

Variation in critical care services across North America and Western Europe*

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Objective: Critical care represents a large percentage of healthcare spending in developed countries. Yet, little is known regarding international variation in critical care services. We sought to understand differences in critical care delivery by comparing data on the distribution of services in eight countries.

Design: Retrospective review of existing national administrative data. We identified sources of data in each country to provide information on acute care hospitals and beds, intensive care units and beds, intensive care admissions, and definitions of intensive care beds. Data were all referenced and from as close to 2005 as possible.

Setting: United States, France, United Kingdom, Canada, Belgium, Germany, The Netherlands, and Spain.

Patients: Not available.

Interventions: None.

Measurements and Main Results: No standard definition existed for acute care hospital or intensive care unit beds across countries. Hospital beds varied three-fold from 221/100,000 population in the United States to 593/100,000 in Germany. Adult intensive care unit beds also ranged seven-fold from 3.3/100,000 population in the United Kingdom to 24.0/100,000 in Germany.

Volume of intensive care unit admissions per year varied ten-fold from 216/100,000 population in the United Kingdom to 2353/100,000 in Germany. The ratio of intensive care unit beds to hospital beds was highly correlated across all countries except the United States ($r = .90$). There was minimal correlation between the number of intensive care unit beds *per capita* and health care spending *per capita* ($r = .45$), but high inverse correlation between intensive care unit beds and hospital mortality for intensive care unit patients across countries ($r = -.82$).

Conclusions: Absolute critical care services vary dramatically between countries with wide differences in both numbers of beds and volume of admissions. The number of intensive care unit beds *per capita* is not strongly correlated with overall health expenditure, but does correlate strongly with mortality. These findings demonstrate the need for critical care data from all countries, as they are essential for interpretation of studies, and policy decisions regarding critical care services. (Crit Care Med 2008; 36:2787–2793)

KEY WORDS: critical care; intensive care unit; world health; health services; cross-cultural comparison; beds

There are substantial differences in healthcare systems, resources, and clinical outcomes among countries, but little is known about international differences in critical care services (1–3). As medical practice has shifted over the past 20 years, hospital costs tend to dominate health expenditure in developed coun-

tries, and critical care services represent a large proportion of these costs (4, 5). Life expectancy in developed countries continues to increase, and many countries have rapidly aging populations, potentially placing a greater demand on medical services overall, and critical care in particular (6, 7). All countries struggle to optimize quality of care while mini-

mizing costs; a full understanding of differences in underlying health services is essential for determining appropriate health policy goals for critical care delivery, both at the local and national level (1, 8). Research in critical care also now routinely involves international collaborations and data collected from multiple countries (9–12). Background information on these healthcare systems is often lacking and may influence the interpretation of results (13).

Given the paucity of data that exist on international variation in critical care, we sought to provide data on the distribution and delivery of critical care services in countries that routinely contribute to the critical care literature. We then examined the correlation between critical care services, health-care expenditure, and critical care outcomes. Some of the results of this study have been previously reported in the form of an abstract (14).

*See also p. 2942.

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The authors have not disclosed any potential conflicts of interest.

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Online supplementary data can be viewed at <http://www.ccmjournal.org>.

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DOI: 10.1097/CCM.0b013e318186aec8

MATERIALS AND METHODS

Identification of the Countries for Comparison. It was not practical to seek information on critical care services in all countries. Therefore, as a starting point, we chose to identify eight countries that routinely contribute data on critical care research. This was accomplished using a literature search of three general medical journals. For details of the search strategy, please see Appendix A in the online supplement.

Identification and Collection of Information on National Critical Care Services. A collaborator in each country of interest who had experience in critical care health services research was identified. Because we were interested in available information, we sought only crude information on the provision of national critical care services that could be reasonably compared between countries. In particular, we specifically asked each collaborator to provide: 1) population data for 2005, 2) total number of acute care hospitals, 3) total number of acute care hospital beds, 4) total number of adult intensive care units (ICUs) (excluding stand-alone coronary care units), 5) total number of ICU beds (total vs. staffed, if available), 6) median number of ICU beds per unit, 7) total number of ICU beds by ICU specialty, 8) hospital admission per year, 9) ICU admissions per year, 10) ICU admissions mechanically ventilated per year, and 11) definitions of acute care hospital beds and ICU beds. Each researcher first sought publicly accessible data where possible, and other data sources as nec-

essary. We sought data from 2005, or as close as possible to 2005, that was referenced (see online data supplement, Appendix B for full resource references for each country). Any definitions of intensive care beds stated in the data were also collected. If multiple sources were available for the same information, each country-specific researcher assessed the relative quality of the different data sources. Although critical care data are for adult intensive care beds only, rates are expressed per entire populations (including children) unless specified. Basic data were summarized in table form. Pearson correlation coefficient and linear regression were used to examine the relationship between ICU beds and hospital beds.

Correlation With Healthcare Spending, Disease Incidence, and Outcomes. Data on healthcare expenditure (calculated using purchasing power parity) were taken from the Organization for Economic Co-operation and Development 2007 (15). (The most recent data on health expenditure *per capita* across countries were from 2004). ICU beds *per capita* were correlated with health expenditure using the Pearson correlation coefficient.

Very few studies in intensive care report collected data by individual country. We used data on observed hospital mortality from the Simplified Acute Physiology Score 3 study (www.saps3.org), as well as frequency of, and outcomes from, sepsis reported in the Sepsis Occurrence in Acutely Ill Patients study (10) to examine the relationship between available ICU resources (ICU beds) and case-mix and

outcomes from intensive care across countries. Correlations were assessed using the Pearson correlation coefficient. All data management and statistical analyses were performed using Excel 2003 (Microsoft, Redmond, WA) and Stata 8.0 (StataCorp LP, College Station, TX). This study was reviewed by the local Institutional Review Board and received exempt status.

RESULTS

Definition of Intensive Care. The definitions available for the intensive care beds counted in each country are shown in Table 1. Clear definitions for the data sources used were not available for all countries.

Baseline Critical Care Data for Eight Countries. Relevant data on baseline population and hospital resources are shown in Table 2. Overall age distributions of the populations were very similar (see online data supplement Appendix C). *Per capita*, Germany had the most acute care hospital beds, and the United States had the fewest. Overall critical care resources for the eight countries identified are shown in Table 3. Germany (24.6) and Belgium (21.9) had the highest number of ICU beds per 100,000 population, seven-fold higher than the United Kingdom (3.3), which had the lowest of all eight countries. There was enormous variation

Table 1. Available definitions of intensive care beds from each country

Country	Beds Counted	Definition of Intensive Care Beds in Data
US	Adult only (no. pediatric beds in the United States subtracted out)	Critical care services defined as those provided in separate units with round-the-clock nursing, equipment necessary to care for the critically ill, and a nurse-to-patient ratio of no greater than 1 to 2
France	Adult only	"Critical care is for patients presenting or susceptible to acute multi-organ failure, directly threatening life and necessitating auxiliary support" (translated from the French law)
UK ^a		
England	Adult only. Includes high-dependency unit or CCU beds if in a combined unit	"Used for intensive care (level 3) on census day"
Wales	Adult only	Average daily available beds for "intensive care"
N. Ireland	Adult only	Level 3 beds
Scotland	Adult only	Funded, level 3 beds
Canada	Adult only	"Special care unit codes denote admission to medical intensive care unit, surgical, subspecialty, or combined medical-surgical intensive care unit. Special care units are the units in which seriously ill patients are closely monitored"
Belgium	Adult only	For patients with one or more organ functions compromised
Germany	Adult only. May include some CCU beds	"Beds that are provided for intensive care treatment"
Netherlands	Adult only	Definitions of level 1,2,3 intensive care beds according to the international literature (25)
Spain	Adult only. May include some intermediate care beds	No clear definition

CCU, coronary care unit.

^aLevel 3 care defined as "Patients requiring advanced respiratory support alone or basic respiratory support together with support for at least two organ systems. This level includes all complex patients requiring support for multi-organ failure" (16).

Table 2. Reported population and acute care hospital services for eight countries

	Total Population	Acute Care Hospitals	Acute Care Hospital Beds	Acute Care Hospital Beds/100,000 Population
US	296,410,404	7914 (2004)	655,664 (2004)	221 (2004/2005)
France	61,044,684	2134 (2003)	231,900 (2004)	380 (2004/2005)
UK	60,218,000	1815 ^a	179,512	298
Canada	32,754,119	622 ^b	98,262	300
Belgium	10,511,382 (2004)	121	52,548	500 (2004/2005)
Germany	82,500,800	1695 (2004)	489,433 (2004)	593 (2004/2005)
Netherlands	16,305,526	97 (2004)	49,304 (2004)	302 (2004/2005)
Spain	44,108,530	669	146,598	332

Data are from 2005 unless specified in parentheses.

^aLast count of individual hospitals in England is 1991. Data from Wales are from 2000–2001, and data for Scotland and Northern Ireland are from 2004–2005; ^bDoes not include data from the province of Quebec.

Table 3. Adult critical care services for eight countries

	Total Adult ICUs	Total Adult ICU Beds	Adult ICU Beds/100,000 Population	Adult ICU beds as % of All Acute Care Hospital Beds	ICU Admissions/yr	ICU Admissions/yr/100,000 Population
US	5980 (2000) ^a	59,162 (2004)	20.0 (2004/2005)	9.0 (2004)	5,700,000 (1999) ^a	1923 (1999/2005) ^a
France	550 (2004)	5707	9.3	2.5	260,000 (2004)	426 (2004/2005)
UK	268 (2002–2005)	2131 (2003–2005)	3.5 (2003–2005)	1.2 (2003–2005)	130,000 ^a	216 ^a
Canada ^b	319	3388	13.5	3.4	97,813	389
Belgium	135	2304 ^b	21.9	4.4	110,475 (2004)	1051 (2004–2005)
Germany	NA	20,259	24.6	4.1	1,941,347	2353
Netherlands	115 (2006)	1367	8.4	2.8	76,000	466
Spain	258	3628	8.2	2.5	NA	NA

Data are from 2005 unless specified in parentheses.

ICU, intensive care unit; NA, not available.

^aExtrapolated from survey/subsample data; ^bDoes not include data from the province of Quebec. Calculation per 100,000 population have excluded Quebec population from the denominator.

in the volume of admissions to intensive care; Germany had six times as many admissions to ICU (*per capita*) compared with Canada, and ten times as many as the United Kingdom.

To examine the relative proportion of critical care beds, we compared the availability of ICU beds *per capita* with hospital beds *per capita*. Figure 1 demonstrates that the number of ICU beds (*per capita*) is highly correlated with hospital beds across all countries, excluding the United States ($r = .90$).

Specialty ICUs. Table 4 shows the distribution of specialty ICUs. We were unable to provide a detailed breakdown of ICU type and bed number for all eight countries due to limitations on available data. The relative distribution of specialty ICUs vs. general ICUs was not uniform across countries, with specialty ICUs making up anywhere from 7% (Netherlands) to 20% (Canada) of units.

ICU Beds and Healthcare Spending per capita. Once the baseline data on ICU beds were collected, we examined whether there was an association between ICU beds *per capita* and healthcare

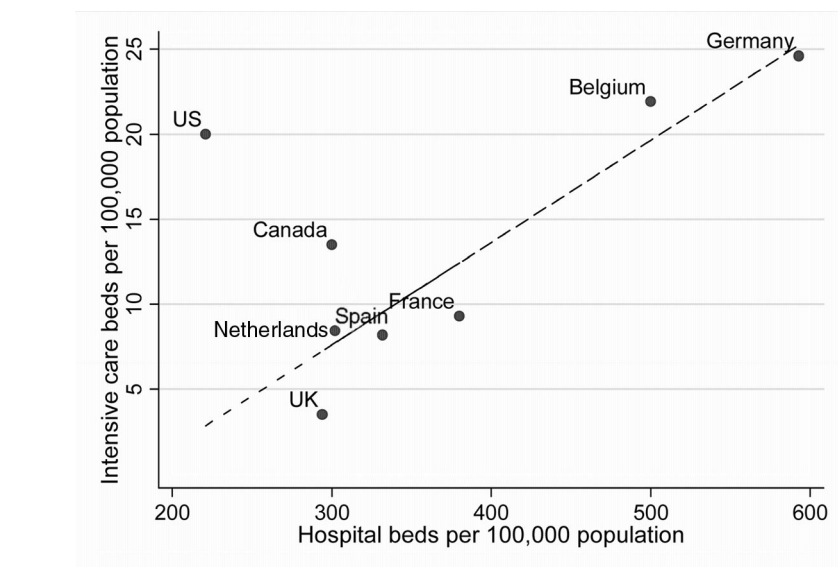


Figure 1. Correlation between reported beds: acute care hospital beds vs. intensive care unit beds per 100,000 population in eight countries.

spending *per capita*. Figure 2 shows that there is in fact only a weak correlation between the two ($r = .48$).

ICU Beds, Disease Frequency, and Mortality. We also explored whether

there was an association between ICU beds and the reported hospital mortality for intensive care patients using available published data from large international studies on intensive care (10, 17). Using

Table 4. Distribution of reported specialty ICUs and/or ICU beds in eight countries

	Distribution of Types of ICUs, n (%)				Distribution of ICU Beds, n (%)			
	Medical	Surgical	Mixed Med/Surg	Other	Medical	Surgical	Mixed Med/Surg	Other
US ^a	714 (12)	725 (12)	3865 (65)	676 (11)	NA	NA	NA	NA
France	NA	NA	NA	NA	938 (17)	704 (12)	3158 (56)	865 (15)
UK ^b	NA	NA	NA	NA	NA	NA	1409 (78)	391 (22)
Canada ^c	21 (6)	43 (12)	228 (62)	73 (20)	113 (3)	439 (11)	2500 (65)	793 (21)
Belgium ^a	10.2 (13)	7.4 (9)	54.6 (69)	6.5 (8)	NA	NA	NA	NA
Germany	NA	NA	NA	NA	8507 (42)	7149 (35)	NA	4603 (23)
Netherlands	1 (1)	2 (2)	103 (90)	8 (7)	NA	NA	NA	NA
Spain	NA	NA	NA	NA	NA	NA	NA	NA

ICU, intensive care unit; NA, not available.

^aExtrapolated from survey/subsample data; ^bEngland only; ^cDoes not include data from the province of Quebec.

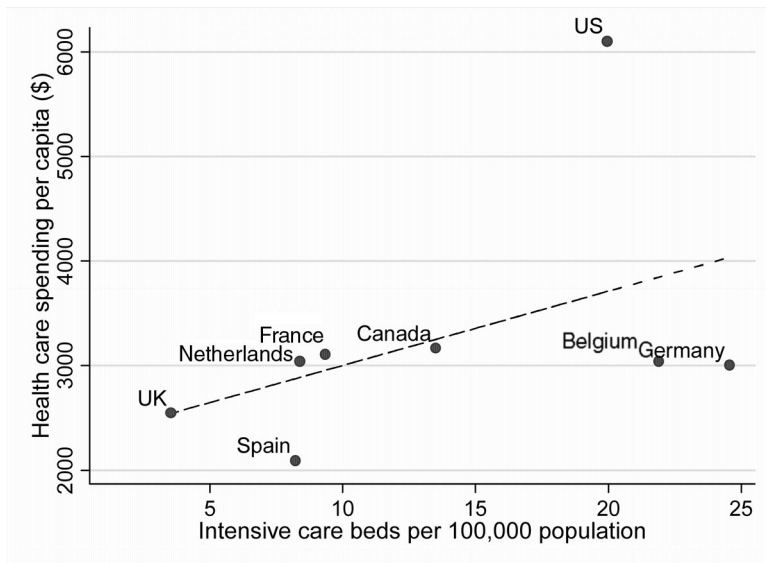


Figure 2. Correlation between intensive care unit beds per 100,000 population and healthcare spending *per capita* in eight countries (equivalent spending in dollars, using 2004 data from Organisation for Economic Co-operation and Development).

data from patients in six countries who were admitted to intensive care with sepsis (the Sepsis Occurrence in Acutely Ill Patients study), there were very strong inverse correlations between ICU beds *per capita* and both the reported frequency of sepsis in the ICUs in different countries ($r = -.85$), and the hospital mortality for these patients ($r = -.82$) (see Fig. 3). When we examined mortality data from the Simplified Acute Physiology Score 3 study, there was a very strong correlation ($r = -.82$) between ICU beds *per capita* and hospital mortality for ICU patients (see Fig. 4).

DISCUSSION

This study demonstrates large variations in critical care beds and admission

rates across eight countries. However, for all countries examined except the United States, there was a very strong correlation between critical care beds and hospital beds *per capita*, such that for every increase of 100 beds per 100,000 population there are an extra 3.5 ICU beds. The US is an outlier, having clearly adopted a different model that shifts the emphasis on resources away from acute care hospital beds and toward ICU beds. Halpern et al. (18) demonstrated this pattern from 1985 to 2000, noting a decrease of 26.4% in overall hospital beds and a concomitant increase in critical care beds of 26.2%. The decrease in hospital beds may also be due to an increased use of chronic care facilities, allowing patients to be discharged sooner from acute care hospital beds (19).

Differences in national spending on healthcare, and intensive care, are well documented (2). For instance, the US is by far the biggest spender on healthcare (15% of the gross domestic product) with Germany, France, and Canada in the middle (9%–11%), and Spain and the United Kingdom at the lower end (7%–8%). Surprisingly, there was not a strong correlation between greater provision of ICU beds and higher healthcare spending *per capita*. What does appear to correlate inversely is the provision of ICU beds and the case-mix in the ICU, and hospital mortality for these patients. Using data from two large, multi-national studies, we were able to explore these associations. The very strong correlation with the frequency of sepsis reported in ICUs in six countries suggests an effect of available resources on case-mix. The idea that the percentage of patients in the ICU with sepsis would increase if fewer ICU beds were available makes intuitive sense and may help to explain some of the variation seen in studies reporting the frequency of diseases in the ICU (10, 20). Furthermore, ICU beds also correlate highly with hospital mortality for intensive care patients. Again, this makes sense as one would expect a “sicker” patient population in the ICU if beds are more limited, and consequently a higher reported mortality for that ICU. This explanation for variation in reported mortality is strengthened by the fact that the same strong correlation between ICU beds *per capita* and mortality was found with data from two, unrelated studies of critical care patients across multiple countries. Other comparisons of the United States (with a relatively high number of ICU beds *per capita*), with other countries have also noted differences in case-mix and outcomes, likely

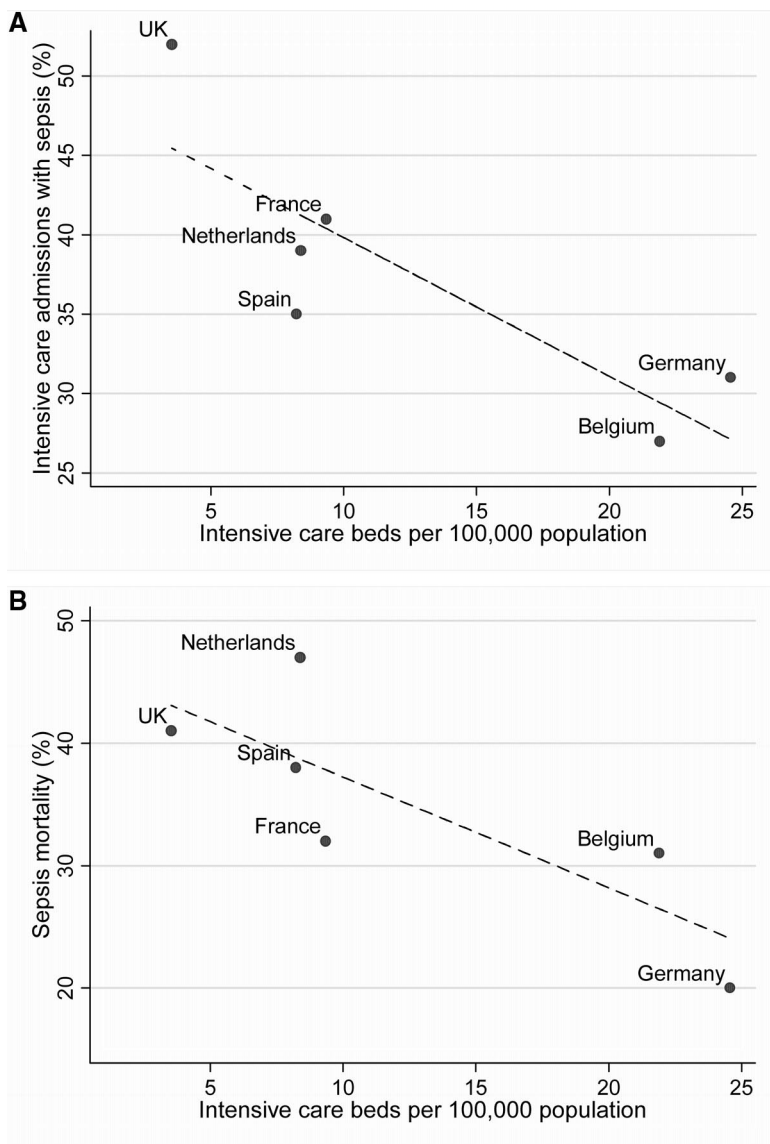


Figure 3. Correlation between intensive care unit beds per 100,000 population and the frequency of sepsis and hospital mortality for sepsis patients admitted to the intensive care unit (using data from the Sepsis Occurrence in Acutely Ill Patients study).

driven by these differences in bed availability (21–24).

Of course, our finding is one of correlation and not causation. Many other factors may play a role in the differing outcomes of intensive care patients across countries. In particular with these data, we cannot fully explore the alternate interpretation that having fewer ICU beds is merely a marker of poor care delivered in intensive care. This analysis also does not take into account differences in populations with regard to age distribution or disease prevalence. More detailed analysis of the patient characteristics, patterns of care, and outcomes are needed to fully understand the reasons for differences between countries.

Prior attempts to quantify critical care services tend to either include older data (1, 8), or lack consistency with regard to data and references reported across countries (see country series in the journal *ICU Management*). Every collaborator on this study had difficulty locating all of the relevant information, and all required use of multiple data sources. Many had to send queries to government agencies and intensive care societies. In a few circumstances, even the specific governmental agencies responsible for healthcare or statistical data did not have the necessary information, and data were obtained from surveys, private companies, or could not be located at all. Although we attempted to standardize our data collection and

obtain the most recent data available, in some cases our data are older. Furthermore, a limitation of our method for acquiring data are differences in definitions regarding what constitutes an acute care hospital bed, an intensive care bed, and how beds/admissions are counted in different countries. In particular, in the United States, where there seem to be few acute care hospital beds compared with many other countries, there are data to suggest that this may be offset by increasing use of skilled nursing facilities (19). It is possible that such facilities in the United States (and possibly some other countries) provide care similar to that delivered in some acute care hospitals. Clearly, despite the patterns observed in our study, the overall provision of intensive care beds may be driven by many factors in each country. Further work is needed to understand the complexity of these patterns across countries.

We have attempted to identify definitions of intensive care beds used in data collection in each country to clarify any differences. Some countries seem to focus on the nurse to patient ratio, or need for close monitoring, whereas others focus on the ability to support organ systems. Because of these differences, what may constitute an intensive care bed in one country may be considered a step-down or high-dependency bed in another. With the ever-increasing international nature of intensive care research and clinical discussion, international consensus definitions regarding what constitutes an intensive care bed are needed. Perhaps a more practical approach, given the many variations on care that can be delivered, would be a “minimum” definition, to ensure some similarity in level of care delivered. One example might be the ability to provide mechanical ventilation, and support of one other organ system.

The eight countries chosen here for comparison are a very small portion of the countries that routinely provide critical care. Any initial list of countries would be arbitrary, whether based on continent, gross domestic product, healthcare expenditure, or research activity. We did not attempt to generate an exhaustive description of critical care research, or a definitive list of countries; our search strategy was designed to provide data for select countries that would be considered of interest due to their relatively prominent contribution to recent critical care evidence. Given the high adoption rate across the globe of

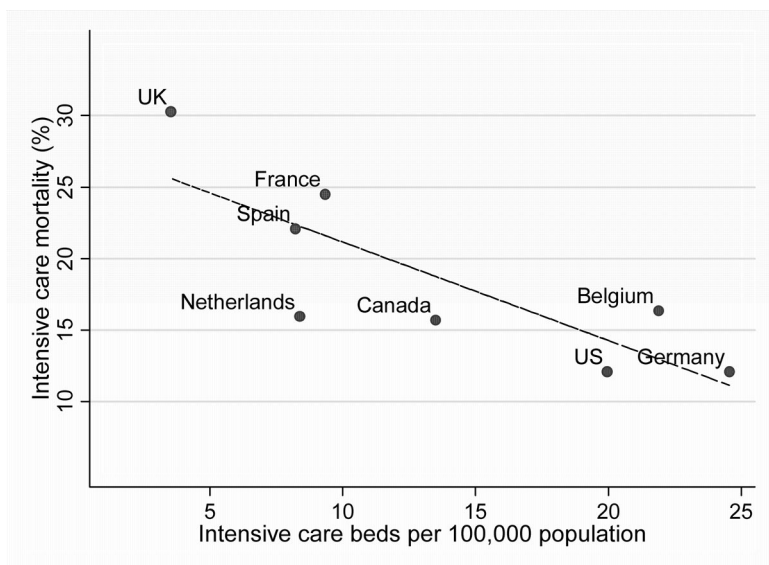


Figure 4. Correlation between intensive care unit beds per 100,000 population and hospital mortality for intensive care unit patients (using data from the Simplified Acute Physiology Score 3 study).

new treatments and strategies based on studies published in top-tier journals, it seemed that gaining an understanding of the ICU resources in the countries providing these data would be of utmost importance. This list also allowed us to correlate our findings with data from two multinational studies of ICU outcomes. It is likely that a broader search of the literature would generate a different list of countries with regard to frequency of data published. A previous examination of countries contributing to critical care and resuscitation journals by Boldt et al. (25) derived a list of countries that is similar (both containing the United States, Canada, United Kingdom, France, Germany, and The Netherlands), while we did not include Japan and Italy in our list.

Delivery of healthcare occurs at the local, regional, and national level, but rarely do healthcare budgets extend beyond national borders. Some countries, for example France and Spain, have healthcare systems that tend to be based on regional structures, rather than country-wide systems; extrapolated regional data may not always be valid at the national level. Yet, no planning for healthcare at either the regional or national level can occur without detailed information about the resources available. The difficulties in obtaining accurate information only highlight the need for better understanding and documentation. Such information is essential to improve understanding of the variation in healthcare delivery and costs between countries, to

improve policy decisions and allow for change for optimal delivery of care.

CONCLUSIONS

Absolute critical care services vary dramatically among countries, with wide differences in both numbers of beds and volume of admissions. Critical care resources seem to correlate with critical care case-mix and mortality. Knowledge of critical care resources in all countries is essential for interpretation of clinical studies, and for policy decisions regarding critical care services.

ACKNOWLEDGMENT

We thank Dr. Shuang Wang from the Department of Biostatistics at Columbia University for her assistance with this article.

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APPENDIX A

To identify countries for inclusion in this study, we performed a literature search for critical care research published in three prominent general medical journals – *New England Journal of Medicine (NEJM)*, *Journal of the American Medical Association (JAMA)*, and *The Lancet* – between January 2001 and December 2005. Articles for inclusion were original research articles on adult, critical care topics (patients, interventions and outcomes) that included patient data derived from a stay in an ICU. Articles were excluded that: 1) related to the Severe Acute Respiratory Syndrome, as these were not representative of routine critical care research; 2) were not primarily focused on a critical care topic, but included patients cared for in a critical care setting (e.g. peri-operative management interventions); 3) focused on surgical cardiac patients; 4. focused on pediatric or neonatal critical care. The following Medline search strategy was used: *Subject headings:* Critical Care, Intensive Care Unit; *Keywords:* Critical Care, Intensive Care, Intensive Therapy, ICU, ITU. Further searching was performed using individual journal websites. For the *NEJM* website: original and special articles under the “Critical Care” Topic Collection; *JAMA* website: articles under the “Critical Care/Intensive Care Medicine” Collection; *The Lancet* website: articles with the phrases “critical care” or “intensive care” anywhere in the title, abstract, or main text of the article. All articles identified by this search strategy were reviewed by hand by one of the authors (HW). For all articles that met the inclusion criteria, a list of the countries where data collection occurred was extracted based on available information regarding data sources in the text of the articles. A point was then awarded to each country that contributed patient data from at least one ICU.

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Table 1 Studies identified using the search criteria with a breakdown by number of countries, and number of units/centers included in each study

Author	Journal	Year	# of Countries	# ICUs (H)*	List of Countries
Bernard	<i>NEJM</i>	2001	11	164 (H)	Australia, Belgium, Brazil, Canada, France, Germany, The Netherlands, New Zealand, South Africa, Spain, US
Bottiger	<i>Lancet</i>	2001	1	NA	Germany (not specifically stated)
Cook	<i>Lancet</i>	2001	4	15	Australia, Canada, Sweden, US
Cremer	<i>Lancet</i>	2001	1	1	Netherlands (not specifically stated)
Ely	<i>JAMA</i>	2001	1	2	US
Ferrand	<i>Lancet</i>	2001	1	113	France
Ferreira	<i>JAMA</i>	2001	1	1	Belgium
Gattinoni	<i>NEJM</i>	2001	2	28	Italy, Switzerland
Hilbert	<i>NEJM</i>	2001	1	1	France
Merrier	<i>JAMA</i>	2001	1	8	France
Nouira	<i>Lancet</i>	2001	1	2 (H)	Tunisia
Rivers	<i>NEJM</i>	2001	1	1	US
Schortgen	<i>Lancet</i>	2001	1	3	France
Stiell	<i>Lancet</i>	2001	1	3 (H)	Canada
Van den Berghe	<i>NEJM</i>	2001	1	1	Belgium
Warren	<i>JAMA</i>	2001	19	211 (H)	Australia, Austria, Belgium, Brazil, Czech Republic, Denmark, Finland, Germany, Hungary, Israel, Netherlands, New Zealand, Poland, South Africa, Spain, Sweden, Switzerland, UK, US
Annane	<i>JAMA</i>	2002	1	19	France
Bernal	<i>Lancet</i>	2002	1	1	UK
Brealey	<i>Lancet</i>	2002	1	1	UK
Corwin	<i>JAMA</i>	2002	1	65 (H)	US
De Jonge	<i>JAMA</i>	2002	1	5	France
Esteban	<i>JAMA</i>	2002	20	361	Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, France, Greece, Ireland, Italy, Mexico, Peru, Portugal, Spain, Tunisia, UK, Uruguay, US, Venezuela
Keenan	<i>JAMA</i>	2002	1	1	Canada
Manns	<i>NEJM</i>	2002	1	3 (H)	Canada
Mehta	<i>JAMA</i>	2002	1	4 (H)	US
Nuckton	<i>NEJM</i>	2002	1	2 (H)	US
Ostrowsky	<i>NEJM</i>	2002	1	1	US
Schiff	<i>NEJM</i>	2002	1	1 (H)	Germany
Vincent	<i>JAMA</i>	2002	15	146	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK
Abraham	<i>JAMA</i>	2003	17	245 (H)	Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Israel, Italy, The Netherlands, Poland, Spain, Sweden, Switzerland, UK, US
Bruynseels	<i>Lancet</i>	2003	1	1	Belgium
Chastre	<i>JAMA</i>	2003	1	51	France
Cook	<i>NEJM</i>	2003	4	15	Australia, Canada, Sweden, US
Davis	<i>JAMA</i>	2003	1	1	US
De Jonge	<i>Lancet</i>	2003	1	2	The Netherlands
Ely	<i>JAMA</i>	2003	1	2	US
Finney	<i>JAMA</i>	2003	1	1	UK
Girou	<i>JAMA</i>	2003	1	1	France
Hebert	<i>JAMA</i>	2003	1	23 (H)	Canada
Herridge	<i>NEJM</i>	2003	1	4	Canada
Neuhauser	<i>JAMA</i>	2003	1	77–117	US
Richard	<i>JAMA</i>	2003	1	36	France
Schneiderman	<i>JAMA</i>	2003	1	7 (H)	US
Sharshar	<i>Lancet</i>	2003	1	1	France

Table 1. —Continued

Author	Journal	Year	# of Countries	# ICUs (H)*	List of Countries
Sprung	<i>JAMA</i>	2003	17	37	Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Greece, Ireland, Israel, Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, UK
Brower	<i>NEJM</i>	2004	1	23 (H)	US
Ely	<i>JAMA</i>	2004	1	2	US
Esteban	<i>NEJM</i>	2004	8	37 (H)	Argentina, Brazil, Colombia, Italy, Saudi Arabia, Spain, US, Venezuela
Finfer	<i>NEJM</i>	2004	2	16 (H)	Australia, New Zealand
Guerin	<i>JAMA</i>	2004	1	21	France
Landrigan	<i>NEJM</i>	2004	1	1 (H)	US
Lockley	<i>NEJM</i>	2004	1	1 (H)	US
Spragg	<i>NEJM</i>	2004	11	109 (H)	Austria, Belgium, Canada, France, Germany, The Netherlands, South Africa, Spain, Switzerland, UK, US
Taylor	<i>JAMA</i>	2004	1	46 (H)	US
Abraham	<i>NEJM</i>	2005	34	516 (H)	Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Czech Republic, Denmark, Egypt, Finland, France, Germany, India, Italy, Lebanon, Mexico, The Netherlands, New Zealand, Norway, Philippines, Romania, Russia, Saudi Arabia, Singapore, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, UK, US
Baudouin	<i>Lancet</i>	2005	1	1	UK
Cepeda	<i>Lancet</i>	2005	1	2 (H)	UK
Harvey	<i>Lancet</i>	2005	1	65	UK
Levy	<i>Lancet</i>	2005	1	NA	France
Rubinfeld	<i>NEJM</i>	2005	1	21 (H)	US
Uchino	<i>JAMA</i>	2005	23	54 (H)	Australia, Belgium, Brazil, Canada, China, Czech Republic, Germany, Greece, Indonesia, Israel, Italy, Japan, Netherlands, Norway, Portugal, Russia, Singapore, Spain, Sweden, Switzerland, UK, US, Uruguay
Vanhorebeek	<i>Lancet</i>	2005	1	1	Belgium

(H), hospitals; *NEJM*, *New England Journal of Medicine*; *JAMA*, *Journal of the American Medical Association*. Some studies specify number of “centers” or “institution” rather than the number of intensive care units ICUs.

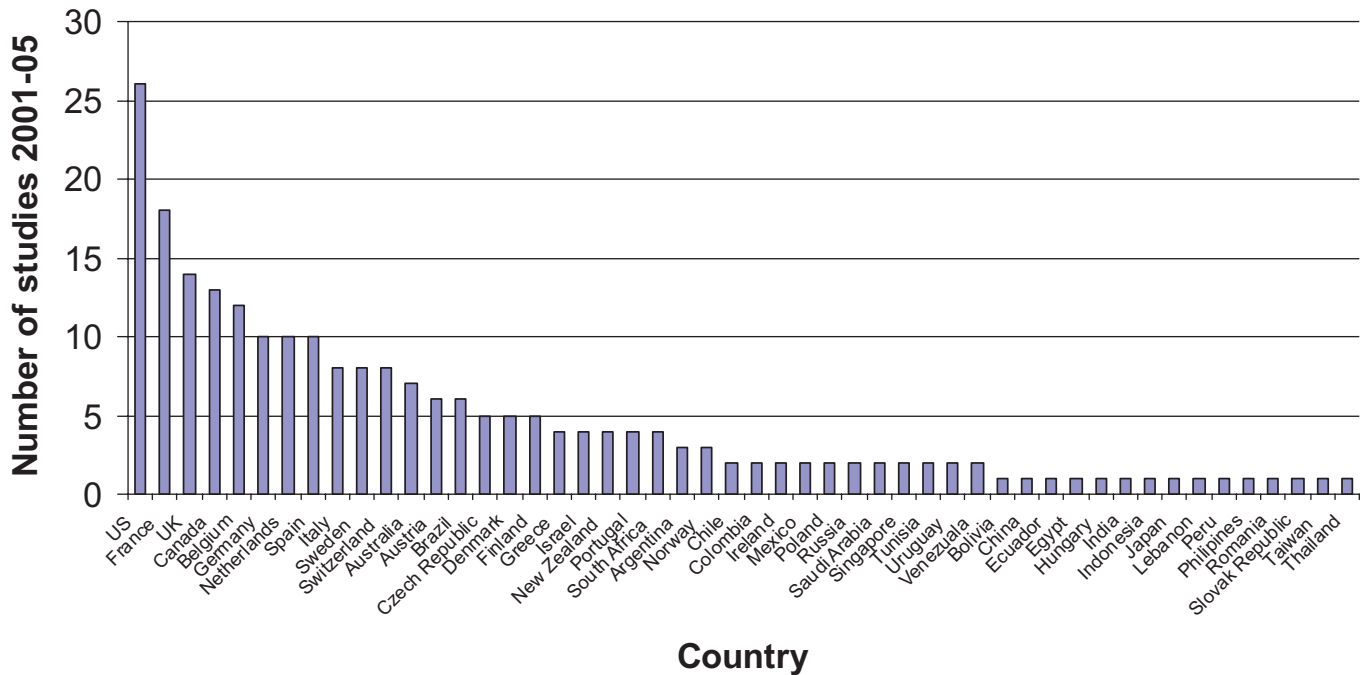


Figure 1. Number of critical care studies in selected general medical journals involving data from each country.

APPENDIX B

Sources used in each country for national data.

United States

Census Data

<http://www.census.gov/popest/national/asrh/NC-EST2005-sa.html>

Hospital Resources/Admissions

Direct calculations using National Medpars dataset, 2004.

ICU Resources/Admissions

Number of intensive care units from: Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J Jr, for the Committee on Manpower for Pulmonary and Critical Care Societies (COMPACCS) Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease. *JAMA* 2000; 284: 2762–2770.

Number of intensive care beds: direct calculation using National Medpars dataset, 2004 for number of intensive care beds (subtracting 3,899 US pediatric intensive care beds, using data from Randolph AG, Gonzales CA, Cortellini L, Yeh TS, Growth of pediatric intensive care units in the United States from 1995 to 2001. *J of Pediatrics* 2004; 792–798.

Number of intensive care admissions: Kersten A, Milbrandt EB, Rahim MT, Watson RS, Clermont G, Angus DC, Linde-Zwirble WT. How big is critical care in the US? *Crit Care Med* 2003; 31(Suppl):A8.

France

Census Data

Institut National de la Statistique et des Etudes Economiques, (INSEE) http://www.insee.fr/fr/ffc/docs_ffc/elp_reg_dep.htm

Hospital Resources/Admissions

Direction de la Recherche des Etudes, de l'Evaluation et des Statistiques (DREES - Ministère de la Santé) (2003).

Organisation de Coopération et Développement Economique (OCDE)/Organisation for Economic Co-operation and Development (OECD) <http://www.oecd.org/home/> (2004).

ICU Resources/Admissions

ICUs directory, edited by the Société de Réanimation de Langue Française (2004).

Direction de l'Hospitalisation et de l'Organisation des Soins (DHOS - Ministère de la Santé) (2005).

United Kingdom

Census Data

<http://www.gad.gov.uk/Population/2004/uk/wuk045y.xls>

Hospital Resources/Admissions

England

M. Hensher, N. Edwards, Hospital provision, activity, and productivity in England since the 1980s, *BMJ* 1999 319; 7214:911–14.

<http://www.performance.doh.gov.uk/hospitalactivity/statistics/> 2000–01

Wales

<http://new.wales.gov.uk/topics/statistics/wales-figs/health/hospitals/?lang=en> (2004–05)

Northern Ireland

http://www.dhsspsni.gov.uk/index/stats_research/stats-pubs/stats-hospital_community_statistics/stats-hosp_stats_05.htm (2004–05).

Scotland

<http://www.isdscotland.org/isd/3780.html> (April 2004–March 2005).

ICU Resources/Admissions

England

ICU numbers, beds and specialties:

http://www.performance.doh.gov.uk/hospitalactivity/data_requests/critical_care_beds.htm (Jan 2005 data).

Wales

<http://new.wales.gov.uk/topics/statistics/headlines/health-2007/health-2006/health-2004/hdw20040908/?lang=en> (2003–04, number of ICU beds).

Statistical Bulletin, Hospital Activity 2003–04, Volume 1: Bed use and inpatients (number of ICUs).

Northern Ireland

McCormick J, A critical care system in transition? - the Northern Ireland perspective, *Nursing in Critical Care*. 2006; 11(2):61–62.

Scotland

<http://www.scottishintensivecare.org.uk/sicsag/annual%20report/2005/index.htm> (data are for 2004).

Canada

Census Data

<http://www.statcan.ca/english/edu/clock/population.htm>

<http://www40.statcan.ca> - summary table link 101/cst01/demo10a

Hospital Resources/Admissions

Canadian Institute for Health Information (CIHI) http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=statistics_results_source_cmdb_e. Canadian MIS Database Hospital Expenses Net of Recoveries, By Province, Territory and Canada-1999–2000 to 2003–2004 and Preliminary 2004–2005. ***Excluding Quebec.

<http://www.oecd.org/dataoecd/19/13/36956887.pdf> (2004).

ICU Resources/Admissions

Canadian Institute for Health Information (CIHI) http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=statistics_results_source_cmdb_e. Canadian MIS Database. Number of Hospital Inpatient Days, Inpatient Admissions, Ambulatory Care Visits, Emergency Visits and Day/Night Care Visits, by Province, Territory and Canada, 1999–2000 to 2003–2004 and Preliminary 2004–2005. Accessed November 29 2006. ***Excluding Quebec.

Belgium

Census Data

http://Statbel.fgov.be/figures/d21_nl.asp (2006).

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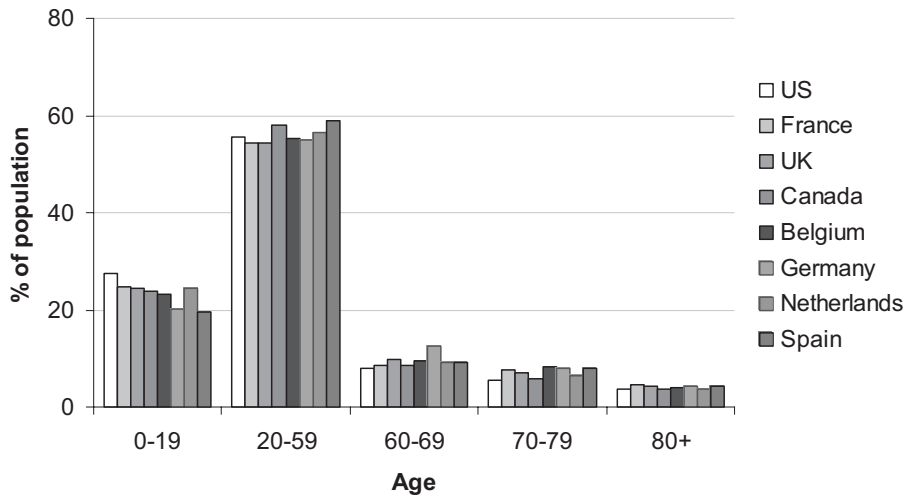
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APPENDIX C

Distribution of population by age for eight countries (2005, except 2006 for Belgium).



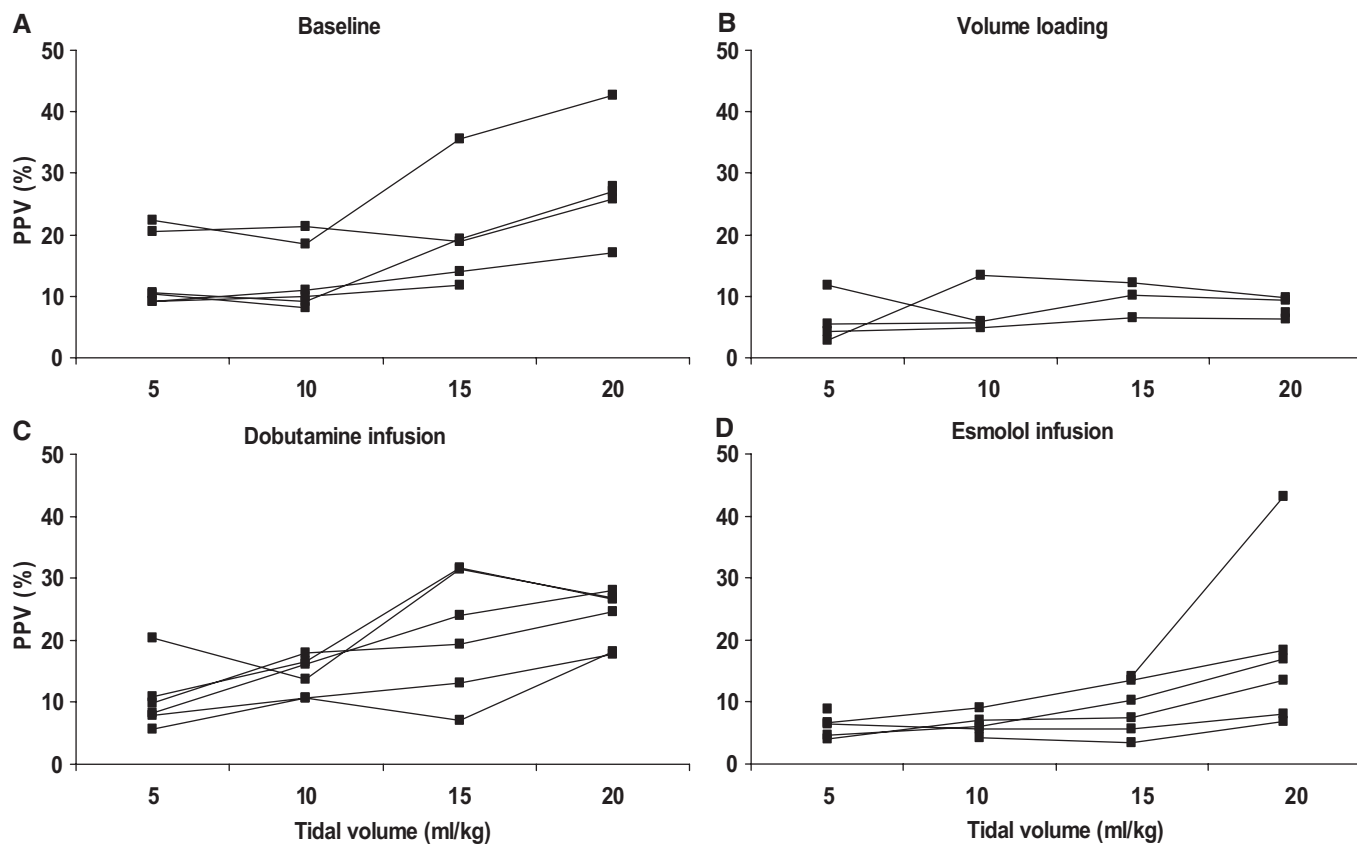


Figure E1. The effect of esmolol infusion, dobutamine infusion, and volume loading in the calculation of pulse pressure variation (*PPV*) for all tidal volumes and all animals.

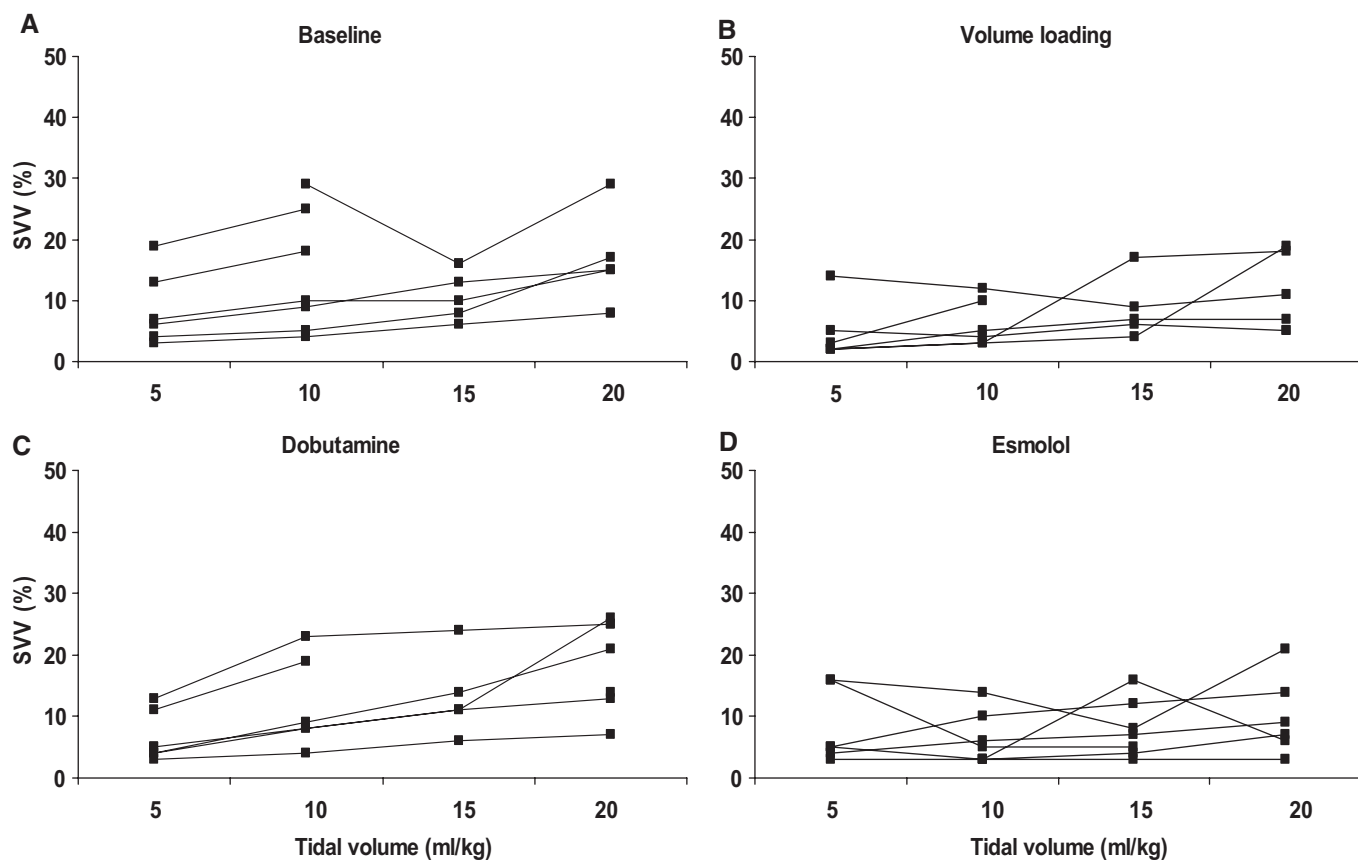


Figure E2. The effect of esmolol infusion, dobutamine infusion, and volume loading in the calculation of stroke volume variation (SVV) for all tidal volumes and all animals.