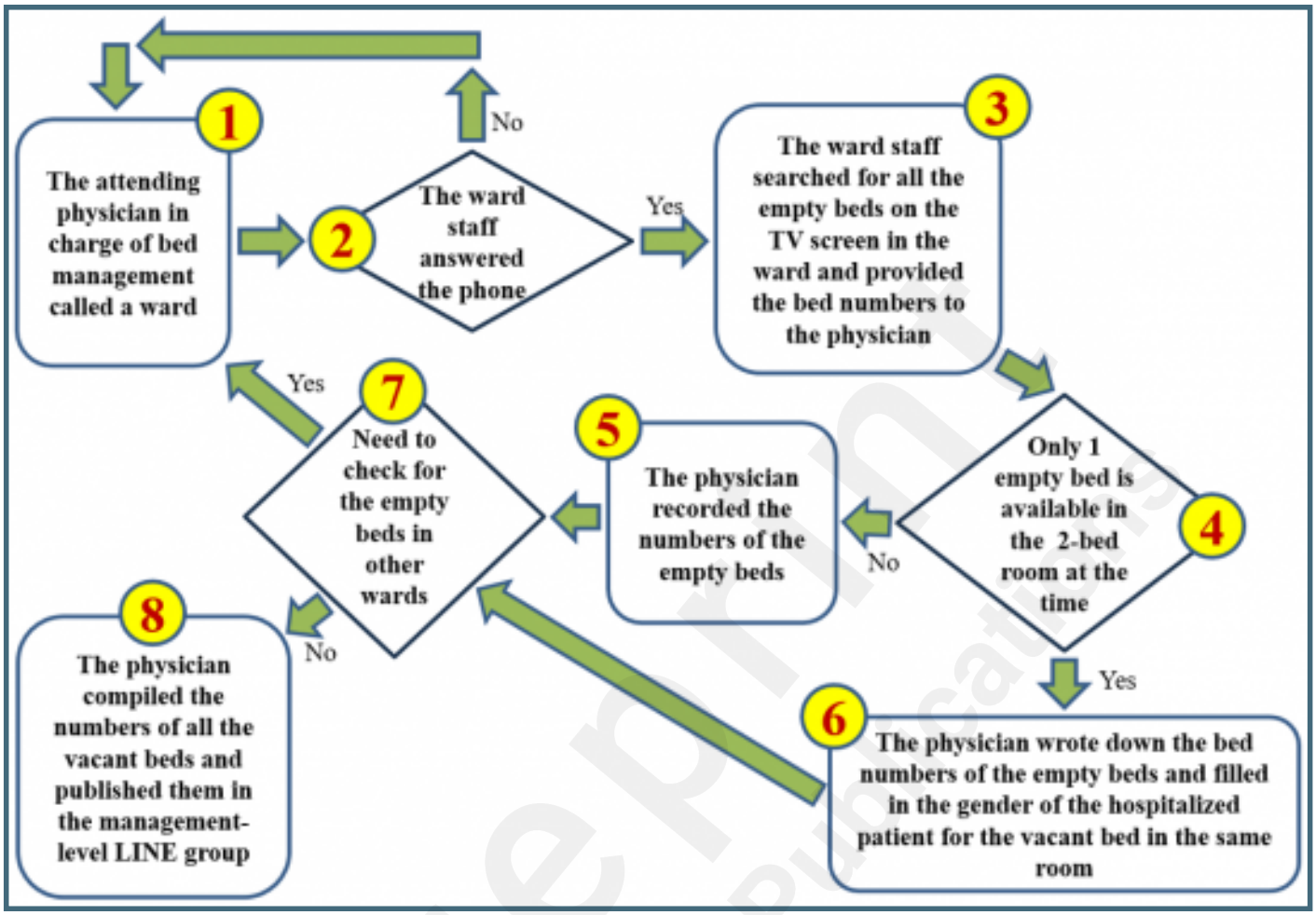
Supplementary Files

Figures

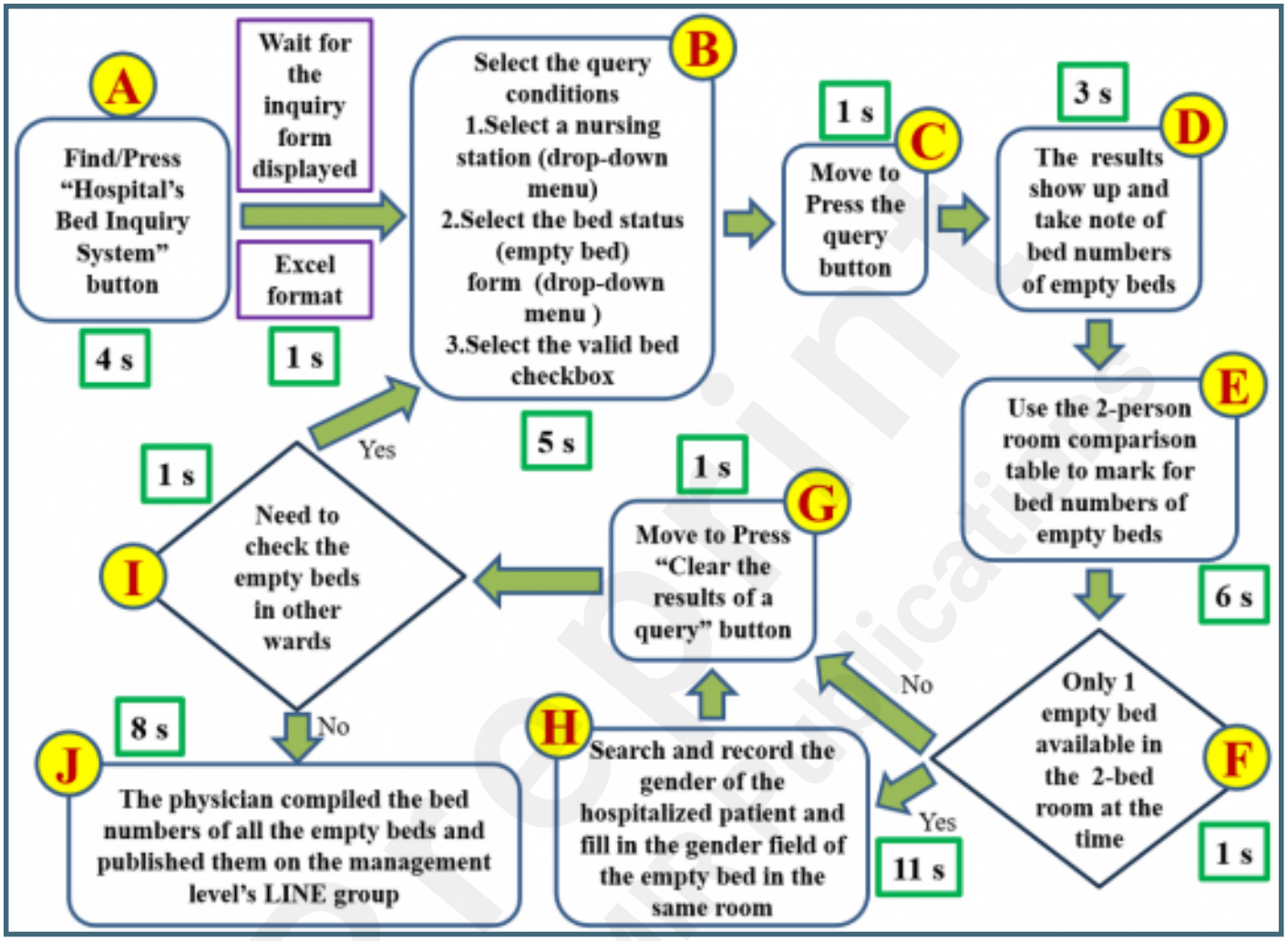
The structured eight-step problem-solving framework of Toyota Business Practice.



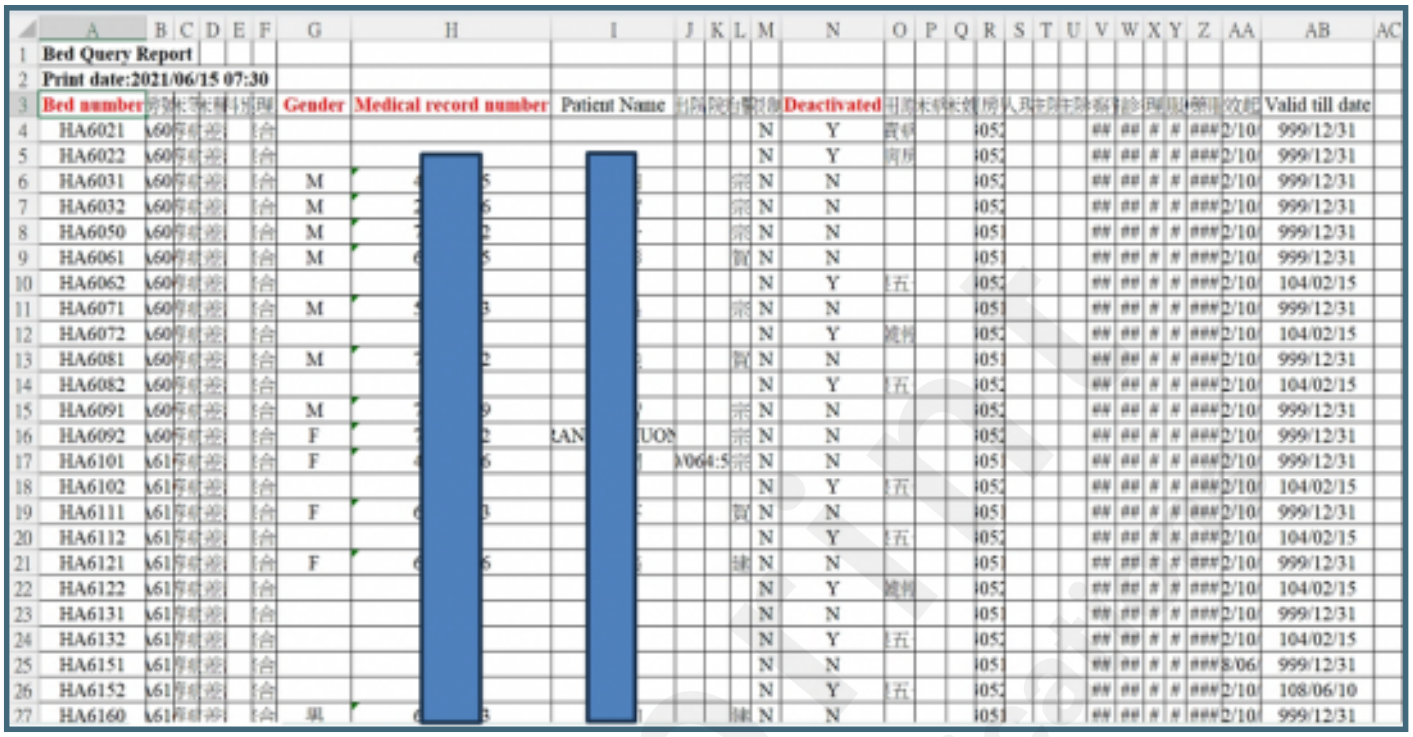
Mapping the entire process of querying bed availability led to the creation of a value stream map.



The value stream map illustrates the built-in query function of the hospital bed inquiry platform, used to check all available beds across the hospital. The times shown in seconds reflect the fastest possible query duration for a physician proficient in computer operations, assuming only one available bed is found. These represent the minimum time required for the query process. s: seconds.

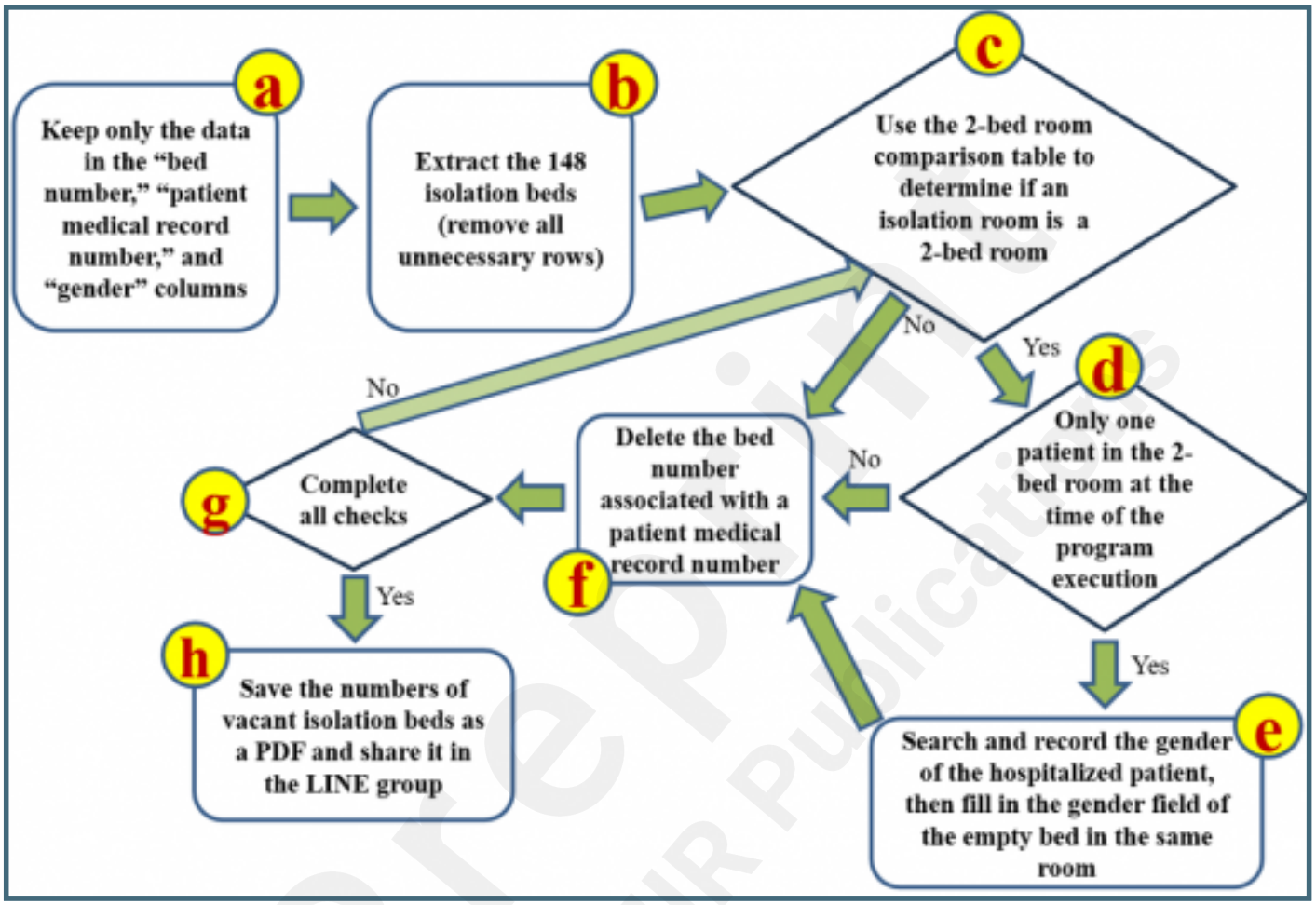


A simplified version of the Exported Raw Data .xls file. From the 28 available columns, only 3, highlighted in red, are necessary for use.

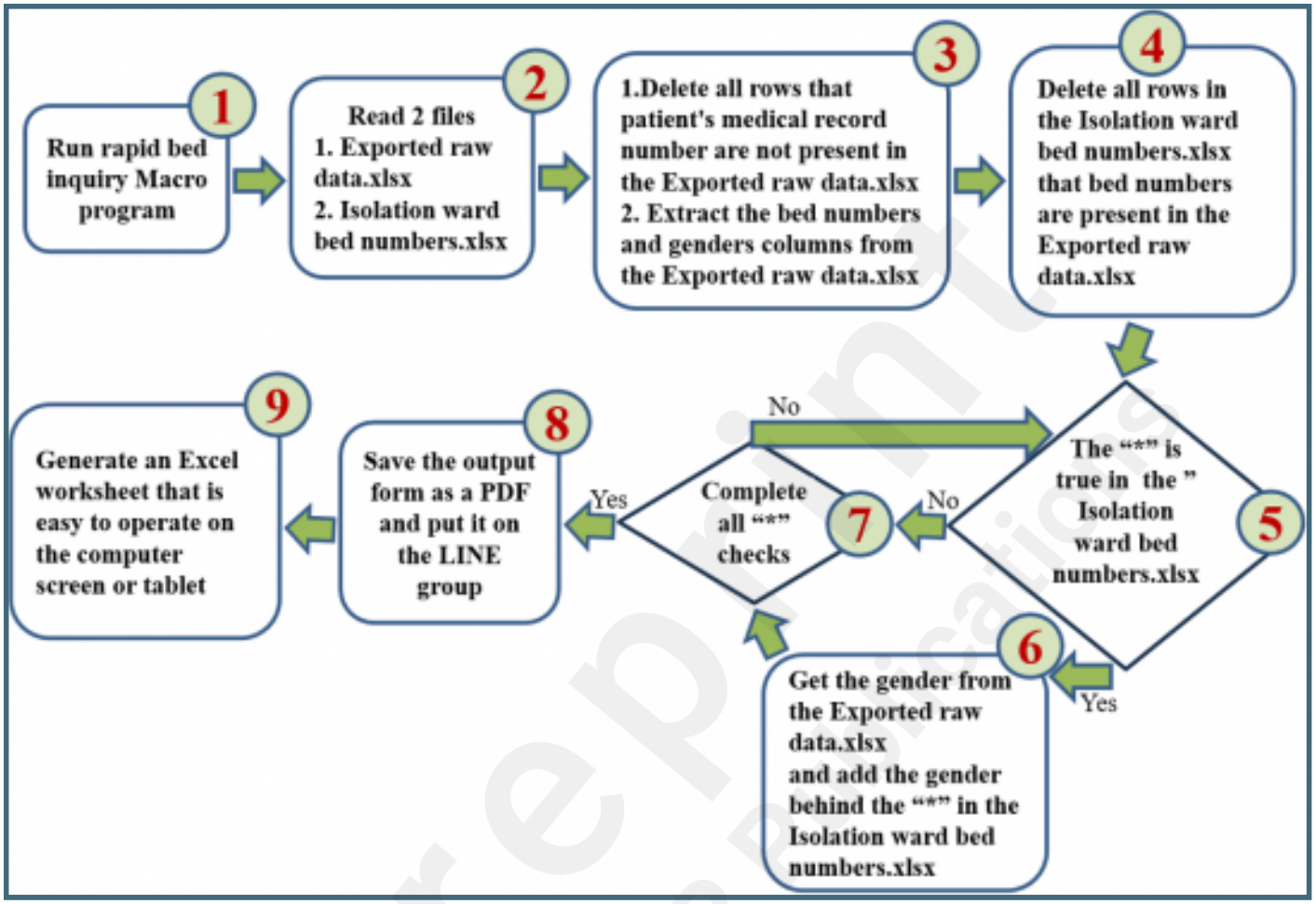


	A	G	H	I	M	N	Valid till date
1	Bed Query Report						
2	Print date:2021/06/15 07:30						
3	Bed number	Gender	Medical record number	Patient Name		Deactivated	Valid till date
4	HA6021				N	Y	999/12/31
5	HA6022				N	Y	999/12/31
6	HA6031	M			N	N	999/12/31
7	HA6032	M			N	N	999/12/31
8	HA6050	M			N	N	999/12/31
9	HA6061	M			N	N	999/12/31
10	HA6062				N	Y	104/02/15
11	HA6071	M			N	N	999/12/31
12	HA6072				N	Y	104/02/15
13	HA6081	M			N	N	999/12/31
14	HA6082				N	Y	104/02/15
15	HA6091	M			N	N	999/12/31
16	HA6092	F			N	N	999/12/31
17	HA6101	F			N	N	999/12/31
18	HA6102				N	Y	104/02/15
19	HA6111	F			N	N	999/12/31
20	HA6112				N	Y	104/02/15
21	HA6121	F			N	N	999/12/31
22	HA6122				N	Y	104/02/15
23	HA6131				N	N	999/12/31
24	HA6132				N	Y	104/02/15
25	HA6151				N	N	999/12/31
26	HA6152				N	Y	108/06/10
27	HA6160				N	N	999/12/31

Value stream map for identifying vacant beds from the Exported Raw Data .xls across the hospital. The strategy focuses on filtering out unnecessary information, retaining only the bed numbers of the 148 isolation beds, along with the patient medical record numbers and gender. For double-occupancy rooms, if only one patient is present at the time of execution, the gender of the admitted patient must be considered when displaying the vacant bed number.



An algorithm based on value stream map construction techniques was used to develop an Excel's Visual Basic for Applications (VBA) macro that automates the manual processes of sorting, deleting, and comparing data.



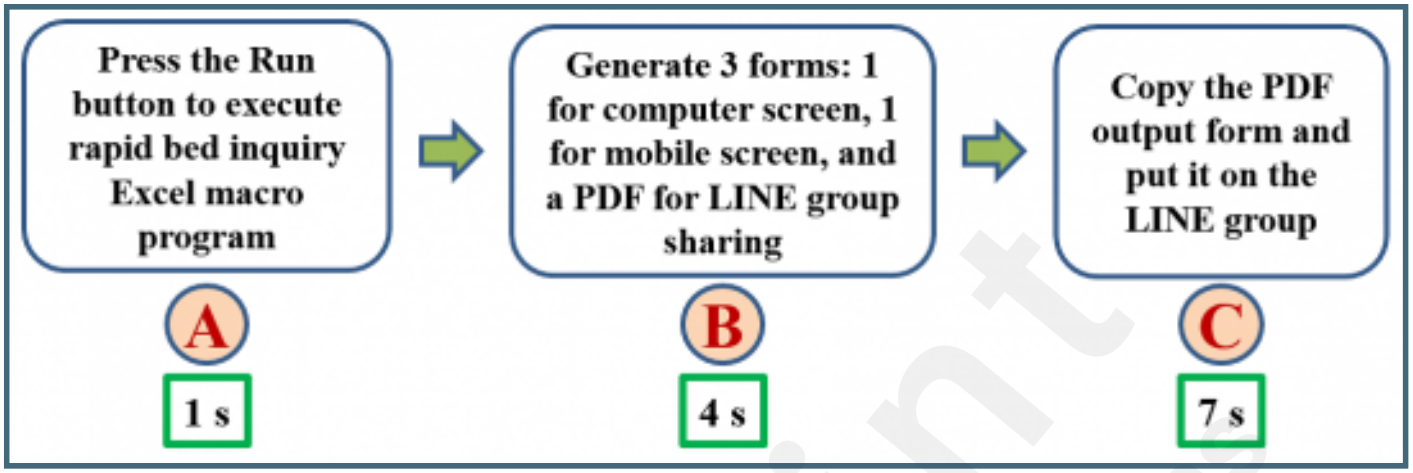
A simplified version of the Isolation Ward Bed Numbers.xlsx format. When the program runs, columns DE, GH, JK, and MN are merged into column AB. Column A lists the available bed numbers, while column B (the Notes column) records bed characteristics. For example, a "*" signifies a two-bed room, "HD" indicates a dialysis-ready bed, and "INS" marks that the patient in the adjacent bed has mental instability.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Bed number	Notes		Bed number	Notes		Bed number	Notes		Bed number	Notes		Bed number	Notes
2	HA9010	/HD		HA8111	/INS*		HA7020			HA6031	*		HICU17	
3	HA9020	/HD		HA8112	/INS*		HA7101	*		HA6032	*			
4	HA9030	/HD		HA8121	*		HA7102	*		HA6050				
5	HA9050	/HD		HA8122	*		HA7131	/HD*		HA6091	*			
6	HA9060			HA8131	/HD*		HA7132	/HD*		HA6092	*			
7	HA9070			HA8132	/HD*		HA7210	/HD		HA6101				
8	HA9080			HA8210			HA7221	*		HA6111				
9	HA9090			HA8320			HA7222	*		HA6121				

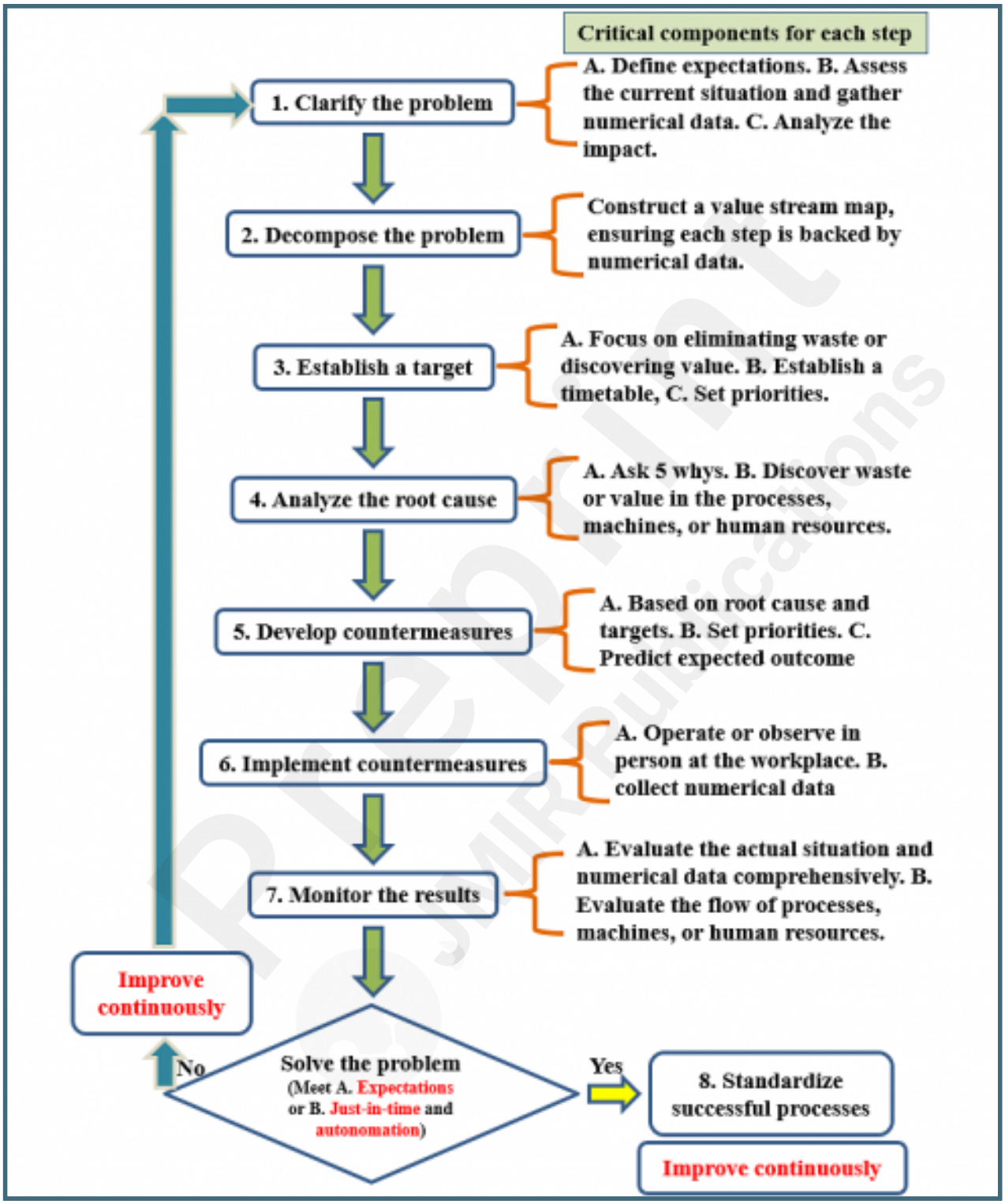
PDF form exported for upper management reference. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.

xxxx branch	6/15/2021	*Room for two Ask: call the nurse station	INS: mental instability(roommate)
Vacant bed No.:			
A9:Empty 5 bed(s)	HA9020/HD	HA9120/HD	HA9150/HD
	HA9170	HA9220	
A8:Empty 3 bed(s)	HA8102*M	HA8112/INS*F	HA8132/HD*F
A7:Empty 1 bed(s)	HA7092/INS*F		
A6:Empty 7 bed(s)	HA6101	HA6151	HA6261*
	HA6262*	HA6282*M	HA6312/Ask*M
	HA6360		
HICU17:	occupied		

The completion of the isolation ward bed inquiry Excel macro has significantly streamlined the process for bed control physicians to quickly query available beds, leading to an updated value stream map that reflects the improved workflow.



Overview of the Toyota Business Practice problem-solving process, detailing the critical components of each step.



Multimedia Appendixes

Calculate the time spent (measured in seconds) on querying the availability of vacant beds in ward A9, A8, A7 and A6 based on the value stream map in Figure 2.
URL: http://asset.jmir.pub/assets/92e1947eb57cd68a10a574cd22fbafbd.docx

The “Five Whys” technique was used to identify the root cause of the problem: “Why aren't calls answered promptly?”.
URL: http://asset.jmir.pub/assets/bd367d2cb66c31648046429a4f53d4e3.png

This is the menu screen of the hospital bed inquiry platform. When you press the “Query” button, the computer displays 761 bed records, with each record containing 28 fields.
URL: http://asset.jmir.pub/assets/749ca4ed7a18032b51136744b97e2b1c.png

The built-in query function of the hospital bed inquiry platform enables users to check bed availability across different wards in the hospital.
URL: http://asset.jmir.pub/assets/e4c9f528383b61e5f6f53dcc3ee27734.png

In collaboration with the Medical Affairs Office, we applied the “Five Whys” method to identify the root cause of the problem: “Why do we need to use the double room comparison table to identify double occupancy rooms?”.
URL: http://asset.jmir.pub/assets/e0a325e0816d88e88e3f427db387b8c4.png

Scope of human research cases exempt from review by the ethics committee.
URL: http://asset.jmir.pub/assets/f4b96f6ff92fc62cef97744ccf9ef8c1.doc

Large-screen form for use by bed control physicians on computers or tablets. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.
URL: http://asset.jmir.pub/assets/240de36bfc59364e83d50f3e200de5f5.png

Smartphone form designed for mobile use by bed control physicians. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.
URL: http://asset.jmir.pub/assets/5f0860bfdca739a47f1cec81146c4923.png

The original Excel macro code developed for the Quick Isolation Bed Inquiry System has been adapted for compatibility with Microsoft Office 365.
URL: http://asset.jmir.pub/assets/75315b9247b8e2dcf9e69dae790b1f30.docx

The Excel macro, with minor adjustments, offers versatility for various applications. For instance, integrating ward codes enabled us to efficiently monitor bed availability and occupancy across different wards, while adding an attending physician's list facilitated the tracking of patient loads for each physician across various wards. A "*" signifies a two-bed room, "HD" indicates a bed equipped for dialysis, and "INS" denotes that the patient in the adjacent bed has mental instability.
URL: http://asset.jmir.pub/assets/ac5524f0b8d1a68b42d00eab6f6e7637.png

The Toyota Business Practice (TBP) closely aligns with the Plan-Do-Check-Act (PDCA) cycle, a proven framework for problem-solving and continuous improvement. TBP's eight steps correspond to PDCA's four stages: the "Plan" phase includes the first five TBP steps, "Do" corresponds to the sixth step, "Check" to the seventh, and "Act" to the eighth. This alignment underscores the critical role of thorough planning in problem-solving and highlights TBP as a comprehensive tool for resolving issues effectively.
URL: http://asset.jmir.pub/assets/e6708201ae6a4343399761be71b49234.png

The Quick Isolation Bed Inquiry System's Excel macro can be easily adapted for a variety of applications with minor modifications or additional functions. By incorporating ward or department codes, we were able to track bed availability and occupancy in specific wards or departments. Adding an attending physician’s list also enabled us to monitor the number of patients each physician was responsible for across different wards. Additionally, the system can provide statistics on how many patients in each ward are expected to be discharged the following day. ENT: Otorhinolaryngology. CVS: Cardiovascular surgery. Obs/Gyn: Obstetrics and Gynecology.
URL: http://asset.jmir.pub/assets/3bec5d12c4122897eb4386ac83658671.png