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The intensive care unit volume–mortality relationship, is bigger better? An integrative literature review

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ABSTRACT

Objective: To explore the association between patient volume in intensive care units (ICUs) and risk-adjusted mortality.
Background: Large multi-speciality ICUs are emerging in response to increasing demand for critical care. Consolidation of resources through regionalisation of services aims to contain costs and optimise demand management and operational synergies. Higher patient volumes in ICU have been associated with improved outcomes. Limited evidence exists, however, to suggest an optimal volume of patients in terms of risk-adjusted mortality.
Review method: Retrospective integrative literature review.
Data sources: EMBASE, PubMed and Cumulative Index to Nursing and Allied Health Literature electronic databases.
Inclusion criteria: Primary studies of risk adjusted mortality in adult ICU patients published between 1995 and 2012.
Exclusion criteria: Studies of admissions following elective procedures.
Results: Twenty quantitative observational studies were included in this review. Studies were primarily retrospective with three conducted prospectively. Nine studied mechanically ventilated patients, six included all admissions to ICU, three reported on patients with sepsis and one study each on patients post cardiac arrest and those receiving renal replacement therapy. A significant association was evident in sixteen studies suggesting a lower risk of adjusted mortality in higher-volume units. The association was not consistent across all diagnosis. A non-linear relationship observed in two studies noted no mortality benefit occurring above a volume threshold of 450 cases annually per diagnostic category and above 711 cases not specific to a diagnostic group.
Conclusion: Patient mortality may be improved in large capacity ICUs. However, the association is not consistent across all diagnostic groups. Risk adjusted mortality is increased in low volume ICUs. There appears to be a high volume threshold at which point the risk adjusted mortality benefit is also lost suggesting a window of optimal ICU organisational performance exists between low and high volumes. Further prospective research is recommended into clinical outcomes in high volume ICUs to explore association between organisational efficiency and quality of care.

Introduction

Internationally the demand for intensive care is growing and the resources required are significant.[1] Growth in demand, driven by increased patient acuity, multiple comorbidities, population ageing and increasing therapeutic complexity, leads to escalating costs.[2,3] In Australia, for example, during 2009/2010 there were 124,991 admissions to ICU accounting for 391,600 bed days.[4] At a cost of $4000 (AUD) per ICU day the estimated annual

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expenditure was $1.56 billion.[5] Annual growth in demand compounds costs. In Australia from 2004 to 2010 demand for intensive care increased four per cent annually while in comparison the United States demand increased on average by ten per cent annually between 2000 and 2010.[4,6]

Organisational transformation in ICU is required to improve bed utilisation. Simply increasing bed capacity is not sustainable in terms of both economic and workforce requirements.[7] A key demand management strategy is networking between hospitals for the referral of critically ill patients to access definitive care.[8,9] Regionalisation, or consolidation of services into large capacity ICUs for a defined clinical network or geographic area, is being progressively adopted in many countries to concentrate resources and clinical expertise.[3,10] Small low complexity ICUs are increasingly being transferred and consolidated within regional or tertiary referral ICUs. As a result the available resources and expertise are better utilised, adequate patient volumes and improved access to definitive critical care is achieved.[11]

In hospitals with multiple ICUs, traditionally organised as segregated clinical units operating in isolation, services are increasingly being consolidated into large capacity multi-specialty ICUs referred to as an ICU 'hot-floor'.[12] The principal advantages include concentration of resources, a larger and more flexible ICU bed capacity, standardisation of clinical practice, efficiencies through economy of scale and enhanced operational synergies across critical care subspecialities.[13,14] Predictions of future service provision suggest that ICUs will comprise a much larger proportion of acute hospital beds, increasing from three to five per cent currently to between twenty and thirty per cent of beds.[3]

The association between large capacity high patient volume ICUs and mortality, however, is not well understood and the evidence to date is inconsistent across diagnostic groups. Early studies, conducted across a range of countries in the US, UK and Europe, suggested that critically ill patients have better outcomes in high volume ICUs with a reasonable occupancy rate.[15–18] In 1999 it was observed that larger units reduced average costs through increased economies of scale and also improved patient outcomes by increasing average volumes of activity by clinicians.[19] It was pointed out, however, that there can be no general presumption that larger units produce better outcomes for patients and results of early studies may have suffered from confounding due to heterogeneity of the ICU population.[20]

A recent systematic review of thirteen studies to 2010 concluded that outcomes of specific subsets of ICU patients are better in high volume ICUs.[21] Meta-analysis was not possible due to the heterogeneity of the ICU population and variation in the volume definitions adopted by investigators. The findings conflicted with some earlier studies and were later refuted in a study of mechanically ventilated patients.[22] The studies highlighted the inconsistent association that exists between ICU volume and patient mortality. Conflicting study outcomes, non-linearity of the association observed in some studies, and new studies recently conducted in Finland, United Kingdom, Australia and the United States warrant further contemporary review of the available literature.

Aim

The aim of this integrative literature review was to report on the association between patient volume and risk adjusted mortality in adult ICUs, explore the non-linearity of association and seeks to identify an optimal volume–mortality threshold.

Design

The integrative review strategy included a range of research designs and methods in experimental, non-experimental, qualitative and quantitative studies. This broad perspective enriches the understanding of outcomes measurement through the application of a systematic synthesis to draw conclusions.[23]

Search methods

Electronic databases EMBASE, PubMed and CINAHL were searched using key words: intensive care, critical care, volume, outcome, quality and mortality. Three defined concepts were intersected using Boolean operators: Concept A – terms related to intensive care ('intensive care unit' OR 'ICU' OR 'critical care'); Concept B – terms related to the size of the ICU in regard to workload ('volume' OR 'activity'); and Concept C – terms related to quality of care ('outcome' OR 'mortality' OR 'quality'). Mortality was the specific outcome of interest and 'quality' was included to capture those publications where quality of care was the descriptor of the dependant variable. These concepts were then combined using the Boolean term 'AND' to capture relevant studies.

Previous reviews of the volume–mortality association found limited primary studies undertaken in ICU. Therefore the search was intentionally broad and included all available studies published in English from 1995 to 2012. All study types were considered including cross sectional, cohort studies, case–control and randomised control trials. Reference lists from retained publications were manually searched and additional studies identified.

Inclusion criteria required that studies were: (1) conducted in ICU; (2) involved only adult ICU patients; (3) studied patient mortality against volume; and (4) included risk adjustment of the patient population to control for potential confounding. Studies were excluded if not available in English, consisted of a review or editorial or studied paediatric and/or neonatal populations. Elective procedural sub-populations were also excluded due to preoperative anaesthetic screening for suitability to undergo surgery and post-operative admission to ICU.

Data abstraction

A data abstraction template was used by the principal investigator to record text and empirical results that related to key concepts of interest in this review. Two associate investigators independently verified the results summarised in Table 1.

Synthesis

Exploration of key concepts, and interdependencies, related to patient volume, volume definitions, ICU case-mix, risk adjustment and risk adjusted mortality was undertaken. Methodological quality and statistical significance was then assessed to determine validity and generalisability of study results in Table 1.

Quality appraisal

The integrative review methodology employed here does not support the application of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for quality appraisal.[24] The lack of a standard definition for volume also prevents the use of PRISMA in this review.[25,26] Study methodology was therefore appraised using the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.[27] STROBE encompasses twenty-two criteria to specifically appraise reports on observational and cross-sectional studies.