FICM Workforce Advisory Group: CFWI Review of Critical Care Capacity Planning

Literature Review: Critical Care Bed Numbers Per Population Served

Population-based studies in the developed world suggest that the burden of critical illness is higher than generally appreciated and will increase as the population ages. Critical care capacity has long been needed in the developing world, and efforts to improve the care of the critically ill in these settings are starting to occur. Expansion of critical care to handle the consequences of an ageing population, natural disasters, conflict, inadequate primary care, and higher-risk medical therapies will be challenged by high costs at a time of economic constraint.[1]

Interest in the global burden of critical illness is growing, but comprehensive data to describe this burden and the resources available to provide care for critically ill patients are lacking. Challenges to obtaining population-based global estimates of critical illness and resources to treat it include the syndrome-based definitions of critical illness, incorrect equating of 'critical illness' with 'admission to an intensive care unit', lack of reliable case ascertainment in administrative data, and short prodrome and high mortality of critical illness, limiting the number of prevalent cases. Modelling techniques will be required to estimate the burden of critical illness and disparities in access to critical care using existing data sources. Demand for critical care is likely to increase, related to urbanization, an aging demographic, and the on-going wars, disasters, and pandemics, whereas economic crises will likely decrease the ability to pay for it.[2]

Critical care is recognised to be one of the key acute hospital services. The number of critical care beds has increased since 2000 following the DoH review of critical care services and subsequent publication of 'Comprehensive Critical Care'. In the face of data suggesting that demand for critical care services will increase in the future, we need to ensure that critical care capacity is sufficient to prevent a 'bottleneck' within the hospital system.

Unfortunately, due to the competing demands of emergency and elective admissions, patient flow through the entire hospital can be constrained by inadequate critical care capacity. Such constraints are usually manifest as postponed operations for elective admissions and non-clinical transfers for emergency patients.[3]

In 2000, Lyons et al. suggested that the provision of adult critical-care facilities was not based on a rational or scientific assessment of need and aimed to define the numbers of adult critical-care beds required for a population of 500000. In five hospitals in Wales, UK they classified patients who might be suitable for critical care in intensive-care or high-dependency units. On every 12th day for 1 calendar year, they counted the numbers of such patients admitted in a defined geographical population. A panel of ten intensivists made consensus decisions about whether individual patients were in the appropriate unit. The data were used to predict the numbers of beds and units required for the population. 4058 patients were suitable for critical care, of which 3028 lived in the study area. 56.4% were in general wards, 22.3% in high-dependency units, and 21.3% in intensive-care units. The mean risk of

death was 22.0% and the in-hospital death rate 17.3%. According to the masked consensus, 41.3% of patients required high-dependency beds and 21.5% intensive-care beds. Mean risk of death increased from general wards (14.7%) to high-dependency units (19.2%) to intensive care (37.0%). Based on the consensus decisions, the average daily requirement of intensive-care beds was 21 and of high-dependency beds 43; to meet needs 95% of times required 30 and 55 beds, respectively, in a single critical-care unit.[4]

In 2009 an article was published in the BMJ that aimed to evaluate the impact and cost effectiveness of a programme to transform adult critical care throughout England initiated in late 2000 (Comprehensive Critical Care). Evaluation of trends in inputs, processes, and outcomes during 1998-2000 compared with last quarter of 2000-6 was presented. 96 critical care units in England were analysed and 349,817 admissions to critical care units were included. Adoption of key elements of modernisation and increases in capacity were assessed. Units were categorised according to when they adopted key elements of modernisation and increases in capacity. Trends in inputs (beds, costs), processes (transfers between units, discharge practices, length of stay, readmissions), and outcomes (unit and hospital mortality), with adjustment for case mix. Differences in annual costs and quality adjusted life years (QALYs) adjusted for case mix were used to calculate net monetary benefits (valuing a QALY gain at £20,000 ($33,170, euro22,100). The incremental net monetary benefits were reported as the difference in net monetary benefits after versus before 2000.[5]

In the six years after 2000, the risk of unit mortality adjusted for case mix fell by 11.3% and hospital mortality by 13.4% compared with the steady state in the three preceding years. This was accompanied by substantial reductions both in transfers between units and in unplanned night discharges. The mean annual net monetary benefit increased significantly after 2000 (from £402 ($667, euro445) to £1096 ($1810, euro1210), indicating that the changes were relatively cost effective. The relative contribution of the different initiatives to these improvements is unclear. They concluded that although it is unclear which factors were responsible, collectively the interventions represented a highly cost effective use of NHS resources.[5]

Critical care medicine is a global specialty and epidemiologic research among countries provides important data on availability of critical care resources, best practices, and alternative options for delivery of care. Understanding the diversity across healthcare systems allows us to explore that rich variability and understand better the nature of delivery systems and their impact on outcomes. However, because the delivery of ICU services is complex (for example, interplay of bed availability, cultural norms and population case-mix), the diversity among countries also creates challenges when interpreting and applying data. This complexity has profound influences on reported outcomes, often obscuring true differences.[6]

There is wide variation in all aspects of critical care. Such differences are present even between patients within the same diagnostic group because of variations in the severity of their illness and length of stay can vary dramatically. The case-mix of patients will vary between critical care units depending upon the specific hospital population they serve. Such heterogeneity frequently makes it difficult for managers or purchasers of healthcare to gain an overall picture of how a critical care unit is

operating and makes comparison between critical care units, which might be considered similar, very difficult. This variation becomes more pronounced when you consider variation in practice between UK ICUs and those in Europe.

A recent article in Intensive Care Medicine (2012) aimed to assess the variation in critical care bed numbers in Europe and to understand the differences in these numbers between countries when corrected for population size and gross domestic product. They identified 2,068,892 acute care beds and 73,585 (2.8 %) critical care beds. Due to the heterogeneous descriptions of these beds in the individual countries it was not possible to discriminate between intensive care and intermediate care in most cases. On average there were 11.5 critical care beds per 100,000 head of population, with marked differences between countries. The numbers of critical care beds per country corrected for population size were positively correlated with GDP ($r(2) = 0.16$, $p = 0.05$), numbers of acute care beds corrected for population ($r(2) = 0.12$, $p = 0.05$) and the percentage of acute care beds designated as critical care ($r(2) = 0.59$, $p < 0.0001$). They concluded that critical care bed numbers vary considerably between countries in Europe and that better understanding of these numbers should facilitate improved planning for critical care capacity and utilization in the future.[7]

As healthcare advances, changes in demand for critical care services are anticipated. The role of intensive and high-dependency care will need to change. As stratified patient care evolves, and with an increasing population of elderly patients undergoing major surgery there is a growing demand for critical and high-dependency care beds. Results of an audit comparing the activity of a combined Intensive Care and High-Dependency Unit (ITU/HDU) in 1981 with 1991 has shown an increase in the number of patients admitted, particularly for high-dependency care. The overall mortality in 1981 was 12% compared with 9.5% in 1991. The greatest improvement was seen in ventilated patients, where the mortality was reduced from 54% in 1981 to 30% in 1991.[8]

Existing critical care bed sizing models do not capture the complexity of today's critical care environment, nor have they been formally validated using actual hospital performance data. Computer simulation of patients passing through a critical care unit can evaluate the effects of changes in critical care capacities and selected changes in the case load or case mix.

A study published in Anaesthesia (2003) was designed to address these needs by mathematical modelling and simulation for planning critical care capacity. Using average number of patients expected in a year, average length of stay and a target occupancy level to calculate the number of critical care beds needed was mathematically incorrect because of nonlinearity and variability in the factors that controlled length of stay. For target occupancy in excess of 80%, this simple calculation will typically underestimate the number of beds required. More seriously, it provides no quantitative guidance information about other aspects of critical care demand such as the numbers of emergency patients transferred, deferral rates for elective patients and overall utilisation. The combination of appropriately analysing raw data and detailed mathematical modelling provides a much better method for estimating numbers of beds required.[9]

A paper in Military Medicine (1995) described a mathematical model revealing the relationships between bed capacity, average patient admission rates, average patient length of stay, utilization rate, and overfill rate in intensive care units. Mathematical model predictions were compared to predictions of two kinds of discrete event intensive care unit simulations and to data from a variety of real intensive care units. The methodology applies to any intensive care unit or hospital ward. There was no significant (p < 0.05) difference between measured utilization and overfill rates assessed in actual intensive care units, the rates obtained by discrete event simulations, and the rates predicted by the intensive care unit model. The intensive care unit census model could therefore enhance rational determination of intensive care unit bed and staff requirements.[10]

The high costs of building, equipping, and staffing critical care beds, coupled with more restrictive reimbursement policies, are forcing hospital administrators to seek ways for determining accurately the number of critical care beds needed. Capacity issues may be solved by simply increasing bed numbers and staffing levels. However, we must ensure that present capacity is being used as effectively and efficiently as possible and look for any improvement in patient flow that can be made. As critical care bed spaces are expensive to equip and staff, it is not unreasonable to try and quantify the likely consequences of any capacity changes. This would quantify the enhancement in service delivery in terms of extra patients treated, decreases in postponed elective operations and decreases in non-clinical transfers.

An article in Anaesthesia. (2008) aimed to model patient flows as an aid to decision making for critical care capacities and organisation. Using real data from a number of hospitals, they predicted the patient flows following a capacity or organisational change. Clinically recognisable patient groups obtained through classification and regression tree analysis were used to tune a simulation model for the flow of patients in critical care units. A tuned model which accurately reflected the base case of the flow of patients was used to predict alterations in service provision in a number of scenarios which included increases in bed numbers, alterations in patients' lengths of stay, fewer delayed discharges, caring for long stay patients outside the formal intensive care unit and amalgamating small units. Where available the predictions' accuracy was checked by comparison with real hospital data collected after an actual capacity change. The model took variability and uncertainty properly into account and could provide the necessary information for making better decisions about critical care capacity and organisation.[11]

In an article in Intensive Care Medicine (2003) the relationship between labour cost per patient and the size of intensive care units were analysed. They examined the relationship between major ICU characteristics and labour cost per patient. Four-week prospective data collection, in which the hours spent by each physician and nurse on both in-ICU and extra-ICU activities were collected for eighty Italian adult ICUs.The cost of the time actually spent by ICU staff on ICU patients (labour cost) was computed for each participating unit, by applying to the average annual salaries the proportions of in-ICU activity working time for physicians and nurses. Multiple regression analysis was used to identify ICU characteristics that predict labour costs per patient. Labour cost per patient was positively correlated with ICU mortality and patients average length of stay (slopes =0.67, p =0.048 and 0.09, p <0.0001, respectively). Labour cost per patient decreases almost linearly as the number of

beds increases up to about eight, and it remains nearly constant above about twelve beds. The number of patients admitted per physician (not per nurse) increases with the number of beds (Spearman correlation coefficient =0.567, p <0.0001). Their findings suggest that ICUs with less than about 12 beds are not cost-effective.[12]

The case-mix of patients will vary between critical care units depending upon the specific hospital population they serve. In a paper from Germany (2000) all patients of critical care units from 5 major hospitals were grouped according to the Therapeutic Intervention Scoring System (TISS) over a time span of four weeks. The objective was to establish the critical care patient capacity needed in accordance with the Hessian Guidelines for Critical Care. Sample surveys showed that the ascertained data were highly reliable. 10,756 TISS-classifications were evaluated in total. 9.4% of the classifications have been assigned to general ward, 27.5% to intensive monitoring and 63.1% to intensive treatment. Assuming a standard rate of use of 85% over the year this revealed an average requirement of critical care patient capacity of 6.1% of the total number of beds. The results of the investigation were readily accepted by health insurances and hospitals involved.[13]

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