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Bed utilization pattern of intensive care units affiliated to Ministry of Health: a national study in Egypt prior to the COVID-19 pandemic

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ORIGINAL STUDY

Bed Utilization Pattern of Intensive Care Units Affiliated to Ministry of Health: A National Study in Egypt Prior to the COVID-19 Pandemic

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Abstract

Background: **This study aims to calculate the following bed utilization of intensive care Units (ICU) at the national and regional levels.**

Methods: **A descriptive retrospective record-based study was done in all ICUs affiliated to Ministry of Health and Population (MOHP).**

Results: **ICU admission rate ranged from 0.09% to 0.41% with 0.19%. BOR ranged from 10% to 72% with 60%. The ALS (Days) ranged from 1.92 days to 5.41 days with 3.61 days. The average ABTI per year ranged from 1.42 days to 25.04 days with 2.46 days. The average ABTR ranged from 13.14 to 101.02 with 60.14.**

Conclusions: **Utilization of ICUs affiliated to MOHP is not optimal at the national level and there is a room for improvement.**

Keywords: Intensive care unit (ICU), Bed utilization, Bed occupancy

1. Introduction

There is an increasing demand for intensive care Units' (ICU) beds due to more severe hospital cases with aging of the population. The utilization of ICU beds is ultimately a compromise between optimal uses of this expensive resource while providing adequate care for individual patients [1]. Continuous measurement of ICU bed utilization is required for the purposes of planning, comparisons within and between health systems and providing realistic benchmarks for quality monitoring [2].

In Egypt, Ministry of Health and Population (MOHP) provides ICU services free of charge all over the country however there is no national data base which describes ICU utilization. The current estimates of ICUs occupancy are also limited in that they do not consider potential variation in utilization patterns across ICUs of different types or sizes. All these details are essential to understanding the flexibility of a system composed of many ICUs [3]. To the best of the researchers' knowledge, there is a scarcity of studies about ICU bed utilization at the national level in Egypt. This study aims to measure bed utilization of ICUs affiliated to MOHP in Egypt and its variations between different regions.

2. Population and methods

2.1. Study locality and duration

This study included all ICUs affiliated to Ministry of Health and Population (MOHP) in Egypt during the calendar year 2018 before the COVID-19 pandemic.

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2.2. Study design

A descriptive retrospective record-based study that included all patients admitted to ICUs with different diagnoses.

The following data were collected from statistical department for each hospital/ICU: number of outpatients, emergency patients, ICU admissions, separations (referred, discharged alive, died, referred to other ICU, transferred to other departments), number of available beds, occupied bed days. Egypt was divided into the seven Egyptian regions declared by General Organization for Physical Planning.

The following bed utilization indicators were calculated [4,5]:

1. ICU admission rate (ICAR) = (Number of ICU admissions in a certain year/Number of patients in the same year) * 100. This rate was calculated for all admission from both outpatients' clinics, other departments and emergency room (OPC-ER) combined.
2. Bed occupancy rate (BOR) = (Number of occupied bed days in certain year/Number of available bed days in the same year) * 100
3. Average length of stay (ALS) = Number of occupied bed days in certain year/Number of separations (discharge, transfer & death) in the same year
4. Average bed turnover interval per year (ABTI) = (Number of available bed days − Number of occupied bed days)/Number of separations (discharge, transfer & death). Patients admitted and separated on the same date are allocated a length of stay of 1 day.
5. Average bed turnover rate (ABTR) = Number of separations in certain year/Number of available beds in the same year

2.3. Ethical consideration

The study proposal was approved by IRB of XXXXXX (code: MD/17.11.01). Official approval of the MOHP and participating ICUs were obtained after assurance of data confidentiality.

2.4. Statistical analysis

Data were analyzed manually. Qualitative data were expressed as count and percent and the different indices were calculated according to the above mentioned formula.

3. Results

Table 1 shows that ICAR ranged from 0.09% to 0.41% with 0.19% all over the country. ICAR from ER visits alone ranged from 0.4% to 2.2% with 0.7% all over the country. ICU BOR ranged from 10% to 72% with 60% all over the country. The average length of ICU stays (Days) ranged from 1.92 days to 5.41 days with 3.61 days all over the country. The average ICU bed turnover interval per year ranged from 1.42 days to 25.04 days with 2.46 days all over the country. The average ABTR ranged from 13.14 to 101.02 with 58.63 all over the country.

Table 2 shows that overall ICAR was 0.19% from OPC-ER visits. The highest rate was 0.24% from OPC-ER (Delta) and 0.99% from ER (North Upper Egypt) while the lowest rate was 0.14% from OPC-ER (Greater Cairo and South Upper Egypt).

Table 3 shows that the overall ICU BOR was 59%. The highest rate was 67% (Greater Cairo) while the lowest rate was 43% (South Upper Egypt).

Table 1. ICU bed utilization in Egyptian Governorates (2018).

Governorate	ICU performance indicator					
	ICAR	ICAR (ER)	BOR	ALS	ABTI	ABTR
Cairo	0.21%	1.2%	73%	4.96	1.82	53.78
Qaliubiya	0.12%	1.6%	51%	4.34	4.10	43.21
Giza	0.09%	0.9%	68%	4.88	2.29	50.95
Alexandria	0.24%	2.2%	82%	5.41	1.21	55.08
Beheira	0.12%	0.4%	67%	4.64	2.31	52.53
Matruh	0.29%	1.6%	33%	3.70	7.57	32.38
Damietta	0.41%	0.8%	62%	2.58	1.59	87.46
Dakahlia	0.23%	0.8%	67%	2.86	1.42	85.31
Kafr El-Sheikh	0.15%	0.7%	52%	3.41	3.20	55.23
Gharbeya	0.24%	0.5%	58%	4.22	3.03	50.37
Menoufia	0.22%	0.7%	59%	3.60	2.54	59.47
Port Said	0.42%	0.7%	72%	4.01	1.56	65.49
Suez	0.13%	0.4%	45%	3.80	4.64	43.29
Ismailia	0.15%	0.5%	35%	4.09	7.65	31.10
Sharkia	0.21%	0.6%	65%	3.72	1.96	64.25
North Sinai	0.16%	0.9%	34%	4.10	8.03	30.09
South of Sinai	0.09%	1.8%	10%	2.73	25.04	13.14
Bani Sweif	0.16%	0.5%	58%	3.90	2.80	54.53
Fayoum	0.23%	0.6%	55%	2.59	2.13	77.35
Minya	0.34%	0.5%	66%	2.37	1.24	101.02
Asyut	0.14%	0.6%	68%	3.48	1.66	71.04
the new Valley	0.35%	1.2%	49%	1.92	2.03	92.41
Sohaj	0.10%	1.0%	45%	2.28	2.77	72.19
Qena	0.17%	0.6%	38%	2.64	4.25	52.96
Aswan	0.21%	0.6%	35%	2.68	4.99	47.56
The Red Sea	0.19%	0.4%	53%	2.69	2.36	72.25
Luxor	0.13%	0.4%	45%	2.90	3.51	56.96
Total	0.19%	0.7%	60%	3.61	2.46	58.63

HAR = Hospital admission rate, HAR (ER) = ICU Hospital admission rate (from Emergency Rooms), BOR = Bed occupancy rate, ALS = Average length of stay, ABTI = Average bed turnover interval per year, ABTR = Average bed turnover rate.

Table 2. ICAR in Egyptian geographical regions (2018).

Region	OPC	ER	OPC-ER	Admissions	ICAR
Greater Cairo	11,568,195	2,654,245	14,222,440	19,626	0.14%
Alexandria	6,459,036	2,438,576	8,897,612	15,426	0.17%
Delta	14,817,959	6,159,089	20,977,048	49,722	0.24%
Suez Canal	7,056,481	2,887,207	9,943,688	21,516	0.22%
North Upper Egypt	5,486,830	1,683,130	7,169,960	16,653	0.23%
Asyut	3,420,084	1,300,905	4,720,989	7538	0.16%
South Upper Egypt	6,713,069	2,081,902	8,794,971	11,880	0.14%
Total	55,521,654	19,205,054	74,726,708	142,361	0.19%

OPC = N of patients visiting Outpatient Clinics. ER = N of patients visiting Emergency Rooms. Total OPC-ER = N of patients visiting Outpatient Clinics and Emergency Departments. ICAR= ICU Admission Rates.

Table 3. ICU Bed Occupancy Rate (BOR) in Egyptian geographical regions (2018).

Region	Available bed days	Occupied bed days	ICU BOR
Greater Cairo	141,620	94,602	67%
Alexandria	116,070	74,097	64%
Delta	266,450	161,213	61%
Suez Canal	152,205	82,287	54%
North Upper Egypt	79,935	47,447	59%
Asyut	36,865	23,768	64%
South Upper Egypt	70,810	30,226	43%
Total	863,955	513,640	59%

Table 4 shows that the overall ICU ALS in days was 3.6 days. The highest ALS was 4.82 (Greater Cairo) while the lowest rate was 2.54 (South Upper Egypt).

Table 5 shows that the overall ICU ABTI was 2.46 days. The highest ABTI was 3.42 (South Upper Egypt) while the lowest rate was 1.74 days (Asyut).

Table 6 shows that the overall ICU ABTR was 58.63. The highest ABTR was 74.01 (North Upper Egypt) while the lowest rate was 47.32 (Alexandria).

4. Discussion

Bed utilization indices are objective measures of the efficient utilization of the limited ICUs. Improper utilization of ICU beds results in drain on the hospital resources. The proper utilization of ICU beds is complex and a challenge to attain. Critical and deteriorating patients are admitted to the ICU from different departments or referred from other hospitals. Also acute patients from the ER are shifted to ICU for the better management [6].

This study revealed that ICAR all over the country was 0.19% of patients visiting ERs and other departments combined. This rate is much lower than 1.2%–38.9% across the 118 Veterans Affairs acute care hospitals in USA [7]. This discrepancy could be explained by differences in hospital types, age of patients and severity of diseases.

BOR is an important performance indicator of ICUs as it provides information on the service capacity. In the current study, BOR was 60% all over the country. This rate is much lower than the optimal ICU occupancy rates which were reported to be around 70–75 [8–10]. There is a great variation in BOR across governorates, with the highest rate of 82% in Alexandria, and the lowest rate of 10% in South of Sinai. This could be attributed to lower

Table 5. ICU ABTI in Egyptian geographical regions (2018).

Region	ABD	OBD	Separations	ICU ABTI
Greater Cairo	141,620	94,602	19,626	2.40
Alexandria	116,070	74,097	15,426	2.72
Delta	266,450	161,213	49,722	2.12
Suez Canal	152,205	82,287	21,516	3.25
North Upper Egypt	79,935	47,447	16,653	1.95
Asyut	36,865	23,768	7538	1.74
South Upper Egypt	70,810	30,226	11,880	3.42
Total	863,955	513,640	142,361	2.46

ABD = Available bed days, OBD= Occupied bed days.

Table 4. ICU ALS in Egyptian geographical regions (2018).

Region	Occupied bed days	Number of separations	ICU ALS (days)
Greater Cairo	94,602	19,626	4.82
Alexandria	74,097	15,426	4.80
Delta	161,213	49,722	3.24
Suez Canal	82,287	21,516	3.82
North Upper Egypt	47,447	16,653	2.85
Asyut	23,768	7538	3.15
South Upper Egypt	30,226	11,880	2.54
Total	513,640	142,361	3.61

Table 6. ICU ABTR in Egyptian geographical regions (2018).

Region	Available beds	Separations	ICU ABTR
Greater Cairo	398	19,626	49.31
Alexandria	326	15,426	47.32
Delta	748	49,722	66.47
Suez Canal	428	21,516	50.27
North Upper Egypt	225	16,653	74.01
Asyut	104	7538	72.48
South Upper Egypt	199	11,880	59.70
Total	2426.84	142,361	58.63

population density in frontiers governorates. Another contributing factor is self-referral to highly specialized university hospitals with high-quality services rather than local small hospitals.

Low BOR is a waste of both human and monetary resources. Too high occupancy means excessive work that negatively affects morale. Also it may be associated with refusal or delayed admissions to ICU and increased severity of illness on later admission to the ICU [10−12]. Furthermore, full occupancy leads to turning away patients and jeopardize both reputation and future referrals. It was postulated that full occupancy is unobtainable as the discharge of existing patients and subsequent admission of new patients is not instantaneous and time is required for servicing and resetting the bed space [13]. BOR varies according to place and size of hospital as well as season and presence of emergency services.

The BOR of 60% all over Egypt is intermediate to findings in other countries. A more or less similar rate was reported in USA between 2000 and 2005, national ICU occupancy rates ranged from 65% to 68% [14]. In 2010, the average national ICU occupancy rate was 66% [15]. Another US study reported that ICU occupancy ranged from 57.4% to 82.1% over a three years period [16]. In a Bangalore hospital: BOR was 61.11% [17].

Much higher rates were reported in both developed and developing countries. BOR of 91.12% and 96.947% in Iran [18], 69.75% in Nepal [19], 75.53% and 98.5% in India [20,21], 74.7% in Malawi [22], 83.8%−94.4% in Taiwan [23] and 83.8%−88.2% in England before and during the COVID-19 pandemic [24].

ALS in the ICU has been used as a measure of resource utilization as it impacts upon bed availability and leads to long waiting times. A patient with prolonged ICU stay consumes a significant share of the ICU resources and adversely affects the health status by increasing the risk of infection, complications and mortality [25−27]. ALS is often used as an indicator of adequate bed utilization. All other things being equal, a shorter stay will decrease the cost per discharge. Decreased ALS, increased BOR with good BTR are indicators of optimum utilization of ICUs beds [28].

ALS in ICU is an important estimate relating to the stability of the healthcare system in terms of ICU bed occupancy [29]. However, as two units could have the same BOR but different ALS, these two rates should be examined together to properly assess the unit activity [10].

In the current study ALS (in days) all over the country was 3.6 days, with the highest rate in Alexandria (5.4 days), and the lowest rate in The New Valley (1.9 days). This ALS is short but it is quite different from one ICU to another depending upon the type of cases, nature of emergency and severity of illness. ALS is being recommended to be around 5−6 days for efficient utilization of ICU [30].

Shorr [31] in his review concluded that length of stay has been documented as short as 24 hours, and as long as 132 days. The ALS (in days) varied form study to another. It was 5.53, 4, 5 and 3.16 in different Indian studies [21,22,24,25,32] 6.5 in Taiwan [27], 6.94 and 4.44 in Iran [18], 5.45 and 7.28 in Nepal [19], 4.8 in Malawi [22], 7.9 and 9.9 in Iran [33] and 10.2 in Turkey [34]. These variations are related to morbidity pattern of admitted cases, chronic cases have long stay compared to acute cases.

ABTR and ABTI are inter-related. The bed turnover rate indicates the speed with which patients on any ICU bed are rotated. The overall ABTR and ABTI were 58.63 and 2.46 days; respectively with marked variability between different regions. Also there was a lower ABTI and a higher ABTR in Governorates with high ICU admission rates vs. Governorates with low ICU admission rates.

ABTR varies in different studies and localities. It was 56.5 in Malawi [26], 60.01 and 52 in India [17,20], 38.6 and 50.4 in Nepal [19] and 31.67 & 25.89 in Iran [18]. Small BTR would indicate fewer people utilizing the hospital. Whereas, increase in BTR appears to be the outcome of increasing admission rates but also indicates that the hospital is operating at a high level of efficiency regarding bed utilization.

ABTI (in days) varies in different studies and localities. It was 1.63 in Malawi [22], 2.02 and 1.5 in India [17,20], 2.86 and 0.08 in Nepal [19], 1 hour and less in Iran [18], 1.63 days in Malawi [26]. It was commented that rapidly declining turnover intervals reflected shortage of ICU beds. Furthermore, negative turnover interval suggests non-availability of beds at certain crucial moments [19,21].

In conclusions, The MOHP affiliated ICUs bed utilization overall Egypt is not optimal; there is underutilization in most of the indicators and there is a room for improvement. Equitable distribution of ICU units with proper logistics and well-trained staffing all over the country, especially frontiers governorates is recommended. Establishment of national electronic health registry for ICUs all over the country will facilitate transfer and co-ordination between different hospitals at the governorate, regional and national levels. ICUs utilization indices should be calculated annually to be the base for planning and evaluation of this important type of health care. There is a need to balance the

availability of ICU beds versus scarce resources and actual utilization in each region of the country. More information is essential to adequately monitor, plan and evaluate activities of ICUs. It is recommended that bed utilization indices be used routinely to assess, analyze and improve the available resources.

Study limitations: ICUs of other health sectors (e.g. university hospitals, private sector, military hospitals) were not included. The underlying reasons for the variability of the studied indices between different governorates and regions were not explored. The study was done before COVID-19 pandemics so the situation is now totally different due to overburden of ICU with COVID-19 patients. However, the results are still valid as there special ICUs and isolation centers for COVID-19 cases.

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Authors' contribution

Abdel-Hady. El-Gilany: concept, design, statistical analysis.

Abeer El Ashry: data acquisition, data analysis, manuscript preparation, literature search.

Mohamed A. Khafagy: definition of intellectual content.

Noha M. El Adawi: manuscript editing, manuscript review, responsibility for the integrity of the work.

Monir Bahgat: Literature search, data collection, drafting the manuscript.

All authors revised the manuscript for its intellectual contents and approved it.

Conflict of interest

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References

[1] Wunsch K, Kasten N, Fuchs R. The effect of physical activity on sleep quality, well-being, and affect in academic stress periods. Nat Sci Sleep 2017;9:117−26.
[2] Costa AX, Ridley SA, Shahani AK, Harper PR, De Senna V, Nielsen MS. Mathematical modeling and simulation for planning critical care capacity. Anaesthesia 2003;58(4):320−7.
[3] Mokhtar S. Critical Care Medicine in Egypt: Problems and Challenges. Egypt J Crit Care Med 2015;3(2):83−5.
[4] Koch G. Basic allied health statistics and analysis. second ed. 2000.
[5] Siddiqui MI. Hospital administration and management in: community medicine and public health edition. Time publishers; 2016. 8th Chapter: Hospital Administration Editors: Shah KS, Mohamaed Iliyas, MA Ansari, Muhammad Irfanullah Siddiqui.
[6] Cowan RM, Trzeciak S. Clinical review: emergency department overcrowding and the potential impact on the critically ill. Crit Care 2005;9:291−5.
[7] Chen LM, Render M, Sales A, Kennedy E, Wiitala W, Hofer T. Intensive Care Unit Admitting Patterns in the Veterans Affairs Health Care System. Arch Intern Med 2012; 172(16):1220−6.
[8] ESICM Work13.Valenti n A, Ferdinande P. Recommendations on basic unit requirements for intensive care units: structural and organizational aspects. Intensive Care Med 2011;37(10):1575−87.
[9] Valenti n A, Ferdinande P. Recommendations on basic unit requirements for intensive care units: structural and organizational aspects. Intensive Care Med 2011;37(10): 1575−87.
[10] Tierney LT, Conroy KM. Optimal occupancy in the ICU: A literature review. Aust Crit Care 2014;27(2):77−84. 2014.
[11] Akman O, Ozturk C, Bektas M, Ayar D, Armstrong MA. Job satisfaction and burnout among paediatric nurses. J Nurs Manag 2016;24:923−33.
[12] Rewa OG, Stelfox HT, Ingolfsson A, Zygun DA, Featherstone R, Opgenorth D, et al. Indicators of intensive care unit capacity strain: a systematic review. Crit Care 2018; 22:86.
[13] Ridley S, Rowan K. Be wary of occupancy figures. Health Trends 1997;29(4):100−5.
[14] Halpern NA, Pastores SM. Critical care medicine in the United States 2000−2005: An analysis of bed numbers, occupancy rates, payer mix, and costs. Crit Care Med 2010;38: 65−71.
[15] Halpern N, Pastores S. Critical care medicine beds, use, occupancy and costs in the United States: a methodological review. Crit Care Med 2015;43(11):2452−9.
[16] Wunsch H, Wagner J, Herlim M, Chong D, Kramer A, Halpern S. ICU Occupancy and mechanical ventilator use in the United States. Crit Care Med 2013;41(12): 2712−9.
[17] Shukla D. A study on intensive care unit with special reference to utilization in a selected hospital. M. Sc. Thesis in Hospital Administration. Rajiv Gandhi University of Health Sciences; 2006. Available at: http://52.172.27.147:8080/jspui/bitstream/123456789/2425/1/CDLHOSP00007.pdf. [Accessed 29 December 2021].
[18] Eraghi M, Beigmohammadi M, Soleimani A, Mojtahedzadeh M. Intensive care unit staff and resource utilization: Is it an effective factor? Iran J Public Health 2013; 42(9):1021−5.
[19] Shrestha RR, Vaidya PR, Rana RB. Intensive Care Unit Bed Utilization of a Tertiary Care Hospital: A Five-Year Trend Analysis. Postgrad Med J NAMS 2015;15(2):1−4.
[20] Sett A, Sundresh J. Bed utilization pattern of intensive care unit of a tertiary care hospital in Kolkata. Global J Res Anal 2017;l6(1):619−23.
[21] Shafa D, Mutaharra HA, Bukhari IA, Naqishbandi JI, Mufti S. Utilization of intensive care units in a tertiary care hospital. JK Pract 2008;15(Suppl.2):S26−8.
[22] Wong A, Prin M, Purcell L, Kadyaudzu C, Charles A. Intensive Care Unit Bed Utilization and Head Injury Burden in a Resource- Poor Setting. Am Surg 2020;86(12): 1736−40.
[23] Cheng K, Lu C, ChungY, Huang M, Shen H, Chen H, Zhang H. ICU service in Taiwan. J Intens Care 2014;2:8.
[24] O'Dowd A. Hospital bed occupancy rates in England reach dangerously high levels. BMJ 2021;374:n2079.
[25] Arabi Y, Venkatesh S, Haddad D, Shimemeri AA, Malik SA. A prospective study of prolonged stay in the intensive care unit: predictors and impact on resource utilization. Int J Qual Health Care 2002;14(5):403−10.
[26] Gilio AE, Stape A, Pereira CR, Cardoso MF, Silva CV, Troster EJ. Risk factors for nosocomial infections in a

critically ill pediatric population: a 25-month prospective cohort study. Infect Control Hosp Epidemiol 2000;21: 340−2.
[27] Abelha FJ, Castro MA, Landeiro NM, NevesAM Santos CC. Mortality and Length of Stay in a Surgical Intensive Care Unit. Rev Bras Anestesiol 2006;56(1):34−45.
[28] Ravikiran E, Vijaya K. Utilization of beds in tertiary care hospital. J Acad Hosp Admin 2003;15(2):7−12.
[29] Lapidus N, Zhou X, Carrat F, Riou B, Zhao Y, Hejblum G. Biased and unbiased estimation of the average length of stay in intensive care units in the Covid-19 pandemic. Ann Intensive Care 2020;10(1):135.
[30] Deva S, Mutaharra HA, Bukhari IA, Naqishbandi JI, Samiya M. Utilization of intensive care units in a tertiary care hospital. J K Practioner 2008;15:S26−8.
[31] Shorr A. An update on cost-effectiveness analysis in critical care. Curr Opin Crit Care 2002;8(3):337−43.
[32] Agrawal A, Gandhe MB, Gandhe S, Agrawal N. Study of length of stay and average cost of treatment in Medicine Intensive Care Unit at tertiary care center. J Health Res Rev 2017;4:24−9. Available at: https://www.jhrr.org/temp/JHealthResRev4124-3340888_091648.pdf.
[33] Ala S, Pakravan N, Ahmadi M. Mortality Rate and Outcome among Patients Admitted to General Intensive Care Unit during "Morning-Hour" Compared with "Off-Hour" International. J Clin Med 2012;3:171−7.
[34] Toptas M, Samanci N, Akkoc E, Esma Yucetas E, Cebeci E, Sen O, Can M, Ozturk S. Factors Affecting the Length of Stay in the Intensive Care Unit: Our Clinical Experience. BioMed Res Int 2018:4. Article ID 9438046.