Commentary

Attending to the lightness of numbers: toward the understanding of critical care epidemiology

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Related to *Research* by Laupland, see page 513

Abstract

Most of the epidemiological studies in critical care do not express their results in terms of population burden of critical illness. This happens because the population at risk of critical illness is particularly difficult to estimate, once intensive care units (ICUs) receive patients from many sources. The study by Laupland in this issue of *Critical Care* provides a good estimate of the incidence of admission to ICUs in the Calgary Health Region. He considered the Calgary Health Region population as the denominator and explored the effects of a changing numerator according to the residency status (resident in Calgary or not) on the estimation of the burden of admission to the ICU. He demonstrated that if the residency status were not known, the incidence of admission to the ICU would have been overestimated by more than 50%. Furthermore, non-residents had a lower mortality despite higher Acute Physiology and Chronic Health Evaluation (APACHE) II and Therapeutic Intervention Scoring System (TISS) scores. There is tremendous variability in decisions to admit a patient to the ICU and the epidemiology of critical care is influenced by them in a subtle but inextricable way. An understanding of the population epidemiology of critical illness and the use of the ICU, the variations in these parameters, and factors that influence this variation is extremely important. The notable effect of a changing numerator on the estimation of the population burden of ICU admissions in the study by Laupland illustrates how fluid our estimates of disease incidence and mortality – the mainstays of epidemiology – can be.

Keywords critical illness, critical care, epidemiology, community health planning

A lot of epidemiology is simple division. Divide the number of new cases of a disease by the number of people at risk of developing it and you have its incidence. Divide the incidence of the disease in people exposed by the incidence in those unexposed and you have the relative risk. The standardized mortality ratio (SMR) is just the observed number of deaths divided by the number of deaths predicted by a reference population.

In critical care, we spend a lot of time thinking about the epidemiology of the numerator – the patients with critical illness who are admitted to an intensive care unit (ICU). Although this is no trivial matter, there is great difficulty in deciding which patients have which critical illness syndromes; far less attention has been paid to the denominator. These are the patients who are not critically ill and patients with critical illness who are not admitted to the ICU. Most of the epidemiological studies in critical care do not express their results in terms of population burden of critical illness – in other words, they fail to account for the population at risk, namely the denominator. Some studies do a superb job of evaluating the numerator (careful examination of patients in an ICU with the disease under study) but, because they studied patients at selected institutions, the population denominator, and hence the incidence, cannot be determined [1,2]. Other studies have

ICU = intensive care unit.

used the entire United States population as the denominator but use a numerator extrapolated from relatively limited observations [3,4]. We therefore do not have very good population data on the burden of critical illness or the burden of intensive care needs.

In critical care epidemiology, denominators have not been fully understood because they are difficult to estimate. ICUs are at the apex of a complex health care system and receive patients from many sources. The geographic population at risk for illness that should be used as a denominator to generate disease incidence figures might be considerably different than the population from which the ICU admits its patients. This is particularly true at hospitals that provide care to critically ill patients transferred from other ICUs and at hospitals that provide specialized procedures to patients who subsequently become critically ill.

The study by Laupland in this issue of *Critical Care* provides a good estimate of a population denominator and also demonstrates the dependence of epidemiological studies on the way in which numerators are chosen [5]. He studied admissions to the four ICUs of the three hospitals of the Calgary Health Region over a 4-year period. By linking critical care data to a regional administrative health database, he determined whether or not admitted patients were residents in the health region. He considered the region population as the denominator and explored the effects of a changing numerator according to the residency status on the estimation of the burden of admission to the ICU. Had the investigator ignored where the admitted patients lived, two errors would have occurred. First, the population burden of ICU admission requirement would have been overstated by more than 50%. Second, Laupland showed that non-residents' mortality was lower even though they had higher Acute Physiology and Chronic Health Evaluation (APACHE) II and Therapeutic Intervention Scoring System (TISS) scores. This probably reflects the reasons, poorly explored in the article, that non-residents received care in an ICU outside their health care region.

In planning for resource use for a given health care region, understanding the population needs for intensive care is crucial. This is particularly true if the residents of a community pay for the health care for out-of-region patients. Furthermore, recognition that results of epidemiological studies in critical care are so dependent on organizational issues is important to our understanding of critical care epidemiology [6,7]. Previous studies have suggested that outcomes in the ICU are influenced by admission source. Rosenberg and colleagues [8] followed up an earlier observation by Escarce and Kelley [9] and demonstrated that critically ill patients who had been transferred from another hospital had worse outcomes than those directly admitted to the studied medical ICUs even after adjusting for severity of illness.

The epidemiology of critical care is influenced by the factors that affect decisions to admit patients to the ICU. We know there is tremendous variability in these decisions. For example, in the USA there is a threefold variation in the use of the ICU during the hospitalization in which death occurs. In the region with the lowest use, 8.9% of elderly patients who die in the hospital receive care in the ICU before death, whereas 28.5% are admitted to an ICU before death in the region with the highest admission rate [10]. There is also marked variability in the use of the ICU solely for monitoring [11]. Therefore, the *epidemiology* (scientific study of the incidence, causes, and distribution of diseases in a population) of critical illness will always be inextricably linked to the *health services research* (scientific study of the organization, delivery, and financing of health care) of critical care.

The influence of organizational features of the ICU on critical care epidemiology can be subtle. Take, for instance, the conflicting results of studies regarding the influence of day and time of admission on patient outcome [12,13]. These studies have been used to draw conclusions about the effect of different levels of clinician staffing on ICU outcome. There are, however, other important issues in the comparison of outcomes between patients admitted in the ICU during the day versus at night or on a weekday versus at the weekend. For instance, the care of routine elective postoperative patients during weekdays could influence ICU bed availability for transfer patients and lead to shifting their admissions to the weekend. A decision to hold patients in an emergency room setting for resuscitation (which may improve their outcome) might also affect the time at which they are admitted to an ICU bed and whether they die before ICU admission [14]. The availability of an ICU outreach team that can provide ICU level of care outside the ICU can affect the timing of admission. Even reimbursement rate and physicians' influence have been shown to affect the use of ICU beds [15]. These are not easy factors to identify and study in single-center studies and are extremely difficult to control for in multi-center studies where the factors may vary between institutions.

Mindful understanding of the population epidemiology of critical illness and the use of the ICU, the variations in these parameters, and factors that influence this variation is extremely important. The notable effect of a changing numerator on the estimation of the population burden of ICU admissions in the study by Laupland illustrates how fluid our estimates of disease incidence and mortality – the mainstays of epidemiology – can be.

Competing interests

The author(s) declare that they have no competing interests.

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