การพัฒนาการจัดการห่วงโซ่อุปทานของเครื่องมือแพทย์ปราศจากเชื้อ: กรณีศึกษาในโรงพยาบาลรัฐของประเทศไทยภายใต้งบประมาณที่จำกัด

IMPROVING THE SUPPLY CHAIN MANAGEMENT OF STERILE MEDICAL DEVICES: A CASE OF THAILAND'S PUBLIC HOSPITALS UNDER FINANCIAL CONSTRAINTS

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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาการจัดการห่วงโซ่อุปทานของเครื่องมือแพทย์ปราศจากเชื้อในโรงพยาบาลรัฐของประเทศไทยและปรับปรุงกระบวนการทำให้ปราศจากเชื้อของโรงพยาบาลที่ได้รับการจัดสรรงบประมาณที่จำกัด ผู้ให้ข้อมูล ได้แก่ เจ้าหน้าที่หน่วยจ่ายกลางจำนวน 3 คน และผู้ใช้บริการเครื่องมือแพทย์จากแผนกต่าง ๆ จำนวน 6 คน ในโรงพยาบาลชุมชนขนาด 60 เตียง (เรียกว่า โรงพยาบาล A) เครื่องมือในการวิจัย ได้แก่ แบบตรวจสอบรายการ แบบสัมภาษณ์ และแบบบันทึกข้อมูล จากการสังเกตและเอกสารทุติยภูมิ เก็บรวบรวมข้อมูลช่วงแรกระหว่างเดือนมกราคมถึงพฤษภาคม พ.ศ. 2559 วิเคราะห์ข้อมูลเชิงคุณภาพด้วยการวิเคราะห์เนื้อหา แล้วนำข้อมูลที่ได้มาสร้างแผนภาพเกี่ยวกับการไหลเวียนของเครื่องมือแพทย์ปราศจากเชื้อ ทำให้สามารถระบุประเด็นปัญหา รากสาเหตุ และแนวทางแก้ไขเบื้องต้น ปัญหาหลักในการดำเนินการของหน่วยจ่ายกลาง คือ การบาดเจ็บจากวัตถุมีคมที่เกิดขึ้นในระหว่างการล้างทำความสะอาด สาเหตุของปัญหา ได้แก่ 1) ขาดแนวทางปฏิบัติที่เหมาะสมในการ เช็ดและแช่เครื่องมือแพทย์ที่ใช้แล้ว 2) ปริมาณน้ำยาล้างเครื่องมือผสมเอนไซม์และเครื่องทำความสะอาดเครื่องมือแพทย์ไม่เพียงพอต่อความต้องการ และ 3) ความต้องการเจ้าหน้าที่เพิ่ม ผู้วิจัยจึงได้ศึกษาแนวทางปฏิบัติจากโรงพยาบาลรัฐขนาด 120 เตียงในจังหวัดเดียวกัน (เรียกว่า โรงพยาบาล B) ที่นำเครื่องซักผ้ามาทำความสะอาดเครื่องมือแพทย์มีคมขนาดเล็กได้อย่างมีประสิทธิภาพ และนำผลการศึกษาไปปรับใช้กับโรงพยาบาล A

งานวิจัยเก็บรวบรวมข้อมูลช่วงที่ 2 ระหว่างเดือน ธันวาคม พ.ศ. 2562 ถึง เดือน มกราคม พ.ศ. 2563 เพื่อติดตามผลของแนวปฏิบัติที่โรงพยาบาล A นำไปปรับใช้ ผลการศึกษาพบว่า 1) โรงพยาบาลได้อนุมัติงบประมาณจัดซื้อเครื่องซักผ้าใช้แล้วเพื่อทำความสะอาดหน้ากากออกซิเจนและท่อต่อหลังจากได้รับคำแนะนำจากผู้วิจัย 2) ปัญหาการบาดเจ็บจากเครื่องมือแพทย์ที่มีคมและเจ้าหน้าที่มีปริมาณงานมากเกินไปอยู่ในระหว่างการดำเนินการจัดซื้อน้ำยาล้างเครื่องมือผสมเอนไซม์และขออัตรากำลังเพิ่ม และ 3) การสนับสนุนและการกำกับดูแลจากผู้อำนวยการและ

กระทรวงสาธารณสุขเป็นประเด็นสำคัญที่สุด และการศึกษานี้แสดงให้เห็นถึงความจำเป็นในการประเมินและพัฒนาการปฏิบัติในโรงพยาบาลที่มีงบประมาณอย่างจำกัดเพื่อผลักดันให้เกิดระบบการดูแลสุขภาพของประเทศไทย

คำสำคัญ : โรงพยาบาลรัฐของประเทศไทย, หน่วยจ่ายกลาง, เครื่องมือแพทย์ปราศจากเชื้อ, การจัดการห่วงโซ่อุปทานของโรงพยาบาล, การพัฒนาการดำเนินงาน

Abstract

This research aimed at exploring the supply chain management of sterile medical devices in Thailand's public hospitals and improving sterilization procedures given limited budget allocations. The key informants included three staff members from the sterilization unit and six members from various user departments at one of Thailand's district hospitals, a 60-bed facility, referred to as "A". Research instruments included a checklist, interview form, and record forms for reviews and observations. Content analysis was employed for qualitative data analysis. The first phase was conducted from January to May 2016. A clear picture of the device flow was revealed and mapped out, enabling the identification of weaknesses, root causes, and potential solutions. We determined that injury from sharp objects during hand-washing was a key problem. We found that (i) there were no practices for wiping and soaking instruments right after use, (ii) insufficient amounts of enzymatic detergents and washer-decontaminators, and (iii) there was a need to hire additional staff members. The investigation was further conducted into another public hospital, a 120-bed facility located in the same province, Hospital "B". "B" effectively used a washing machine for the pre-washing of oxygen masks and tubing, which was subsequently recommended for adoption by "A".

Later, from December 2019 to January 2020, we assessed the implementation, improvements, and flaws of the practices at Hospital "A". Firstly, the hospital allocated a budget for a used washing machine. Next, among the most serious issues found were high injury rates and excessive staff workloads, in which "A" stated that was in the process of purchasing the enzyme mixing tool cleaner and requesting additional staff. Finally the monitoring and support by the director with the supplementation from the Ministry of Public Health (MOPH) was the most crucial aspect. Our study showed the necessity to evaluate and develop the practices of hospitals with limited budgets, and contributed to Thailand's healthcare system.

Keywords : Thai public hospitals, central sterile supply department (CSSD), sterile medical devices, healthcare supply chain management, operations improvement

Background and significance

Healthcare supply chain management (HSCM) follows the flow from producers, purchasers, distributors, hospital storage, patient care units, and patients. Most hospitals operate multiple supply chains, starting from purchase planning through waste disposal, of which medical device handling represents a key supply chain in terms of medical care services and costs (NHS, 2014; Yoon, Lee, & Schniederjans, 2016). Medical devices used within the aforementioned departments are used in a variety of diagnostic, surgical, and therapeutic

manners in clinical practice (Humphries & McDonnell, 2015).

The chief aim of any sterile service of medical instruments is to provide flexibility, specificity, and consistency in support of the healthcare process (AbuKhousa, Al-Jaroodi, Lazarova-Molnar, & Mohamed, 2014) while maintaining a safe working environment and preventing injuries to healthcare professionals caused by sharp instruments and needle sticks (Adams, 2012). The cycle of decontamination, shown in Figure 1, outlines the important steps involved (NHS Estates, 2004; WHO, 2016).

Figure 1. The contamination life cycle.
(NHS Estates, 2004)

It is widely accepted that exposure to contaminated needle sticks and sharp devices is a fundamental occupational hazard (Gholami, Borji, Lotfabadi, & Asghari, 2013); and that injuries of sharps during both usage and the cleaning processes have been increasing among healthcare workers (Gholami et al., 2013; Kasatpibal et al., 2016), particularly in developing nations.

In Thailand, such occupational risks and their preventive practices of healthcare personnel are being investigated. Injuries often occur when disposing of medical devices, as well as when washing equipment and when carrying them to other places (Honda et al., 2011). Statistically, injuries that occurred after use and prior to disposal comprised 46%, followed by during use (33%), during (or after) disposal (16%), and before use (2%) (Nagao et al., 2007). Interestingly, such injuries are perceived as common problems, together with others issues, such as (i) inadequate training, staffing, budget, and support; (ii) the overuse/misuse of disinfectants; (iii) poorly organized systems; and (iv) an inappropriate usage of single-use devices (Unahalekhaka, 2017).

Other factors include low compliance with safety rules (Kongtip et al., 2018), haste and limited budgets (Kasatpibal et al., 2016), poor system documentation, and insufficient supplies (Boonphasit, 2018). If the views of these authors are correct, then the recovery of this situation is bleak, as Surapong Suebwonglee (the former Deputy Minister of Public Health) stated in 2019, that 60% of Thailand's public hospitals are under financial constraint (Banchanont, 2019; Poosuwan, 2017).

All public hospitals in Thailand must strictly follow the standards of purchasing, sterilization, infection control, structural organization, and budget allocation, as mandated by the Ministry of Public Health (2013). Therefore, most hospital supply chain management systems

are similar in procedures, patterns, systems, and stakeholder involvement. Still, effective supply chain management, including equipment sterilization, varies in response to the directives of individual department heads and/or the hospital directors (Bandoophanit, 2015; Panyaping & Okwumabua, 2006; Sanguanchom, 2010). Despite the fact that a hospital director provides support at the strategic level, decisions in real-time sustainable development are mainly driven by the operational staff. Clearly, factors such as hospital size, type, location, or even budget allocation have a lower impact on supply chain management than staff directives.

We, therefore, must question, "How can hospitals in developing nations achieve the goal of a safe working environment utilizing sufficient medical devices, while meeting the standards of cleanliness; and how do organizational, cultural, and governmental systems impact this goal?"

Several Thai studies have identified contributions to this dilemma; such as (i) the reuse of single-use medical devices (Boonchaisri, Lertwatthanawilat, & Unahalekhaka, 2017), (ii) the development of sterilization system management (Boonphasit, 2018; Nacglud & Noimuenwai, 2018; Pongsrila, Tanakultanyasit, & Chatchawet, 2018), (iii) the unit costs of service (Rewsuwan, 2015), and (iv) customer satisfaction (Sirikoopta, Sirivattanaket, & Tongchai, 2019). Commonly, the sterilization standards used to identify levels of compliance, injuries, and performance were generally viewed from the healthcare professionals' perspective.

Hence, a new perspective of supply chain management would provide a clearer holistic view on the stakeholders' impact on operations, as well as how to gain performance improvements in product flow (Cole, Lindsay, & Barket, 2018; Esain, Aitken, Williams, & Kumar, 2016). Individual interviews and survey questionnaires were found commonly employed. Greater focus on in-depth information generated from using case research methods and the use of mixed instruments were suggested in past studies in the field of operations research (van Vactor, 2011; Voss, Tsikriktsis, & Frohlich, 2002; Yin, 2009). Several studies repeated and confirmed their observations to ensure the performance of practice implementation. All of these are this research contributions.

Research objectives

1. To investigate the supply chain management of sterile medical devices in Thailand's public hospitals.

2. To improve safety and to mandate qualify effective operations.

Research questions

To meet the central objectives, three questions were formulated:

1. "How does the hospital manage the supply chain of sterile devices?"

2. "What are the barriers to addressing an effective sterilization system?"

3. "What practices would allow hospitals to perform better?"

Methodology

This section presents the research design via mixed research methodology, instruments for data collection and analysis, and the research's validity and ethics.

Populations and samples

The selective sampling strategy method was adopted in our selection of case hospital settings due to the followings factors: a) the research team was embedded in the hospital for five months (Phase 1, January to May 2016) in order to observe and implement change(s) as needed; and b) measuring and improving performance levels required the gathering of sensitive information, such as (i) budget allocations for devices, machines, and staff, (ii) procurement policies, (iii) the director's perspective, (iv) feedback from users, (v) the flow of devices, and (vi) identifying problems and potential solutions. Therefore, hospital accessibility and daily transportation, involving distances within a 150 km radius, were two key criteria for selection.

In 2016, only one district 60-bed hospital, referred to as Hospital "A" agreed to be a case organization. After encountering some insoluble problems, Hospital "B", a 120-bed facility in the same region was added to our research, during the single month of March 2016. A comparative study that deeply examined and compared a small number of cases using measurements was then undertaken (Lancaster & Montinola, 1997; Yin, 2009). Its small sample size was acknowledged as a key limitation in the generalization of the outcomes. Some of the effective practices and knowledge obtained at "B" were later implemented at "A". The second phase (Phase 2) employed a longitudinal methodology with which to follow the continuation of the practices implemented in the initial observations, from December 2019 to January 2020 (McGinnis, Kohn, & Spillan, 2010).

Ethics

Since the research was initially conducted prior to the establishment of Khon Kaen University's ethical policy in November 2019 , the ethical applications were exempted. The research maintained anonymity and confidentiality. As a result, all information was used for research purposes only, and the research data is presented in general terms.

Note 1: In order to protect staff confidentiality, all names and workplaces were anonymized.

Note 2: The 'user' in this study refers only to hospital personnel.

Note 3: Permissions were received from the hospitals' director, in conjunction with Khon Kaen University's Dean of the Faculty of Business Administration and Accountancy (document number อว 660301.15.1/ว5428, and received by Hospital "A" as document number 4026).

Data Collection

Interview selection and techniques

The interview method posed appropriate questions regarding beliefs, attitudes, and behaviors (Robson, 2014); and clarified supply chain operations (the handling and movement of medical

devices) (Voss et al., 2002). The 'face-to-face semi-structured in-depth interview' approach was used, in which questions were modified based upon each particular situation. The research scope was explained to all interviewees and a consent form was signed. Each respondent was repeatedly interviewed until receiving complete information.

Observational Approach

Observations involved behavioral patterns, as well as the objects and events used to obtain information (Malhotra, 2010). Observations were carried out during the hospital visits to study the flow of sterile medical devices, as well as how the staff managed them.

Documentation Approach

Statistical data regarding the volume of medical devices in use and in stock, compared with the volume of patient usage can provide very strong evidence in which to identify the performance of the CSSD. We requested this documentation in advance, as we anticipated that much of the information would not be readily available.

Research Indicators

In order to assess the hospitals' performances, clear measurements were implemented according to the standards of the Universal Precautions, Thailand Infection Control Guidelines, as well as the NHS Decontamination Standards (2004), given in Table 1. We also followed the standard supply chain management metrics, including the speed of task (minutes), the volume of the medical devices, shortages (in percentages), user satisfaction, and costs (Rodrigue, Comtois, & Slack, 2013; Serrou & Abouabdellah, 2016; Thiell, Zuluaga, Montañez, & van Hoof, 2011).

Validity and Reliability of Research Instruments

The research design was assessed by five scholars from the Faculty of Business Administration and Accountancy, Khon Kaen University; one of which was a former nurse. The checklist was developed by a scholar knowledgeable in infection control, and was tested for effectiveness, and adjusted prior to field use.

Data Analysis

A large amount of data collected over a five-month period was handled through the content analysis method. Rather than supplying mere descriptions, the main ideas and common themes of the contents were critically examined (Mehrbod, Tu, & Miao, 2012; Stemler, 2001). The analyzed data were then grouped according to their themes, as specified in the indicators. When entering the data into the tables, similarities and differences became evident, consistent with the cross-case analysis method (Miles & Huberman, 1994).

Results

The results section is structured as follows: the background of the case hospitals is presented first followed by the first phase (2016) and second phase (2019-2020) studies.

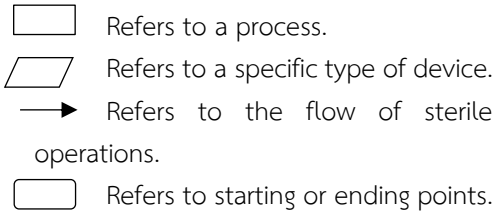
1. Backgrounds of the Case Hospitals

The background section answers the question: " How does the hospital manage the supply chain of sterile devices?"

Hospital "A" is a primary care hospital with 60 beds, located in the Northeast of Thailand, providing basic services, such as outpatient (OPD) and emergency room treatments, a dental clinic and delivery room, and several operating rooms. The CSSD is a key support service for both the operating rooms and the dental clinic.

According to a report from the Healthcare Accreditation Institute (September, 2019), Hospital "A" received a Level 3 (r-3) rating, indicating that it met the current sterilization management standards. The standards focus on (i) patient/customer safety, (ii) standard qualify of all instruments, (iii) hospital personnel safety, and (iv) cost-effectiveness (Unahalekhaka, 2017). Because the CSSD was located at the rear of Hospital 'A', the delivery and collection of medical devices took between 15 to 20 minutes per round. Three CSSD staff members, with five or more years of experience, were responsible for all tasks; from collecting used devices to cleaning and re-distribution. The floor plan was divided into three areas; dirty, clean, and sterile. A paper-based system was used to record the handling of all devices.

The results of the CSSD observations were mapped out as 'device flow', as seen in Figure 2, in which functions of several different types of shapes and lines are described. Areas with a grey background indicate a problematic area. The cleaning process of reusable medical devices starts around 7 am, and usually ends at 4 pm or later. The collection process begins with used devices being placed in a bucket, and then put on a cart, and transported to the CSSD. Upon arrival in the CSSD, the decontamination procedure begins. The wards sort the items into three types: general devices, such as scissors; tubes or lines; and devices used together in sets, such as those used in the dental clinic. Each device is cleaned with normal dishwashing liquid and later steamed for a minimum of one hour and 40 minutes. Tube and line devices were sent to the dryer and were air-dried for two hours to remove any inside liquid.



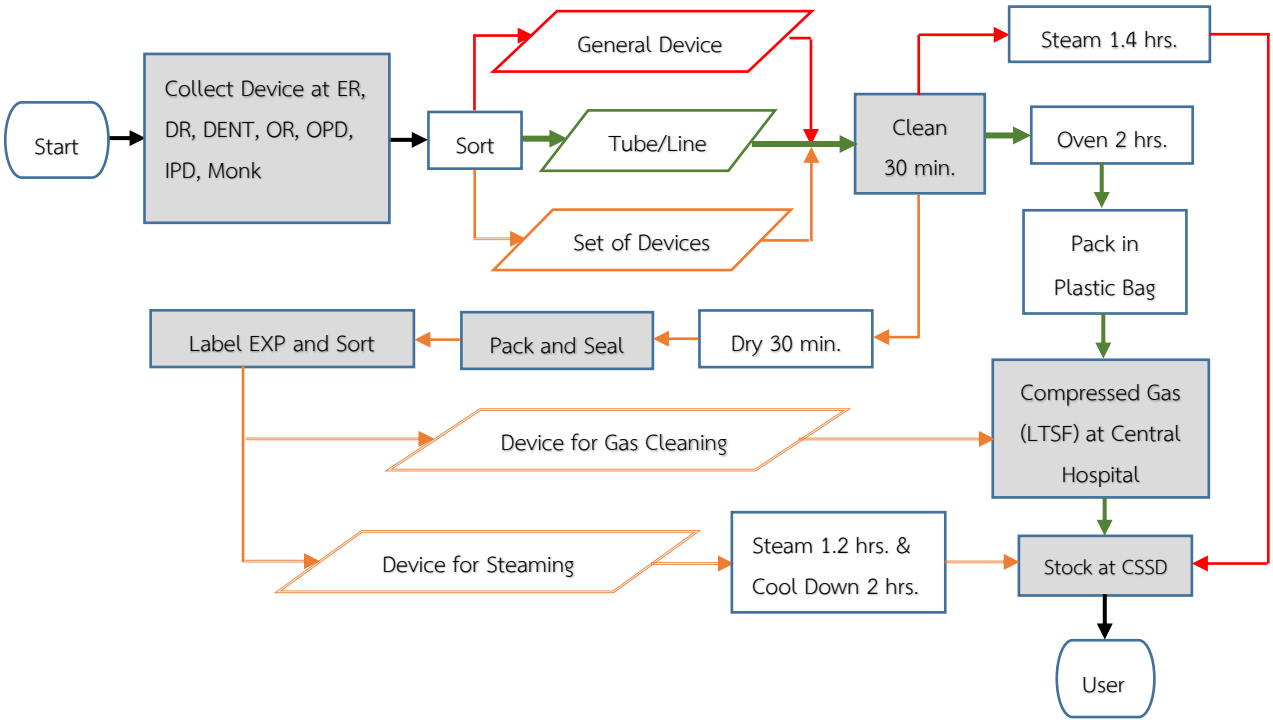


Figure 2. The Operations of the CSSD at Hospital "A".

2. Phase 1 (2016): Findings and Discussion

2.1 Problems Identified and Comparative Study

This section answers the second question: "What are the barriers to addressing an effective sterilization system?" Our comparative study (Table 1) concluded that the larger facility "B" demonstrated practices that meet the required standards, whereas "A" met only some. For example, the use of simple dishwashing liquid to pre-wash devices, as Hospital 'A' had no policy or budget to purchase an enzymatic detergent. Such poor practices led to ineffective decontamination and increased injuries (where bubbles from dishwashing liquid inhibited the staff's visibility; and, therefore, their ability to identify sharp points hidden in the sink).

Other areas of neglect found that the staff (i) did not clean equipment after use on a daily basis, (ii) walked from the dirty zone to the clean zone, (iii) did not always wear protective clothing (boots, eyeglasses, mask, gloves, and cap), and (iv) did not re-process the used (dirty) sterile devices. These practices were, of course, contrary to the standards of Universal Precaution as well as the Infection Control Guidelines.

Table 1 Practices and universal precautions of the CSSD

Process	Hospital "A"	Hospital "B"
1. Zone: dirty, clean, and sterile	[Followed]	[Followed]
2. Appropriate sharps segregation	[Against] Practice: Sharps were mixed with others in the same container. Outcome: High injuries, time consuming.	[Followed] Practice: Sharps were sorted and kept in a separate container. Outcome: Low injuries.
3. Sufficient protections for pre-decontamination	[Against] Practice: Soak and drain 30 minutes before hand washing sharp devices. Outcome: High injuries.	[Followed] Practice: Put sharp devices in a basket to await cleaning by a washing machine. Outcome: Low injuries, time saving.
4. Use of enzymatic detergents for decontamination	[Against] Practice: Use of dishwashing liquid. Outcome: Poor decontamination, increased injuries.	[Followed]
5. Use of a washer-decontaminator	[Against] Practice: Hand wash. Outcome: Increased injuries.	[Followed] Practice: Use of a washer at 70-80 c. Outcome: Met standards, but time consuming.
6. Wipe all devices after decontamination	[Against] Practice: Some were air-dried. Outcome: Increased sedimentation.	[Followed]
7. Tax producing and expiry dates	[Followed]	[Followed]
8. Bowie-Dick test and Spore test	[Followed] Note: The gas cleaning process was outsourced, so they did not conduct the Bowie-Dick test.	[Followed]
9. Sufficient and clear work guidelines; e.g., at machine	[Against] Practice: Some machine had no guidelines. Outcome: Staff cannot solve primary problems when the machine was not functioning.	[Followed]

2.2 Potential Solutions Derived from Hospital "B"

This section answers the third question: "What practices would allow hospitals to perform better?"

a) Appropriate segregation and pre-decontamination of sharp devices

Hospital "B" sorted and kept the used medical devices in a separate container. The acceptable guidelines dictate that the users are responsible to wipe and soak their used instruments in an enzyme solution at the place of use, prior to transporting them to the CSSD, which was not practiced at Hospital "A".

The experiment was therefore undertaken by comparing the speeds of cleaning 20 devices (large and small). Table 2 points out that if the user wipes the devices with a wet towel or tissue paper and soaks them before brushing, it will significantly reduce the brushing time from three minutes/piece, or a total time of 60 minutes; to twenty seconds/piece, or a total time of twelve minutes. This conforms to the standards of the NHS.

Table 2 Preferred ways to manage medical devices

Device	Wipe	Soak	Brushing Speed
Large sharp devices, such as scissors	/	X	50 seconds/piece, total time 16.67 min
	/	/ (5 min)	20 seconds/piece, total time 11.67 min
	X	X	3 minutes/piece, total time 60 min
	X	/ (10 min)	2 minutes/piece, total time 40 min
Small sharp devices, such as forceps and syringes	/	X	40 seconds/piece, total time 13.33 min
	/	/ (5 min)	25 seconds/piece, total time 8.33 min
	X	X	1.5 minutes/piece, total time 30 min
	X	/ (10 min)	1 minutes/piece, total time 20 min

b) The use of enzymatic detergents in decontamination

As previously mentioned, “A” used a simple dishwashing liquid in the washing stage that generated from one to five injuries for each staff member over the course of their employment. The staff, claiming to be aware of such danger, considered this to be an acceptable hazard and took precautions. Learning from “B”, the adoption of enzymatic detergents was accompanied by another effective practice; using a washer-decontaminator to clean sharp devices (Figure 3). Injury rates declined and the decontamination life cycle (Figure 1) became faster and more effective.

Figure 3. Washing medical devices using a washer-decontaminator (Unahalekhaka, 2017).

In order to save costs, Hospital “B” also used a commercial washing machine, top-lid type, to clean sharp instruments. Figure 4 shows devices kept in two baskets awaiting dishwasher cleaning. The experiment at Hospital “B” was repeated in order to evaluate the effectiveness of a washing machine in the decontamination process, which included the practice of first wiping and soaking the instruments.

Figure 4. Devices placed in two baskets prior to cleaning in the washing machine.

Twenty medical devices were cleaned (tested) with and without the washing machine, focusing only on the devices that were wiped and soaked beforehand, at the source. The experiment results (Table 3) determined that (i) small devices that caused injuries in hand-washing should be machine washed; however, (ii) larger devices are more suitably washed by hand, as machine washing was found to leave stains on the device surfaces.

Table 3 Preferred way to manage device handling.

Device	Cleaning	Speed of Brushing	Result
Large sharp devices, such as scissors	Hand	20 seconds/piece, total time 11.67 min	Clean
	Washing Machine	30 min for 20 pieces	Not clean (having stains)
Small sharp devices, such as forceps	Hand	25 seconds/piece, total time 8.33 min	Clean, high risk of injury
	Washing Machine	30 min for 20 pieces	Clean

In short, Section 2.2 revealed the most effective practices: (i) users should wipe and soak devices at the source (place of use) before sending them to the CSSD, (ii) the CSSD should use enzymatic detergents to remove stubborn organic debris, and (iii) hospital administration should allocate a budget for purchasing a washer-decontaminator, or a used washing machine.

3. Phase 2 (2019): Findings and Discussion

The outcome of this phase reflects staff performance post-investigation in 2019.

3.1 The Current Situation at Hospital "A"

We learned that Hospital "A" recently passed the HA evaluation, which included the CSSD. We further noted that a new director had been employed in Hospital "A" just three months earlier, and that tremendous growth had occurred throughout the year (2016) in response to increasing patient volume. A new building, the "Priest Building", was completed in December 2016. CSSD still employed the initial three female staff members, controlled by the head nurse of the operating room (OR). The three rotated their responsibilities each month, which included: (Task 1) collecting used devices, cleaning, and delivering clean devices; (Task 2) packing; and (Task 3) sterilization. On weekends, only a single staff member is available for all three tasks, as each employee typically works 26 days per month. The performance changes also included the implementation of a compressed gas system near the CSSD, which was previously managed by the central hospital. Lastly, an older used washing machine was purchased by the three staff members to clean the medical devices. They soon discovered, however, that the machine was not suitable for cleaning smaller sharp items, although it proved adequate for oxygen masks, tubing, and gloves. They also purchased brushes with their own funds.

3.2 Problems Identified

a) Stock

Because the area for stocking devices is relatively small, the volume of the stock is less than that of the typical amount of usage in one day. Therefore, most items used in the morning were 'recycled' for use again in the afternoon. A faster sterilization process was, therefore, the first concern of our focus group. The second concern was that a limited budget did not allow for the purchase of more reusable devices, such as a safety or backup stock; nor were they able to comply with the temperature-controlled stock, as required by the Infection Control Standards (Unahalekhaka, 2017). The constant turnover of medical devices and dental sets exhausted the staff in their attempt to keep up with the fast-moving pace; as well as adversely affected the general level of healthcare service (Bandoophanit & Breen, 2018).

b) Dishwashing liquid

As dishwashing liquid was still in use at Hospital "A", accidents continued to happen. A recent injury to one of the workers resulted in the need for a blood

test and administration of AZT Zidovudine (ZDV), also known as azidothymidine (AZT), as an antiretroviral medication used to prevent and treat HIV/AIDS. We learned through the focus groups that several companies had demonstrated their enzymatic detergents at Hospital "A", and even left sample bottles free-of-charge. The participants were all in agreement as to their effectiveness and awaited their introduction into the CSSD. The staff further stated that an automatic 'ultrasonic cleaner' (costing 30,000-40,000 Baht) would be more suitable for managing sharp devices and would eliminate the need for handwashing.

c) Heavy buckets

Staff members were often found carrying metal devices in buckets weighing 25-30 kilograms or more. This resulted in physical discomfort and pain, often resulting in lower back problems; especially among the older workers. The Labor Act of Thailand, however, states that female workers must not be expected to carry anything weighing more than 25 kilograms. As a result, a round trolley containing a large bucket was employed for instrument delivery (Figure 5). The trolley, however, was unstable, fell over, and crashed into people. Its height proved to be inappropriate and obstructive, causing the staff to simply place a smaller bucket on the lid of the larger one. A proper trolley or cart must therefore be considered.

Figure 5. Collecting used dental devices via the trolley.

d) A single staff member for three tasks

While patient volume was thought to be lower at this time, in fact, the workload remained unchanged. The CSSD was overworked, often resulting in the staff members skipping their lunch in order to keep up with demand.

e) Limited budget

Hospital "A" receives an allocated budget commensurate with a 30-bed-sized hospital. That this does not allow them the same level of standardization as larger, more endowed hospitals, was not considered by the Ministry of Public Health (MOPH), observed the interviewees.

3.3 Potential Solutions

The final discussions with the head of CSSD clarified several issues. One, dishwashing liquid, was used together with free-trial enzymatic detergents at sufficient volumes. We were further informed that the purchase of enzymatic detergents was approved by the director, and was in progress. The used washing machine was purchased with the hospital budget, and not the three workers, as initially claimed. Regarding the enzymatic

detergents, Bandoophanit, (2015) recommended using self-produced effective microorganisms (EM), from the fermentation of sour fruits or vegetables, particularly bergamot. This organic liquid was inexpensive and successfully cleaned various metal devices, such as chamber pots, medical carts, glassware, saline bottles, and operating room floors. Still, further research into the development and use of EM products on organic, protein, and triglyceride-based debris is needed.

For the transportation of devices, recommendations were made to provide a better method of transportation; allocate a male worker for the task; and report such health conditions as injuries from lifting to hospital administration.

Conclusion

The case study research undertaken at the CSSD of Hospitals "A" and "B" focused on the longitudinal observations necessary in order to meet the sterilization standards of the HSCM. Phase 1 (2016) of our investigation provided a clear picture of the sterile device management facilities and identified several problems, as well as potential solutions. The most significant concerns were that of injuries which occurred in the cleaning of sharp metal devices, and poorly-cleaned devices. The primary objective of this phase was, therefore, to determine more appropriate ways to improve the cleanliness of the devices while maintaining staff safety, despite having a seriously deficient (CSSD) budget.

Problems identified were: (i) used devices were not wiped and soaked after use by the wards; (ii) dishwashing liquid was used instead of an enzymatic detergent, (iii) an insufficient number of CSSD staff, and (iv) the lack of a washer-decontaminator. These findings suggest insufficient support on behalf of the previous hospital director, and are consistent with the findings of Honda et al., (2011); Kasatpibal et al., (2016); and Unahalekhaka, 2017. This contradicts the practices held at Hospital "B", which maintained the CSSD required standards regardless of the hospital's financial situation.

In 2019, a revisit to Hospital "A" confirmed three major changes: the purchase of a used washing machine, a compressed gas system, and increasing Director's support. The washing machine proved sufficient to clean some items, such as oxygen masks and tubing, but not smaller sharp instruments, as revealed in Phase 1. Other problems remained unchanged; including those relating to employee health, the lifting heavy objects (predominantly by female workers), injuries occurring when washing sharp instruments, and insufficient device quantities.

One might say that most public hospitals have financial problems and that issues, such as insufficient resources and injuries, are commonplace. The most interesting point in this study was that sustainable improvements were completed by proactive hospital Director and staff under severe financial constraints, consistent with Bandoophanit (2015). Further recommendations are that the new

director continually supports (her) subordinates to further implement other useful practices, and establish an open discussion to receive feedback on any developmental difficulties. Regular monitoring by both the director and various hospital committees is highlighted.

Recommendation

Therefore, that further research should be conducted to further the improvement of CSSD practices throughout Thailand, particularly in cases of hospitals with limited budgets. The best practices should be gathered and communicated to all hospitals. Such contributions would benefit Thailand's healthcare supply chain practices, associated with the MOPH's Sufficiency Economy Philosophy.

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