Optimal Occupancy in the ICU: A literature review

Executive Summary Report

Acknowledgements

This report prepared by Karena Conroy is based on work completed by the NSW Intensive Care Coordination & Monitoring Unit (ICCMU) and is an extract from the following publication that provides a more detailed and comprehensive summary of the literature.

1. **Key Findings**

1.1 There was a lack of an operational definition and no commonly accepted or used method for calculating ICU occupancy in the literature, leading to marked differences in annual occupancy figures across individual units.

1.2 Some methods underestimate occupancy levels e.g. midnight census; and others overestimate them e.g. midday census.

1.3 High occupancy levels may have a negative effect on patient outcomes e.g. hospital mortality and ICU readmission rates; and can restrict access to ICU services.

1.4 There currently does not appear to be definitive evidence on what the optimal target for ICU occupancy should be however it could be around 70-75%, but lower for smaller/rural ICUs with less than 5 beds.

1.5 A number of factors both intrinsic and extrinsic to the ICU can impact on calculation methods that need to be considered when interpreting occupancy figures.

1.6 The most accurate method of calculating occupancy is to divide the total number of patient bed hours by the total number of available bed hours – excluding the times beds are not in use.

1.7 There was a notable lack of relevant literature in Australia highlighting the need for further research that takes the Australian context of ICU and critical care into consideration.

2. **Recommendations**

2.1 The contents of this report to be considered and recommendations endorsed by the Intensive Care Services Network (ICSN).

2.2 Actively apply, and encourage unit level adherence to, the occupancy calculation method identified in the literature review as the most accurate.

2.3 The Intensive Care Coordination & Monitoring Unit (ICCMU) to continue work on operationalising and measuring ICU occupancy to inform Key Performance Indicators (KPIs) for NSW ICU services.

2.4 Continue to support the Critical Care Resource System (or similar) to ensure real-time measurements (that inform KPIs) are possible.

2.5 Strategies and research projects relevant to furthering the evaluation of occupancy measurement and the determination of optimal occupancy levels for ICUs be identified and included on the ICSN Performance Working Group’s work plan.
3. Introduction

In intensive care, occupancy is regarded as a measure of resource use, unit activity, workload, and increasingly as a quality indicator in combination with other related measures\(^ {1-5}\). Accurate and consistent measurement of occupancy is required for the purposes of unit, hospital and health system planning, comparisons within and between health systems and providing realistic benchmarks for quality monitoring\(^ {1,6,7}\). The way in which occupancy should be operationally defined, measured, interpreted and used in Australian ICUs, however, is unclear.

The objectives of this literature review were to explore how occupancy has been operationalised, measured, reported, and interpreted and to identify optimal occupancy levels for ICUs.

4. Method

A literature search was performed using the Medline, Embase and CINahl electronic databases and citation tracking identified additional relevant articles. Articles published between 1997 and January 2012, written in English and focused on occupancy in the adult ICU setting were included. Opinion articles such as editorials, letters and comments were excluded. A narrative review of the literature was then undertaken with data abstraction performed using a summary table containing key elements related to the study aims. A second rater then verified the accuracy of abstraction using the first rater’s completed summary table and referring back to the original articles.

5. Results

A total of 16 articles were selected for this review; 13 research studies and three discussion papers. The key findings are summarised below:

- There was a lack of an operational definition of occupancy in the literature.
- There was no commonly accepted or used method for calculating ICU occupancy.
- Two articles specifically investigated and compared commonly used occupancy calculation methods with the intention of identifying the most accurate method for ICUs\(^ {8,9}\). In each of these studies, the comparison was made by applying commonly used calculation methods to the same datasets (outlined in Figure 1). Although the reference methods used by both measured hourly ICU occupancy, they differed on the level of granularity in definition and measurement.
Different calculation methods used produced marked differences in annual occupancy figures across individual units.

Using funded rather than operational beds in the calculation method (as the denominator) underestimates actual occupancy. Bed unavailability i.e. those beds taken out of service for cleaning, maintenance, patient isolation, and temporary changes in staff numbers as a result of staff leave or deployment[^1][^10][^11] should be factored into occupancy measures.

Other methods that underestimate occupancy levels include: using admission and discharge dates only (may miss patients admitted and discharged from the ICU on the same day); census methods for calculating occupancy (can omit patients with short durations of stay[^8]) with midnight census likely to produce the lowest occupancy level of the day as patients who are admitted in the morning and discharged at night will not be included[^1].

Methods that overestimate occupancy include those that round patient duration of stay in the ICU up to the nearest whole day such as calendar date, day-to-day methods and those that use admission and discharge dates only to calculate patient duration of stay[^8]. The census method can also overestimate occupancy, depending on the local admission and discharge practices and the time chosen for calculating occupancy. Using the midday census for example, a patient admitted to ICU at 11:30am on day one and discharged at 12:30pm on day two would be included in the occupancy calculation on both days despite their duration of stay being just over one 24-hour period[^8].

ICU occupancy levels are typically reported as yearly averages however the existence of local daily, monthly and seasonal patterns in ICU occupancy (e.g. peak daytime occupancy, lower

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[^1]: Staff leave or deployment
[^10]: Cleaning, maintenance, patient isolation
[^11]: Temporary changes in staff numbers

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**Figure 1: Occupancy Calculation Methods**

**Thompson & Spiers, 1998[^9]**

- Census- midnight
  1. Calendar date- a bed occupancy day was calculated if a patient occupied a bed during any part of a calendar day
  2. Day-to-day- a bed occupancy day was calculated if a patient occupied a bed from one day to the next or only part of a day
  3. Hourly occupancy- exact number of hours

**Ridley & Rowan, 1997[^8]**

1. Census- midnight (mean & SD of daily proportions)
2. Census- 6am (mean & SD of daily proportions)
3. Census- midday (mean & SD of daily proportions)
4. Duration of admission for all patients admitted during the study period using ICU admission & discharge dates (annual proportion)
5. Duration of admission for all patients admitted during the study period using ICU admission & discharge dates & times & rounded up to the nearest whole day (annual proportion)
6. Duration of admission for all patients admitted during the study period using ICU admission & discharge dates & times (annual proportion)
7. Duration of admission each day using ICU admission & discharge dates & times (mean & SD of daily proportions), for patients treated during the study period

*S D= Standard Deviation
occupancy levels on weekends and over holiday periods, higher occupancy levels during winter months), make average annual occupancy figures inadequate for policy and planning decisions and service evaluation\(^1,4,6,12\).

- High occupancy rates may have a negative effect on patient outcomes such as ICU and hospital mortality and ICU readmission within seven days of discharge\(^2,5\).
- High occupancy also restricts access to ICU services leading to refused or delayed admissions to ICU; cancellation of elective surgery; increased severity of illness on later admission to the ICU; nursing intensive care status patients elsewhere in the hospital; transfer of emergency patients; hospital diversions; and premature discharge\(^1,6,12\).
- There currently does not appear to be definitive evidence on what the optimal target for ICU occupancy should be however, it could be around 70-75\%\(^1,13,14\). This is based on the premise that 100\% 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\(^8\).

6. Discussion

Numerous challenges to setting optimal occupancy levels have been identified in the literature—particularly at the local level where an array of factors both intrinsic and extrinsic to the ICU, can impact on calculation methods and their interpretation. These include:

- using overall occupancy rates mask the diversity of ICU patient case-mix and are therefore inadequate for planning and managing ICU services\(^2,3,6,12\). It has been suggested for example, that high level (i.e. ICU patient) occupancy should be differentiated from low level (i.e. HDU patient) occupancy\(^3,15\).
- Unit and hospital size - there is evidence to suggest that as hospital size increases, ICU occupancy also increases\(^16\). It was argued that smaller ICUs and those located in smaller or rural hospitals need to operate at lower occupancies because they do not have the economies of scale of larger units, i.e. they require more surge capacity proportionally and rural hospitals are less likely to be in close proximity to other facilities\(^1,16\). It has been recommended that smaller ICUs with less than 5 beds should aim to operate at an occupancy rate of 45\%\(^1\). There are no reported evaluations of this in Australian ICUs.
- Factors extrinsic to the ICU that impact on occupancy levels include: the presence of a high dependency unit (HDU) or step-down facility; models of care; and bed management practices.
- It has also been recognised that occupancy is only one measure of unit activity and that it should be considered in conjunction with other unit level information. As two units could have the same occupancy figure but very different levels of patient throughput and length of stay.
(LOS), these should be examined in conjunction with occupancy in order to develop a comprehensive picture of unit activity. Methods used to calculate measures of unit activity however, must also be standardised if comparisons are to be made.

Implications for practice

After reviewing the literature pertaining to occupancy calculation methods, the following method is recommended for use across the board.

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\text{Occupancy} = \frac{\text{Total number of patient bed hours}}{\text{Total number of available bed hours}}
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- In this definition, ‘bed hours’ can be as precise as the data collection system allows i.e. for ICUs that have clinical information systems, the time can be calculated to the second.
- Accurate calculation of occupancy must be focused on beds rather than patient admissions - the number of hours a bed is occupied reflects the actual patient occupancy of an ICU for any given time period.
- If these data are not available, occupancy can be calculated from patient admissions data by using the sum of the duration of admissions for each patient admitted during the time period for which occupancy is being calculated. There are limitations to this approach that compromise the accuracy of occupancy figures: 1) patients admitted prior to the study period but who occupied a bed in the unit during that time are excluded; and 2) parts of patient stays that extend beyond the study period are included as long as the patient was admitted during the study period.
- Wherever possible the following beds should be excluded from the denominator of the occupancy calculation: physical beds that the unit is not funded to staff; temporarily unavailable beds due to cleaning after patient discharge; closed beds due to maintenance, staff leave or deployment.
- When using reported occupancy figures and comparing international studies it is important to consider which, if any, beds have been excluded from the calculation of the denominator.
- In addition to overall occupancy, ICU occupancy by different patient types should also be examined to give a more comprehensive understanding of unit activity.
- Calculating daily occupancy at the local ICU level allows for observation of variations within and between weeks, months and years. For planning and evaluation activities however, it may be more appropriate to calculate and display monthly variation in occupancy rates to allow for comparisons and the detection of seasonal trends.
Further research

The lack of relevant literature in Australia highlights the need for further research that takes the Australian context of ICU and critical care into consideration. Specific areas of need in occupancy research include the:

- frequency and length of time beds are unavailable (e.g. re-setting the bed space, staff shortages) and what impact this has on occupancy measurement;
- impact of both the intrinsic and extrinsic factors on unit occupancy and how they should be used to calculate more specific occupancy targets for each ICU and ensure optimal occupancy levels are maintained;
- immediate and long term effects of step-down facilities in the hospital and alternate models of care on ICU occupancy;
- impact of high occupancy in adult ICUs on measures of service delivery both in the ICU and more broadly across the hospital.

7. Conclusion

The literature review explored occupancy operationalisation and measurement, issues surrounding occupancy reporting, use, and interpretation, and the determination of optimal occupancy levels for ICUs. There was significant variation in the calculation of occupancy and although it has not been widely tested, the proposed measurement method has been drawn from existing work. It is evident that average annual ICU occupancy must not be considered in isolation. The array of factors discussed that impact ICU occupancy include: daily, weekly and monthly variations in occupancy; unit level factors such as patient case-mix, LOS, throughput and unit size; and factors outside of the ICU such as hospital size, presence of step-down facilities in the hospital, models of care and bed management practices. Despite there being no definitive evidence pertaining to optimal occupancy levels, findings from the collective literature suggest poorer patient outcomes and negative impacts on service delivery from around the 70-75% mark, and this should be factored into future service evaluations. Although it is recognised in the literature that ICU occupancy is impacted by many intrinsic and extrinsic factors, the specific effect they have on the maintenance of optimal ICU occupancy cannot currently be determined. More research is required in all areas concerning ICU occupancy, particularly in Australia.
8. References

Note: see publication for full list of references included in the literature review.

