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New ICU Design and Patient Outcome

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ABSTRACT

Hospital length of stay (LOS) is a quality metric health systems use as a proxy of efficient hospital management (1). Many strategies to reduce ICU length of stay (LOS) have been implemented, but few studies have evaluated the role of ICU design in reduction of LOS and outcome.

This study was informed by the need to compare ICU performance in terms of length of stay and outcome before the upgrade of the ICU facilities and organizational structure (January 2018 – December 2019) and after upgrade of the ICU facilities (January 2020 – December 2021). Finally we demonstrate the impact of ICU design in reducing costs of ICU patients.

ARTICLE DETAILS

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INTRODUCTION

Nowadays there is more and more talk about length of hospital stay (LOS) as an indicator of effective hospital management (1). Improving bed turnover, allowing hospitals to match demand with capacity for elective and emergent admissions, intensive care unit (ICU) care, and inter hospital transfers are strongly associated with reduced LOS.(2)

(ICU) is increasingly recognized as essential for improving patient outcomes. An effective intensive care unit requires architectural, structural elements, as well as optimal functionality of the configuration. Recent studies have shown that an efficient ICU design has direct effects on reducing patient mortality as well as reducing the length of stay (LOS), and therefore reducing the cost of treatment. (3)

The ICU services operated at the Armed Forces Hospital Wadi Al Dawassir is a open facility, which care for a mixed cohort of medical, surgical, and pediatric patients. This study was informed by the need to compare ICU performance in terms of outcome and length of stay before the upgrade of the ICU facilities and organizational structure (January 2018 – December 2019) and after upgrade of the ICU facilities (January 2020 – December 2021). Finally we demonstrate the impact of ICU design on decreasing the ICU length of stay.

Setting

Until 2017, the capacity of the Armed Forces Hospital in Wadi Al Dawasir was 100 beds, including 4 beds for the intensive care unit. The hospital intensive care unit consisted of:

- Nursing station
- Open storage space (Medical solutions + Medical devices + Clean utilities + Other medical supplies)
- 3 patients' rooms in addition to one isolation room
- Dirty Utilities
- Doctor's room

The requirements to operate an ICU in 1990 when the hospital was designed are not the same requirements in 2020.

The engineering team took the recommendations of experts and workers in the intensive care unit into consideration and created an integrated and sustainable design with the ability to develop and expand flexibly according to need.

The highest standards have been achieved in storing medicines, medical supplies and hazardous materials separately, safely and easily. The electrical and medical gas outlets were also replaced from the bed head unit in the patient rooms to the pendent system, which increased the possibility of adding devices without the presence of cables that impede movement. The old lighting, which was causing inconvenience to the patient and the health practitioner, was also replaced with another type that was hidden and comfortable for the eyes of the patient and the medical staff. In addition to replacing all old medical devices with newer and highly efficient medical devices and equipment, Air conditioning units were added to raise the efficiency and quality of the air, and to allocate a room for isolation, with the possibility of converting the remaining rooms to negative pressure in the event of the need for more than one isolation room. On the other hand, access to the ICU entrance was restricted to reduce the inconvenience of visitors to patients without permission, by adding doors with magnetic locks, and placing the doctor's office outside in case of need to communicate with the patient's relatives without entering the ICU. An emergency exit has also been added. The design did not overlook the quality of the materials used in the wall and ceiling claddings, as types were selected that combine aesthetics and efficiency in sound insulation and are compatible with infection control requirements. The furniture and finishing materials were of the highest quality. The nursing station was also modernized and sub-nursing stations were installed at the rate of one nursing station for each two rooms, which facilitates the monitoring and follow-up of patients.

Fig 1. Old ICU Design

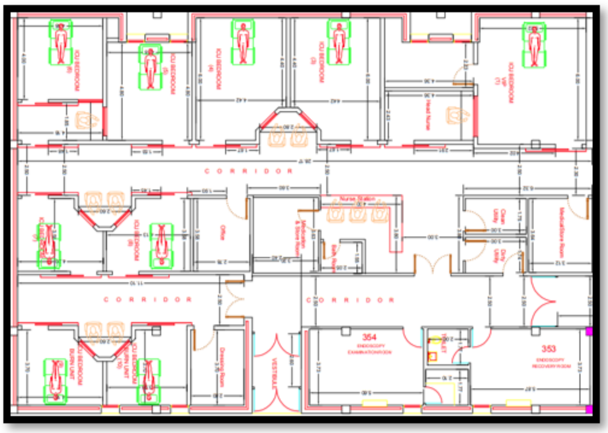

Fig 2. new ICU Design

METHOD

This was a retrospective study of all patients admitted into the ICU service of Military hospital of Waddi Al Dawassir, between January 2018 and December 2021. The study period was divided into 2 years before facility upgrade January 2018 to December 2019 (Period I) and January 2020 to December 2021 (Period II). The study was approved by the Hospital Research and Ethics Committee.

During these periods, a pro forma designed for this study was completed for all the patients from the ICU record book kept strictly in the ICU. Data collected were hospital identification number, specialty from which patient was admitted, length of ICU stay (LOS), the need of ventilation and the outcome of ICU care either discharged, dead, or alive.

The second step was the calculation of the Cost by using the widely used according to the standardized methods for the Payment system in Hospitals.

The daily costs of hospitalization on ICU depend on the need for ventilation. This cost also differs from day to day. On day 1 of the intensive care unit the cost is highest (need to ventilation, $10,794; no need to ventilation, $6,667), then decrease on day 2 (need to ventilation, $4,796; no need to ventilation, $3,496) and stabilized by day 3 (need to ventilation, $3,968; no need to ventilation, $3,184).(7)

During period I and II, we kept the same medical team; the same prevention and infection control protocols as well as the same admission and discharge criteria because these parameters can distort our results.

RESULT

The total number of patients admitted during our study was 356 for period I and 456 during period II. Fig 1 shows the frequency of admission per specialty into the ICU between Period I and Period II. The total number of admissions in

Period I was 356 compared to 456 in Period II (P = 0.06); this represents a 12.4% increase in the total number of admissions.

Fig 2 shows the repartition of patients according to the need to ventilation in first and secondry Period.

Fig 3and 4 show frequencies(n) of mortality and discharges in Period I, discharges remained persistently higher than mortality among medical (185, 43), general surgery (53, 12), cardiology (30,9), and pediatric patients (10, 4). The same remark is noted in the second period.

The highest mean length of stay (LOS) in Period I among the dead was 10.5 ± 9.4 (1–31) days in medical patients and 8.0 ± 4.6 (2–15) days in surgical patients while the highest mean LOS among those who were discharged was 12.8 ± 6.5 (4–23) days and 24 days for neurosurgical and a cardiology, respectively.

In Period II, medical patients of 5.5 ± 6.3 (1–30 days) and surgical patients of 5.8 ± 4.5 (1–15days) had the highest LOS among those who died while the highest LOS among those discharged was 12.7 ± 9.2 (2–39 days) among medical patients and 9.1 ± 4.2 (10–15 days) among surgical patients.

Overall, the mean LOS in Period I was 6.26 ± 5.4 days and in Period II 4.4 ± 2.3 days.

The global LOS was 6.26± 3.9 in Period I and 4.34± 2.5 in period II (p=0.06).

Mean intensive care unit cost was 39,810 +/- 40,810 dollars for patients requiring mechanical ventilation and 9.396+/- 10,569 dollars for those not requiring mechanical ventilation during Period I. During Period II Mean intensive care unit cost per patient was 37,510 +/- 38,560 dollars for patients requiring mechanical ventilation and 7.546+/- 9,589 dollars for those not requiring mechanical ventilation.

The difference between period I and period II was 2.3+/-2.25 dollars for patients requiring mechanical ventilation and 1.85+/- 1.813dollars for those not requiring mechanical ventilation.

Daily costs were greatest on intensive care unit day 1 (mechanical ventilation, 10,794 dollars; no mechanical ventilation, 6,667 dollars), decreased on day 2 (mechanical ventilation, 4,796 dollars; no mechanical ventilation, 3,496 dollars), and became stable after day 3 (mechanical ventilation, 3,968 dollars; no mechanical ventilation, 3,184 dollars).

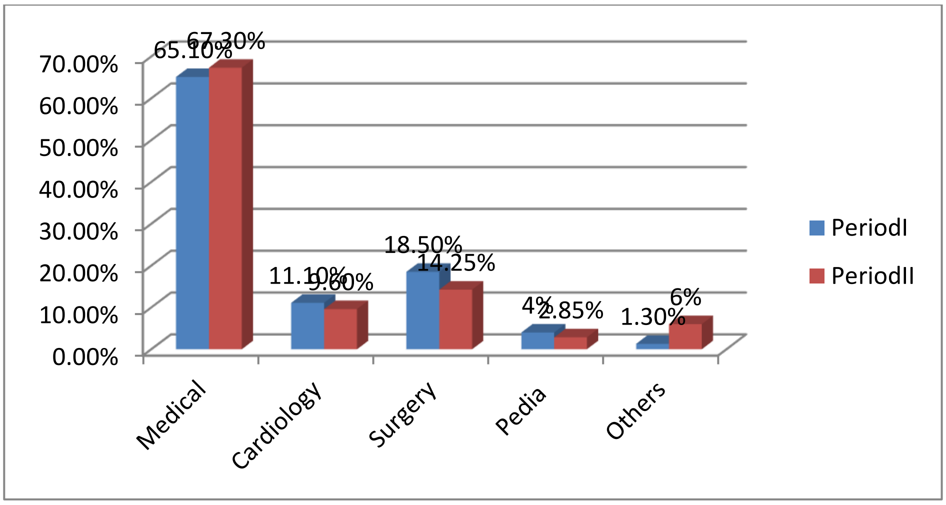

Fig 1. Number of admissios by specialty

Table. length of stay according to specialities

	LOS (Days), mean ± SD (range)							
	Period I				Period II			
	Alive		Dead		Alive		Dead	
	Nber	LOS	Nber	LOS	nber	LOS	Nber	LOS
Medical	195	12.03±6.5 (4-23	33	10.5± 9.4(1–31)	274	12.7±10.5 (2-39)	33	5.5±4.5 (1-11)
Surgery	53	9.5±2.9 (5-24)	12	8.0 ± 4.6 (2–15)	53	9.1±6.4 (1-21)	12	5.8±4.5 (2-12)
Cardiac	30	24	9	2±0.8 (1-3)	39	3±1.8 (1-6)	5	4.9±3.9 (1-15)
Pedia	14	5.3±2.5 (4-9)	4	7±3.2 (4-12)	9	4±2.5 (1=9)	4	2.8±0.6 (2-3)
Others	1	12.8 ± 6.5 (4–23)	9	7±3.2 (4-11)	16	2± 0.8 (2=4)	11	2.3± 0.5 (1-3)

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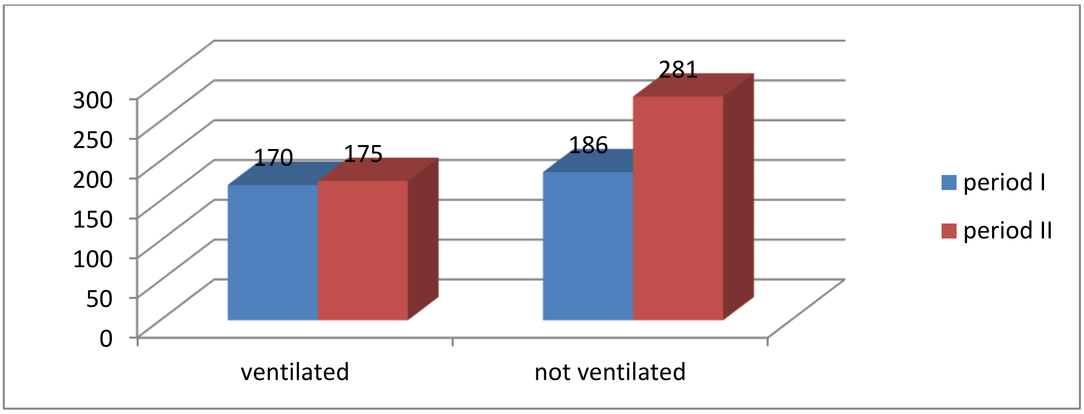

Fig 2. repartion of icu admission according to the need to ventilation

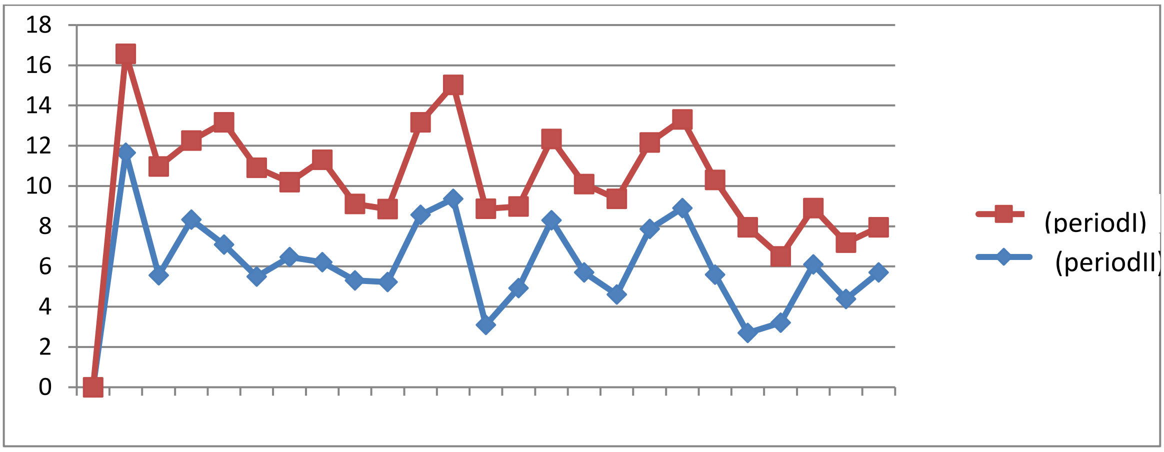

Fig 3. Mean of LOS/ month(perioI and II)

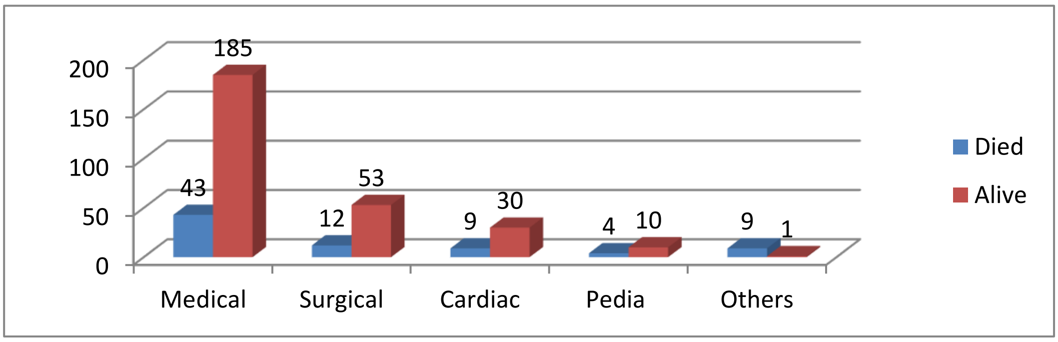

Fig 4. repartition of Died/Alive (periodI)

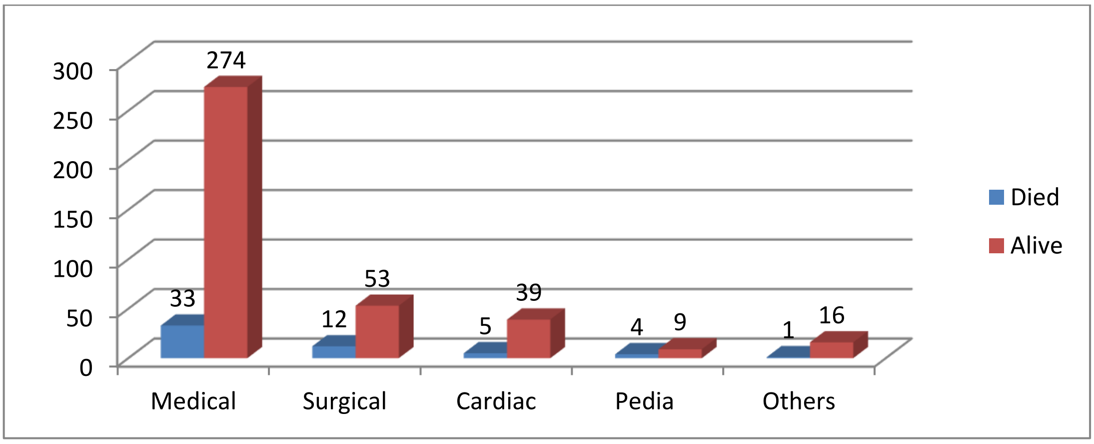

Fig 5. repartition of Died/Alive (Period II)

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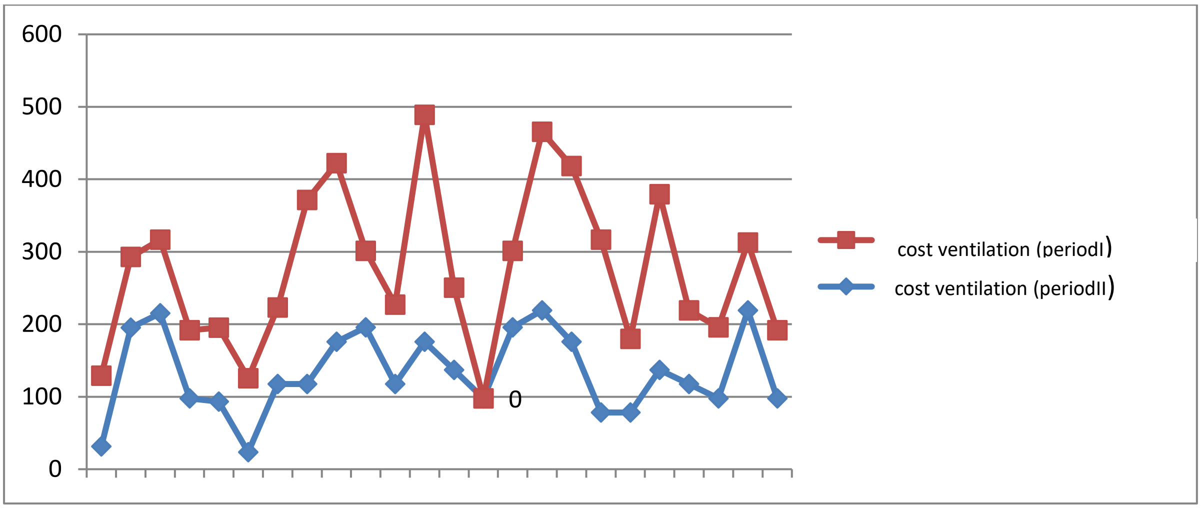

Fig 6. cost per month for ventilated patients(Period I and II)

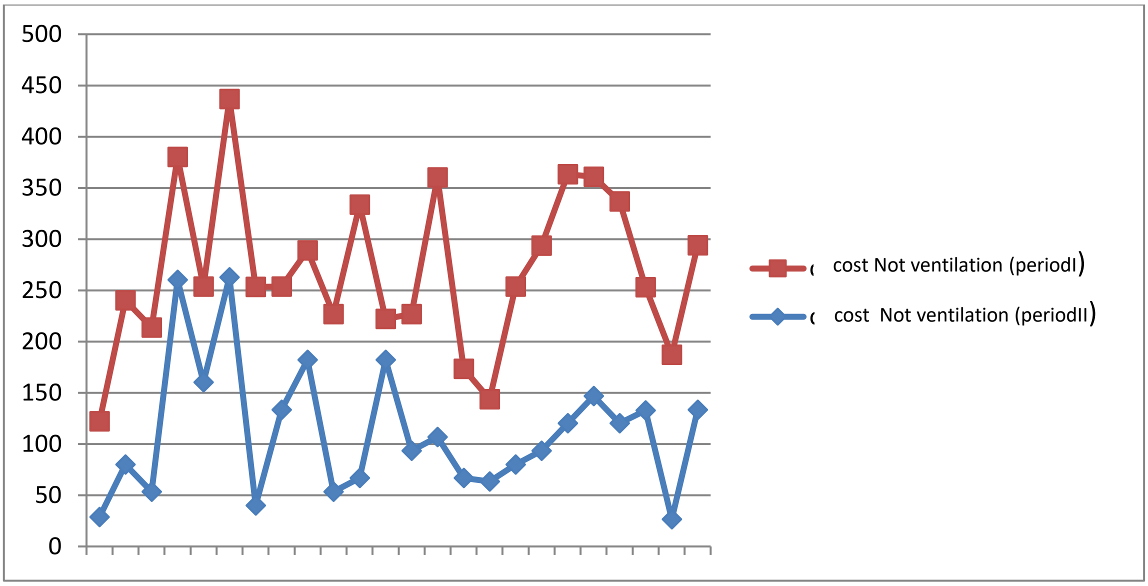

Fig 7. cost per month for Not ventilated patients(Period I and II)

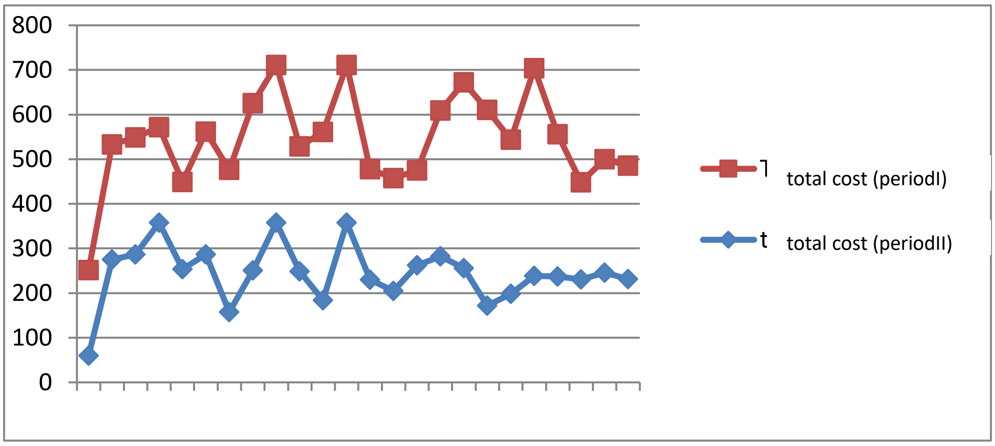

fig 8. total cost per month(PeriodI and II)

DISCUSSION

The requirements to operate an ICU in 1990 when the hospital was designed are not the same requirements in 2020. A change in the operating model of an intensive care unit may affect the design. Also, advanced technology has produced smaller devices, and the number of devices required for patient care has increased (4).

In our study we have about 2 days of reduction between Period I and II and this is related only to ICU innovation. The concept of evidence based design (EBD) originated from a study by Ulrich(5) where shorter length of stay (LOS) had and needed less analgesia if they were assigned to a patient room facing nature. Previous studies showed a positive effect on patients for most forms of exposure to nature. The health benefits of photographic sky fixtures make them better than traditional ceiling tiles. (6)

Florence Nightingale also in his study (7,8) acknowledged the importance of a suitable environment for promoting patients' health and wellbeing.

Poor environments in ICUs can be potentially inimical for the critically ill patients. (9,)

Patient outcomes are influenced by environmental factors such as shape, unit layout, floor material, room features, visibility of medical equipment, nature, lighting, and music. (10,11)

Inappropriate lighting has been shown to cause incidents and increased heart rates, indicating the patients are under stress. (13)

according to WHO recommendations, Noise can disturbe circadian rhythm and cause delirium in intensive care patients. (14)

However, by improving the sound environment in the ICU, the frequency of delirium in critically ill patients was found to decrease significantly.(15,16)

period II of our study was during the COVID-19 epidemic. despite this, we noticed a reduction in mortality in ICU. During both periods, the same admission and discharge criteria were maintained, the same medical team as well as the same standardized infection control protocols (apart from those related to protection against covid-19). Same result was found by Allison et al. in their study. (16,17)

Intensive care is a major cost component in modern healthcare systems (18,19,20). In our sample, cost of mechanical ventilation per patient was more expensive in period I than Period II (2.3+/-2.25 dollars for patients requiring mechanical ventilation and 1.85+/- 1.813dollars for those not requiring mechanical ventilation.). This can be explained by the reduction of LOS resulting from ICU innovation and the new ICU design which helps to provide quick and timely care.

CONCLUSION

this study provides important data on the impact ofICU design as quality improvement project on hospital mortality and length of stay.

Perhaps this standard ICU ward design is so refined that it already decreases mortality rate and LOS. further comparative studies among regions or even hospitals are needed to confirm this point of view.

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