International Journal of Biomedical Engineering and Clinical Science
2023; 9(2): 24-29
http://www.sciencepublishinggroup.com/j/ijbecs
doi: 10.11648/j.ijbecs.20230902.12
ISSN: 2472-1298 (Print); ISSN: 2472-1301 (Online)

Optimum Sterilization Department Design in Low-Medium Healthcare Facilities

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To cite this article:

Khaled Sayed Ahmed, Fayroz Farouk Shereif. Optimum Sterilization Department Design in Low-Medium Healthcare Facilities. *International Journal of Biomedical Engineering and Clinical Science*. Vol. 9, No. 2, 2023, pp. 24-29. doi: 10.11648/j.ijbecs.20230902.12

Received: May 21, 2023; **Accepted**: June 8, 2023; **Published**: June 21, 2023

Abstract: Due to importance of sterilization department design and its relation to rest of sections in hospitals, selection of department location together with internal pathways are very critical issue in hospital design. To minimize the time of sterilization and comply with Infection control rules, the design of sterilization department should follow some specs and guidelines that to facilitate the operation processes and to have maximum effectiveness. In this research, some designs have been studied considering the hospital capacities (Low and medium), available space area for department, operating theater department (number of operating rooms), waste management in addition to sterilization equipment capacities that to optimize the required spaces and area that fit the needed guidelines. The results of this study are to evaluate the current designs and their relations to different departments and indicate the important points of design in addition to illustrating the optimum design for area and cost after applying logistic regression. The results reveal that hospitals with under 100 patient beds capacity and with a maximum of four operating rooms can fit their required functions and guidelines in only two sub-sections areas of CSSD in about 35-50 M2. The two sub-sections are one area for decontamination and washing and the second area is for packing and sterilization together with storage area.

Keywords: Operating Room Design, Waste Management, Hospital Capacity, Available Area

1. Introduction

Recently a massive increase in healthcare costs has occurred although the high demand of healthcare. Due to increasing competition and the limitation of government support, exploring the resources as optimum is a very critical point to maintain the healthcare services within the competed organization. The reuse of instruments after sterilization specially in operating theatre (OT) in the propyl time is a good indicator to introduce the medical services in low cost that operating theatre rooms have been illustrated as the most critical hospital department for highest costs generation [1]. For controlling cost containment, the interactions and relation between operating suites and hospital areas as sterilization, laundry, waste management should be considered furthermore coordination between demands of surgical patients and resources availability [2, 3]. To realize the safety, speed and effectiveness of surgical instruments, these sets must be washed and inspected in decontamination area then packed and sterilized before every operation. Although incineration is the primary way of managing infectious waste, about one third of these wastes are treated in sterilization department [4-7]. Using single use instruments lowers the number of trays furthermore the time of sterilization and reduces the risk of instrument trays noncompliance [8]. Some researchers estimate the sterilization department via models and /or simulation programs [9]. The created models analyzed the capacity of sterilization equipment, cart-washing, staff shifts, and department configuration to measure surgery delay rate, and to plan the expected patient increase in future [10]. Others consider the control and prevention of infectious diseases, isolation rooms and basics of medical building design [11-13].

Based on differentiation of wastes to Hazard Medical waste (HMW) and Non-Hazard medical waste (NHMW), the

World Health Organization (WHO) assigned 15% to HMW. This precent can be divided into 66.6% is infectious waste and 33.3% non-infectious but hazardous waste [14]. In the OR, 90% of NHMW is incorrectly sorted as HMW (infectious or hazardous) [15]. High temperature incineration may be used for medical waste [16]. Most of those wastes have been transported to triage area in sterilization department. In some hospitals, triaging has been performed inside the department before transferring the tools to sterilization department. The sterilization department is one of the most critical sections that should be arranged economically to prevent hospital infection. The collected volume of tools and accessories to be re-sterilized is the effective method to predict / estimate sterilization capacity. Because the sterilization department is response for all sterilization happens in the hospital regardless of where is performed inside Operating Rooms, clinics and / or department, it should be divided into sub-section to deal with contaminated and sterilized materials [17]. Decontamination area location and its pathway is a vital step in keeping infection control at a high level [18-20]. Material and accessory logistics via procurement and staff are important factors in determining the sterilization department space area [21, 22]. In this research, a group of studied cases of sterilization department inside hospitals have been evaluated regarding space area, separation barriers, and complying with infection control rules. After evaluation, clustering of these designs has been performed based on important parameters as hospital capacity, hospital area, number of operating rooms, and sterilization department area.

2. Methodology

Sterilization department is one of the most critical places in hospitals that it includes two opposite and adjacent sides; the first is decontamination space (dirty area) and the second is sterilization/ store area (clean area). Decontamination area is where reusable equipment, tools and instruments are cleaned manually, mechanically by washer disinfectors, or chemically to remove organic matter and to reduce the levels of microbes in used tools. It is negative pressure related to surrounding spaces and receive all infected tools and material while sterilization area is one of the cleanest areas inside hospital that distribute all instruments to operating theater and intensive care units. It is positive pressure related to surrounding areas. There are many factors affect the sterilization department space. These factors as indicated in figure 1 are: 1)- services (steam sterilization, Plasma, and / or endoscopic disinfection). 2)- location (beside operating theater, ICU, waste collection, laundry, and / or in specific location having vertical movement for clean and dirty). 3)- finishing; although the finishing should be anti-bacterial materials, it can be paints, S. S, and / or PVC. 4)- zones; the sterilization department can be divided into sub-sections or zones as triage, decontamination, packing, sterilization, and clean store furthermore the required services as chemical store, waste, water treatment area, toilets, Staff change, manager office, quality, and receiving area for disinfected objects from laundry. 5)- flow; although the flow of work inside sterilization should be in one way as indicated in figure 2, this flow may have two, three, or four stages. The flow may be from decontamination to packing area then sterilization and finally for clean store. Sometimes, the sterilization area and clean store are merged, others have one area for last three areas (packing, sterilization, and clean store).

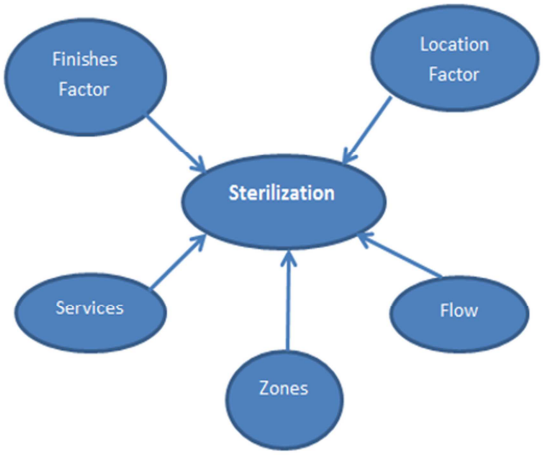

Figure 1. *Sterilization department Factors.*

There are many items that should be considered inside the sterilization department such as: - electric power to support the required power for used systems at the same time. Heat treated drainage system also should be taken into consideration together with water treatment system. Types of fire alarm, firefighting, and air pressure.

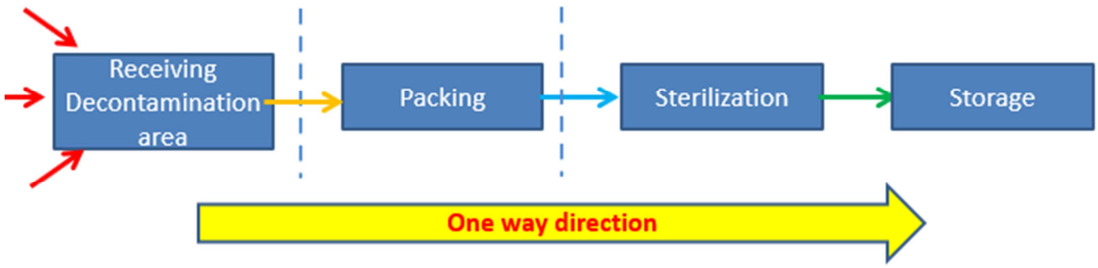

Figure 2. *Sterilization Workflow.*

In this study, forty-eight hospitals have been considered related to hospital capacity, hospital built up area, number of operating rooms, and sterilization department area. At first, the validation step of complying the department design with

infection control in all categories is performed. All hospitals recorded to medical quality accreditation organization. As indicated in table 1, a group of hospitals having hospital capacity and their four major sub-sections. It is noted that more than half of hospitals have only two sections (receiving area/ decontamination), and others have an additional section for packing, sterilization, and storage. Four different designs of sterilization departments related to hospitals capacities (80, 85, 450, and 102 respectively) as shown in figure 3 have analyzed to comply with basic parameters of accreditation as indicated in table 2. All studied hospitals have more than two suitable steam sterilizer to cover hospital needs.

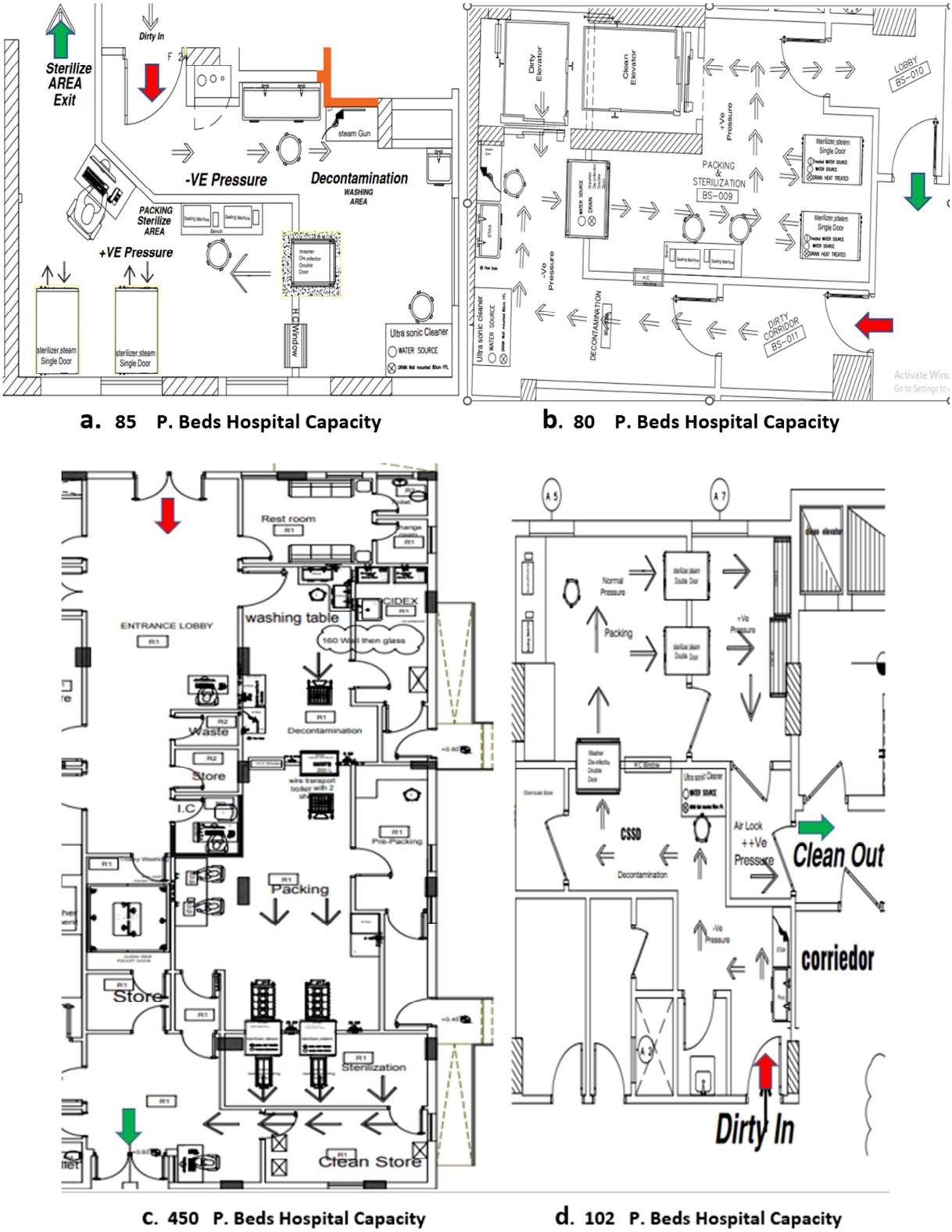

Figure 3. *Sterilization Department Designs.*

Table 1. *Hospital Capacity and CSSD Sub-Sections.*

Hospital Name	Hospital Capacity	BUA M^2	# ORs	Decontamination	Packing	Sterilization	Clean Store
1	86	4,500	4	✓	x	✓ with packing	x
2	88	4,800	4	✓	x	✓ with packing	x
3	102	9,200	4	✓	✓	✓	✓
4	125	10,000	6	✓	✓	✓ with clean store	x
5	70	4,500	4	✓	x	✓ with packing	x
6	82	4,850	4	✓	x	✓ with packing	x
7	450	39,800	14	✓	✓	✓	✓
8	168	14,500	9	✓	✓	✓	✓
9	176	15,000	10	✓	✓	✓ with clean store	x
10	210	18,500	10	✓	✓	✓	✓
11	330	26,000	12	✓	✓	✓	✓
12	600	54,000	18	✓	✓	✓	✓
13	55	5,000	3	✓	x	✓ with packing	x
14	66	5,300	4	✓	x	✓ with packing	x
15	75	5,500	4	✓	x	✓ with packing	x
16	80	5,900	4	✓	x	✓ with packing	x

Table 2. *Sterilization department validation.*

# Design	Hospital Capacity	CSSD sub-sections	Comply with Infection control	Receiving and extract	Dirty- clean barrier
A	85	2	Yes	Yes	Yes
B	80	2	Yes	Yes	Yes
C	405	4	Yes	Yes	Yes
D	102	3	Yes	Yes	Yes

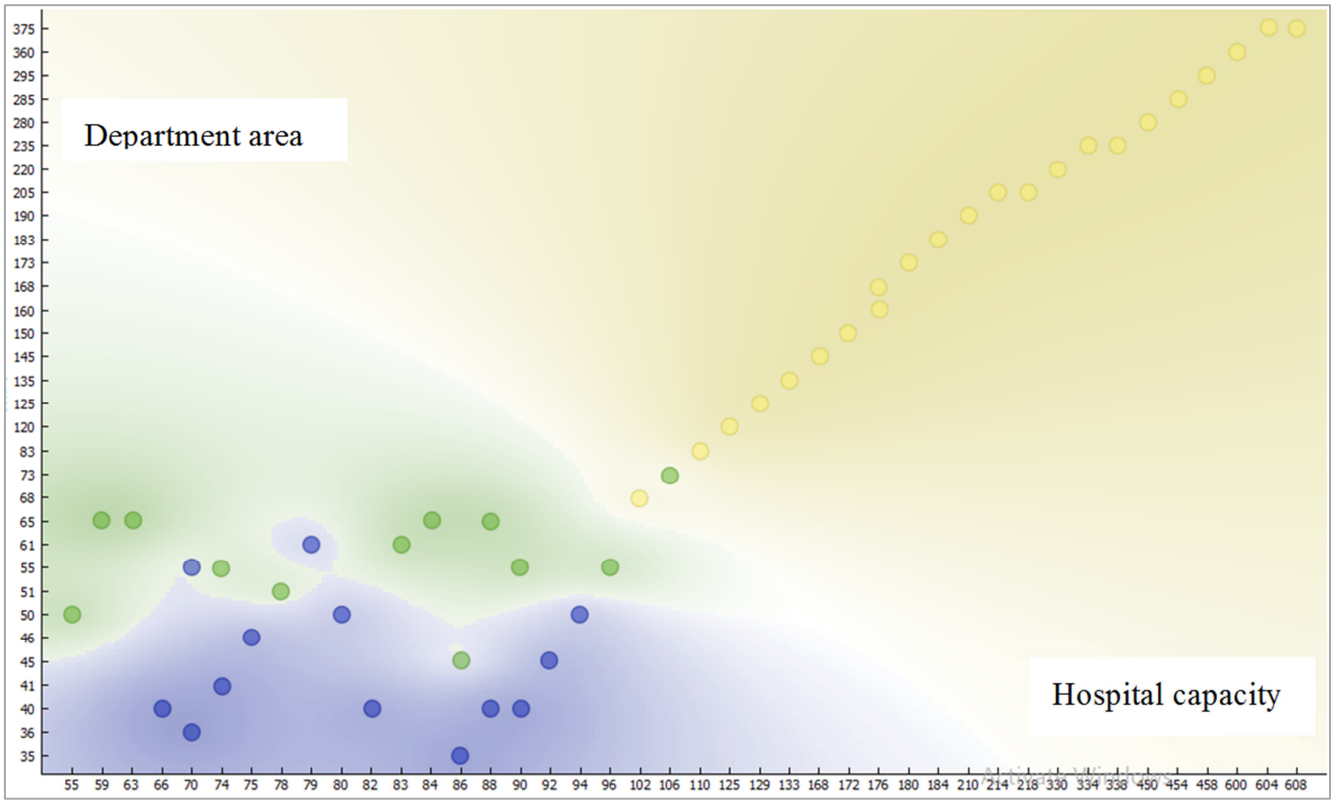

Figure 4. *Clustering of Sterilization Department Sub-Sections.*

3. Results

As indicated in figure 4, clustering of sterilization department sub-sections via logistic regression has been presented where yellow color indicates four sections, green color indicates three sections while blue color indicates only two sections. The axis is the two major parameters: hospital capacity (horizontal axis) and department space area (vertical axis). These two parameters have been studied individually to reflect the direct relation between every parameter and the department sub-sections that the total hospital built up area, and number of operating rooms are not important related to outcomes of the logistic regression.

The relation between these parameters and department sections is indicated in figure 5. There is a good separation between four sections (green color) and others specially in large hospital capacities (above hundred beds). Regarding hospital capacity, hospitals with two sections are more frequent than hospitals with three sections in less than 100 beds hospitals. By increasing the area of sterilization department, hospitals with two and three sections are roughly in the same frequent but differentiated with increasing the sterilization department area.

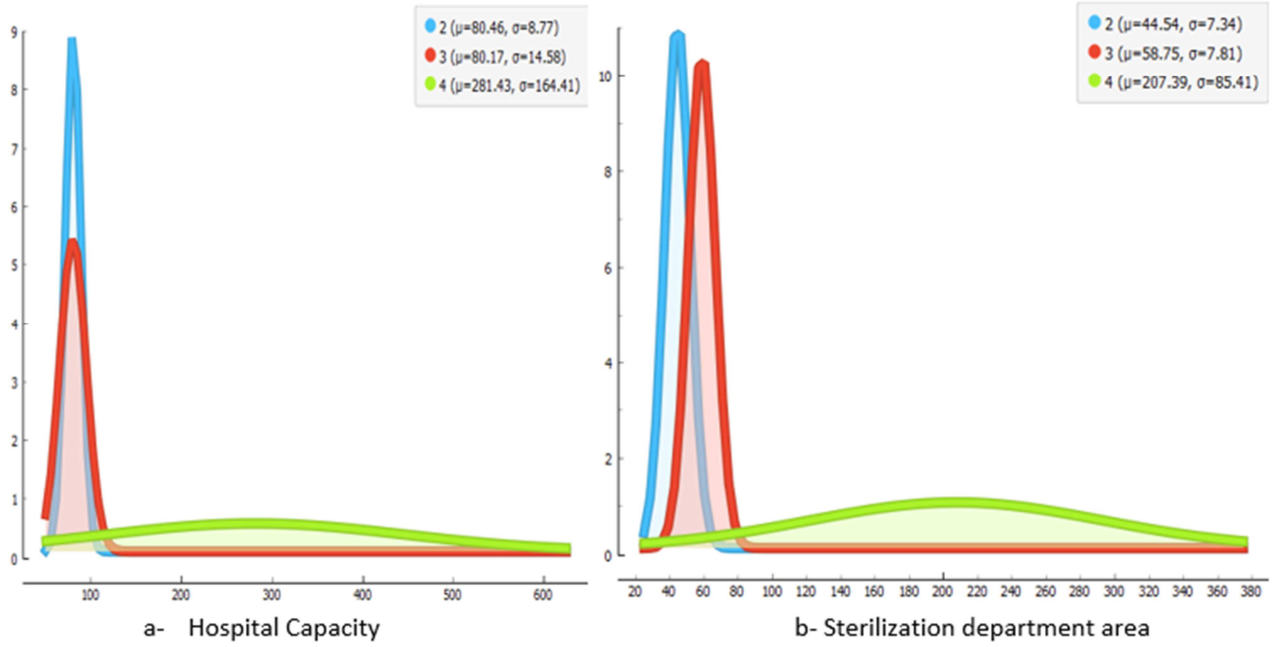

Figure 5. *Relation Between Major Parameters and Sterilization Sub-Sections.*

After keeping medical and non-medical wastes and considering lower hospital capacity as less than hundred beds, a logistic regression has been used for clustering the sterilization sub-sections of forty-eight hospital designs to extract area under curve (AUC) equal to 0.95, F1 equal to 0.853, precision 0.857, Recall 0.854, and specificity 0.936.

4. Conclusion

The Central Sterile Services Department (CSSD) is a section in a hospital where cleaning and sterilization of tools and instruments used in medical procedures takes place. The instruments have been received at decontamination area to be triaged, washed, and cleaned manually or chemically, then go to packing area to be sealed. After packing, the tools will be sterilized into steam / plasma sterilizers. Although the sterilization department can be divided into four sections or more, the low hospital capacity (less than one hundred patient beds) usually uses two sections only. Hospitals with more than a hundred beds uses three up to four sections in sterilization department due to their heavy traffic of processes. The exploring of available space area in low hospital capacity is optimized to minimize the space of every non-medical department even for hospital services as sterilization, laundry and others.

Acknowledgements

We would like to thank all hospitals that have helped and presented their support during this research.

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