Critical Care Bed Capacity in Asian Countries and Regions

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Objective: To assess the number of adult critical care beds in Asian countries and regions in relation to population size.

Design: Cross-sectional observational study.

Setting: Twenty-three Asian countries and regions, covering 92.1% of the continent's population.

Participants: Ten low-income and lower-middle–income economies, five upper-middle–income economies, and eight high-income economies according to the World Bank classification.

Interventions: Data closest to 2017 on critical care beds, including ICU and intermediate care unit beds, were obtained through multiple means, including government sources, national critical care societies, colleges, or registries, personal contacts, and extrapolation of data.

Measurements and Main Results: Cumulatively, there were 3.6 critical care beds per 100,000 population. The median number of critical care beds per 100,000 population per country and region was significantly lower in low- and lower-middle–income economies (2.3; interquartile range, 1.4–2.7) than in upper-middle–income economies (4.6; interquartile range, 3.5–15.9) and high-income economies (12.3; interquartile range, 8.1–20.8) ($p = 0.001$), with a large variation even across countries and regions of the same World Bank income classification. This number was independently predicted by the World Bank income classification on multivariable analysis, and significantly correlated with the number of acute hospital beds per 100,000 population ($r^2 = 0.19$; $p = 0.047$), the universal health coverage service coverage index ($r^2 = 0.35$; $p = 0.003$), and the Human Development Index ($r^2 = 0.40$; $p = 0.001$) on univariable analysis.

Conclusions: Critical care bed capacity varies widely across Asia and is significantly lower in low- and lower-middle–income than in upper-middle–income and high-income countries and regions. (*Crit Care Med* 2019; XX:00–00)

Key Words: critical care; intensive care units; bed capacity; Asia; population

Critical illness knows no boundaries and affects all human beings at some time in their lives (1). Although demand for critical care is expected to increase as populations age and expectations rise, its reach is patchy and its impact inconsistent. Indeed, there exists a huge variability in the availability of critical care across continents and countries (2). Careful analysis of this diversity allows a better understanding of the effect of different healthcare systems on patient outcomes, and steps in this direction have been made in the developed world. Most of these studies have revolved around North America, Europe, Australia, and New Zealand (1–8).

Asia is Earth's largest continent. It is estimated—albeit based mainly on extrapolations of data from the West—that Asia accounts for at least half of the cases of sepsis, acute respiratory distress syndrome, and mechanical ventilation in the world (1). Given the heterogeneous distribution of wealth across Asia's mix of low-, middle-, and high-income countries (9), it is likely to see a larger variability of critical care beds than that in continents like Europe (4). Studies on critical care bed capacity, both in resource-limited and resource-rich parts of Asia, are however lacking (1, 10–15). The aim of the current study is therefore to assess the number of adult critical care beds in Asian countries and regions in relation to population size.

MATERIALS AND METHODS

Countries and Regions

We conducted this Asian Critical Care Clinical Trials Group-endorsed cross-sectional study (the Asian Analysis of Bed Capacity in critical care or ABC study) between September 2017 and September 2019. We adapted methods by Rhodes et al (4), who examined critical care bed capacity in 31 European countries, to facilitate comparisons between Asia and Europe. Although various definitions of Asian countries exist, we referred mainly to the United Nations Asia-Pacific Regional Group (**eTable 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287) (16). We sought to invite a national coordinator from each of these countries and regions who is prominent in the field of critical care and/or the national critical care society, and/or passionate in critical care research. Approval by institutional review boards was obtained where appropriate, according to local regulations in each participating country and region.

Critical Care Beds

Each national coordinator provided information on critical care beds through a questionnaire (**eAppendix**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Critical care beds primarily not only refer to beds in an ICU which are staffed but also includes beds in an intermediate care unit (IMCU) that meet selected criteria. The definition of critical care beds varies across countries and regions and even within countries (17). Units known as ICUs in resource-limited settings may not be considered ICUs in the developed world (10, 11). To ensure applicability across countries and regions, we adapted the definition of an ICU from that of a task force convened by the World Federation of Societies of Intensive and Critical Care Medicine (WFSICCM): an ICU is based in a defined geographic area of a hospital and an organized system for the provision of care to critically ill patients that provides intensive and specialized medical and nursing care, an enhanced capacity for monitoring, and multiple modalities of physiologic organ support to sustain life during a period of acute organ system insufficiency (18). Because some countries and regions differentiate IMCUs (various names include high-dependency units, intermediate care areas/units, step-up units, and step-down units) and ICUs (4, 19, 20), we considered beds in such units in the definitions of critical care beds if the units have at least the capability of level 1 ICUs as defined by the WFSICCM task force, that is, a dedicated space within the hospital with a higher nurse-to-patient ratio than a regular ward, equipped to monitor vital signs and oxygen saturation intensively and the electrocardiogram continuously, and to provide noninvasive ventilation, short-term invasive mechanical ventilation, or simple mechanical ventilation for stable chronically ventilated patients. To allow comparisons with

similar studies, we excluded beds from coronary care, stroke, and pure renal units, as well as PICUs and neonatal ICUs which usually have a very different setup and staffing model from adult units (4). We recorded whether the ICUs and IMCUs were from the public or private sector, and whether they were located in urban or rural areas as generally understood in the respective countries and regions.

To ensure as complete a review as possible, a mix of sources was used to obtain the data, with the following suggested order of preference: official government census or sources, through websites or contacts; national critical care societies, colleges, or registries; counting through personal contacts with links to ICUs and IMCUs; estimation through extrapolation of data and relevant ratios (12); and other means appropriate for each country and region. Where appropriate, data from several sources were added to compute the total number of beds. We sought data that are closest to the year 2017 and recorded methodologic details, together with qualifiers, uncertainties, and notes on unavailable data.

Other Variables

We collected other data to assess associations with critical care bed capacity. Each national coordinator provided information on acute hospital beds using methods similar to the counting of critical care beds. Acute hospitals beds and acute hospitals refer to beds and hospitals which are operational and staffed for acute care. We excluded beds and hospitals which are primarily for rehabilitative or long-term care. In countries and regions where available census provides the total number of hospital beds regardless of whether they are for acute, rehabilitative, or long-term care, we used this number, albeit with qualifiers.

We categorized the countries and regions into low and lower-middle income, upper-middle income, and high-income, using to the World Bank classification which is based on gross national income (GNI) per capita (9). We combined low-income and lower-middle income countries because Nepal was the only low-income country which participated (the others in Asia are Afghanistan, North Korea, Syria, and Yemen). We recorded each country and region's population (number of people living within, including both citizen and non-citizen residents, and the percentage of the population who are ≥ 65 yr old) using the Central Intelligence Agency World Factbook (21); gross domestic product (GDP) per capita using data from the World Bank (22); health expenditure using data from the World Health Organization (23); the universal health coverage service coverage index (a scale of 100 which measures coverage of essential services across four areas: reproductive, maternal, neonatal, and child health; infectious disease; noncommunicable diseases; and service capacity and access) from the World Health Organization and the World Bank (24); and the Human Development Index (a scale of 1.000 which takes into account life expectancy at birth, years of schooling, and GNI per capita) according to the United Nations (25).

Statistical Analysis

We present data as numbers, percentages, medians, and interquartile range (IQR). We used the Mann-Whitney *U* test and the Kruskal-Wallis test to compare nonparametric data between countries and regions in different World Bank income groups. We used both univariable and multivariable linear regression analyses, including evaluating for multicollinearity, to assess associations of the collected variables with the number of critical care beds per 100,000 population in countries and regions. We consider a p value of less than 0.05 as statistically significant. We used IBM SPSS Statistics for Windows (version 20.0; IBM Corp, Armonk, NY).

RESULTS

Enrolled Countries and Regions

Out of 44 Asian countries and regions, five were not contacted because of an absence of contacts within, 12 were contacted but did not respond, and four replied but did not provide data eventually (**eTable 2**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Thus, 23 countries and regions which make up 92.1% of the population of Asia (3,952,975,069 out of 4,292,142,884) were enrolled: 10 low-income and lower-middle–income ones, five upper-middle–income ones, and eight high-income ones (21). **Table 1** provides details of each country and region.

Critical Care Beds

Although most countries and regions have both ICUs and IMCUs, Brunei, China, Kazakhstan, Mongolia, South Korea, and Sri Lanka do not have IMCUs (**eTable 3**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). All countries and regions have official definitions of an ICU except Mongolia, Myanmar, Pakistan, and the Philippines (**eTable 4**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Only Laos (where ICUs in main cities and provinces are very different) and the Philippines (where critical care areas include cardiac catheterization laboratories, operating theaters, and delivery rooms) have a definition/understanding of an ICU which is not in keeping with the WFSICCM definition. Although only Hong Kong, India, Indonesia, Japan, Oman, Taiwan, and Thailand have official definitions of an IMCU, all countries and regions with IMCUs are able to describe their usual understanding of an IMCU (**eTable 5**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Data on the number of IMCU beds in Indonesia, India, Laos, Malaysia, Pakistan, Saudi Arabia, and Thailand are unavailable (eTable 3, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Although a mix of methods was used to obtain data on critical care bed numbers, the commonest approaches were through official government census and sources (17 countries and regions) and counting through personal contacts (13 countries and regions) (**eTables 6** and **7**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). The majority (17 countries and regions) obtained data on acute hospital bed numbers through official government census and sources (**eTables 8** and **9**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287).

Cumulatively, there were 141,034 critical care beds in the studied countries and regions (**Table 2**). With a total

TABLE 1. Characteristics of Countries and Regions

Country and Region	Total Size of Population (2017)	Percentage of Population of ≥ 65 yr Old (2017)	GDP per Capita (USD) (2017)	Current Health Expenditure per Capita (USD) (2016)	Current Health Expenditure as Percentage of GDP (2016)	Universal Health Coverage Service Coverage Index (2015)	Human Development Index (2017)
Low- and lower-middle–income countries and regions							
Bangladesh	157,826,578	6.23	1,563.99	34.2	2.4	46	0.608
India	1,281,935,911	6.24	1,981.50	62.1	3.6	56	0.640
Indonesia	260,580,739	7.01	3,836.91	111.6	3.1	49	0.694
Laos	7,126,706	3.89	2,423.85	55.2	2.4	48	0.601
Mongolia	3,068,243	4.29	3,671.95	140.7	3.8	63	0.741
Myanmar	55,123,814	5.53	1,249.83	62.1	5.1	60	0.578
Nepal	29,384,297	5.17	900.57	45.5	6.3	46	0.574
Pakistan	204,924,861	4.48	1,466.84	39.6	2.8	40	0.562
Philippines	104,256,076	4.49	2,981.93	129.4	4.4	58	0.699
Sri Lanka	22,409,381	9.67	4,104.63	153.1	3.9	62	0.770
Upper-middle–income countries and regions							
China	1,379,302,771	10.81	9,770.85	398.3	5.0	76	0.752
Iran	82,021,564	5.32	5,627.75	415.4	8.1	65	0.798
Kazakhstan	18,556,698	7.65	9,030.32	262.0	3.5	71	0.800
Malaysia	31,381,992	6.10	10,117.57	361.5	3.8	70	0.802
Thailand	68,414,135	10.58	6,578.19	221.9	3.7	75	0.755
High-income countries and regions							
Brunei	443,593	4.84	28,572.11	630.6	2.3	≥ 80[a]	0.853
Hong Kong	7,191,503	16.53	46,220.50	2,462.2	5.9[b]	≥ 80[a,c]	0.933
Japan	126,451,398	27.87	38,331.98	4,233.0	10.9	≥ 80[a]	0.909
Oman	3,424,386	3.49	15,170.35	648.3	4.3	72	0.821
Saudi Arabia	28,571,770	3.44	20,803.74	1,147.3	5.7	68	0.853
Singapore	5,888,926	9.63	60,297.79	2,462.4	4.5	≥ 80[a]	0.932
South Korea	51,181,299	14.12	29,742.84	2,043.9	7.3	≥ 80[a]	0.903
Taiwan	23,508,428	13.72	22,683.7[d]	1,346.7[e]	6.3[e]	≥ 80[a,f]	0.907[g]

GDP = gross domestic product, USD = U.S. dollars.

[a]Values of 80 and over reported as ≥ 80 as the index lacks fine resolution at high values.

[b]Data from Hong Kong's Food and Health Bureau (35).

[c]Official data from the World Health Organization and the World Bank not available; value imputed from knowledge of Hong Kong's healthcare system.

[d]Data from the International Monetary Fund (36).

[e]Data from Taiwan's Ministry of Health and Welfare (37).

[f]Data from Taiwan's Ministry of Health and Welfare (38).

[g]Data from Taiwan's Directorate General of Budget, Accounting and Statistics (39).

population of 3,952,975,069, this works out to 3.6 critical care beds per 100,000 population. The median number of critical care beds per 100,000 population per country and region was significantly lower in low and lower-middle–income economies (2.3; IQR, 1.4–2.7) than in upper-middle–income economies (4.6; IQR, 3.5–15.9) and high-income economies (12.3; IQR, 8.1–20.8) ($p = 0.001$). This number ranged from 0.7 for Bangladesh to 28.5 for Taiwan (Table 2 and **Fig. 1**). Where data were available, there were more critical care beds in the public than in the private sector (except in Bangladesh, Japan, Nepal, the Philippines, and Taiwan) (**eTable 10**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). The vast majority were in urban areas (**eTable 11**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). There was

TABLE 2. Number of Critical Care Beds

Country and Region	ICUs	ICU Beds	IMCUs	IMCU Beds	Critical Care Beds[a]	Critical Care Beds/100,000 Population	Critical Care Beds as Percentage of Acute Hospital Beds
Low- and lower-middle–income countries and regions							
Bangladesh	84	878	41	296	1,174	0.7	3.6
India	[b]	29,997	[b]	[b]	29,997	2.3	3.7
Indonesia	1,910	7,094	[b]	[b]	7,094	2.7	2.3
Laos	22	152	[b]	[b]	152	2.1	[b]
Mongolia	43	271	0	0	271	8.8	2.5
Myanmar	68	331	38	255	586	1.1	1.0
Nepal	67	578	22	237	815	2.8	[b]
Pakistan	114	3,142	[b]	[b]	3,142	1.5	2.5
Philippines	450	2,315	2	20	2,335	2.2	3.7
Sri Lanka	100	519	0	0	519	2.3	0.6
Upper-middle–income countries and regions							
China	3,569	49,453	0	0	49,453	3.6	0.9
Iran	426	3,769	2	21	3,790	4.6	2.9
Kazakhstan	582	3,948	0	0	3,948	21.3	3.9
Malaysia	105	1,060	[b]	[b]	1,060	3.4	1.7
Thailand	1,221	7,100	[b]	[b]	7,100	10.4	5.1
High-income countries and regions							
Brunei	5	58	0	0	58	13.1	4.7
Hong Kong	24	287	41	224	511	7.1	2.7
Japan	590	5,973	401	3,268	9,241	7.3	1.3
Oman	26	196	61	303	499	14.6	8.7
Saudi Arabia	600[c]	6,515	[b]	[b]	6,515	22.8	9.2
Singapore	28	335	30	336	671	11.4	6.6
South Korea	581	5,402	0	0	5,402	10.6	2.0
Taiwan	344	5,758	65	943	6,701	28.5	9.1

IMCU = intermediate care unit.

[a]Critical care beds refer to the sum of IMCU beds and ICU beds.

[b]Data not available.

[c]Number of ICUs estimated from the number of ICU beds.

no significant difference in the proportion of acute hospital beds used for critical care in low- and lower-middle–income incomes (2.5%; IQR, 1.3–3.7%), upper-middle–income economies (2.9%; IQR, 1.3–4.5), and high-income economies (5.7%; 2.2–9.0) ($p = 0.15$). This proportion ranged from 0.6% for Sri Lanka to 9.2% for Saudi Arabia (Table 2; and **eTable 12**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287).

On univariable linear regression analyses, the number of critical care beds per 100,000 population in each country and region was significantly correlated with the number of acute hospital beds per 100,000 population (**Fig. 2**), the universal health coverage service coverage index (**Fig. 3**), and the Human Development Index (**eFig. 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287); but not correlated with health expenditure as a percentage of GDP (**eFig. 2**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287), and percentage of the population who are 65 years old and older (**eFig. 3**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). The r^2 between the number of critical care beds per 100,000 population and GDP per capita was 0.17 ($p = 0.054$) (**eFig. 4**, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). In a multivariable linear regression analysis model including these same variables (the

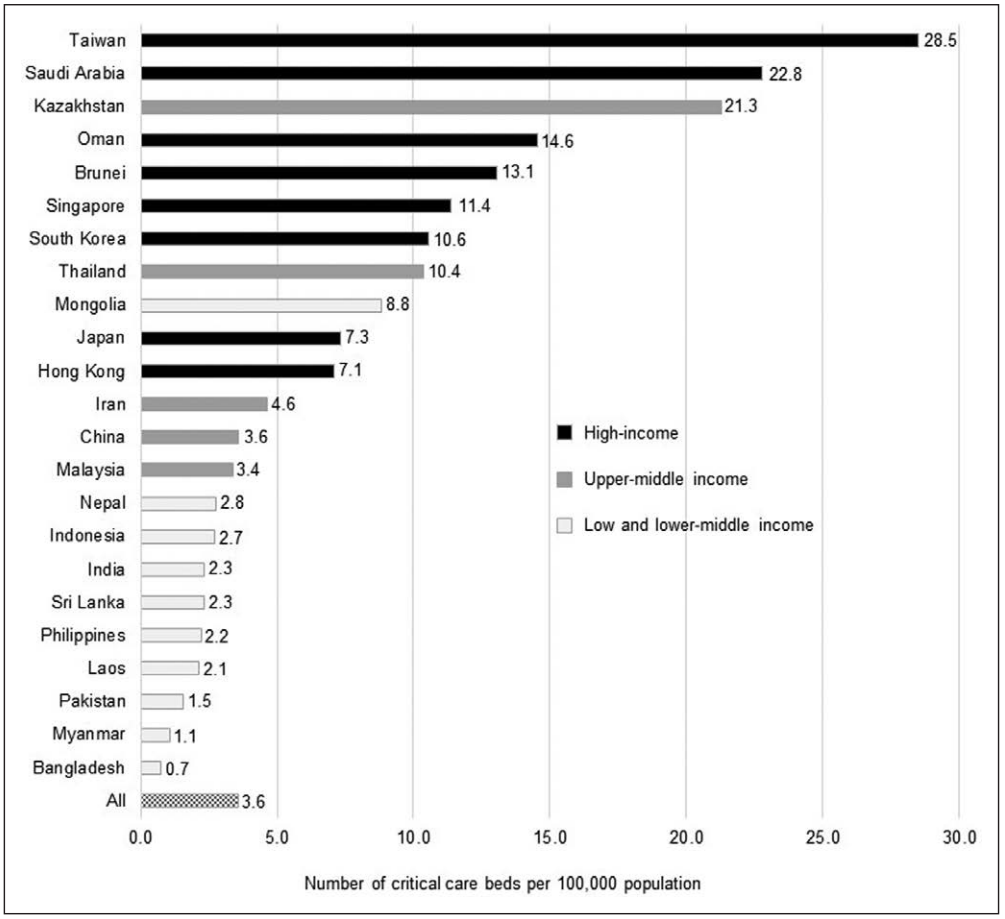

Figure 1. Number of critical care beds per 100,000 population.

universal health coverage service coverage index, Human Development Index, and GDP per capita were removed due to multicollinearity) and the World Bank income classification, the latter was the only predictor of critical care bed capacity in each country and region: high-income economies had an average of 12.2 more critical care beds per 100,000 population than low- and lower-middle–income economies (95% CIs, 4.8–19.6; $p = 0.003$).

DISCUSSION

This is the largest ever survey of critical care bed capacity in Asia, covering an area housing more than 90% of the continent's population. We found the number of critical care beds corrected for population size varied widely across 23 countries and regions, and was significantly lower in low and lower-middle–income economies than in upper-middle–income economies and high-income economies. Indeed, this number was independently predicted by the World Bank income classification on multivariable analysis, and significantly correlated with acute hospital bed capacity, the universal health coverage service coverage index, and the Human Development Index on univariable analysis.

There is a striking heterogeneity in critical bed capacity even among Asian countries and regions with the same World Bank income classification. As shown in Fig. 1, corrected for population size, Taiwan had four times the number of beds compared with Japan, Kazakhstan had six times that of Malaysia, and Mongolia had 13 times that of Bangladesh. The situation is similar in Europe (2, 5, 10), in which Rhodes et al (4) found a sevenfold difference in capacity between Germany and Portugal.

Heterogeneity notwithstanding, we found that low and lower-middle–income economies had significantly fewer critical care beds than upper-middle–income economies and high-income economies. All the low and lower-middle–income countries in our study except for Mongolia had fewer than three critical care beds per 100,000 population, whereas all the high-income ones had at least seven. Specifically for low-income countries, although we found that Nepal has 2.8 critical care beds per 100,000 population, a systematic review found that Uganda was the only other low-income country in the world with corresponding data (0.1 adult ICU beds per 100,000 population) (10, 26). Limiting the analysis to high-income countries and regions, the median number of critical care beds per 100,000 population in our study (12.3; IQR, 8.1–20.8) and the study of Rhodes et al (4) (9.5; IQR, 6.5–13.5 for 28 high-income economies) was similar ($p = 0.13$). It should be noted though that the latter review was conducted back in 2010 and 2011 and did not include private healthcare providers. Corresponding numbers in New Zealand (adult and pediatric beds in 2016), Australia (adult and pediatric beds in 2016), Canada (adult and pediatric beds in 2009), and the United States (adult beds in 2010) were respectively 5.3, 9.0, 9.5, and 27.0 per 100,000 population (7, 8, 27).

We found a moderate correlation between a country or region's critical care bed capacity and the universal health coverage service coverage index and Human Development index. The former index is a measure of the United Nations' Sustainable Development Goal of universal coverage of essential health services (24) but does not specifically evaluate access to critical care. Regardless, there have been calls to consider essential emergency and critical care as part of universal health coverage, although not necessarily in state-of-the-art ICUs (28). The latter index tracks not just health through life

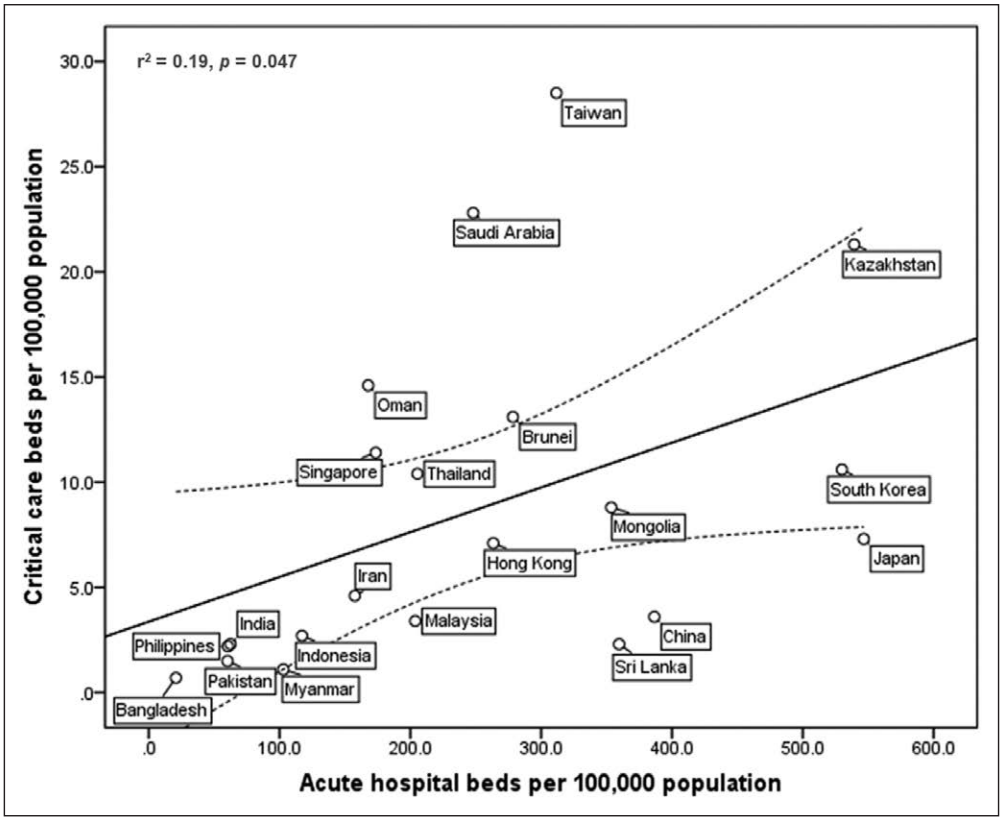

Figure 2. Linear regression analysis of number of critical care beds per 100,000 population against number of acute hospital beds per 100,000 population. *Lines* represent linear regression analysis with 95% CIs.

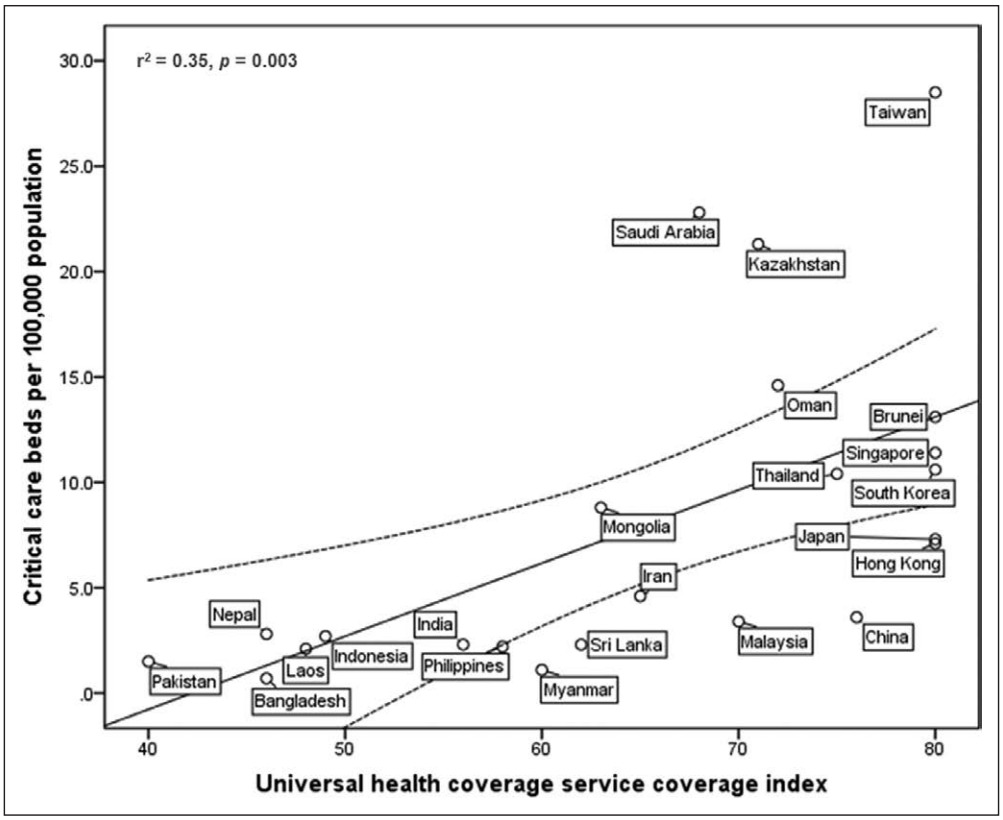

Figure 3. Linear regression analysis of number of critical care beds per 100,000 population against the universal health coverage service coverage index. *Lines* represent linear regression analysis with 95% CIs.

expectancy but also education and income (25). As both indices are known to be higher in high-income economies, their correlation with critical care bed capacity is perhaps unsurprising. Similar to Rhodes et al (4), we found no relationship between critical care bed capacity and health expenditure and ageing in the population. It is likely that critical care bed capacity is influenced by multiple other factors related to healthcare systems and models of care, and availability of equipment and expertise in different parts of the hospital including general wards (11).

Our study has several implications. First, international comparisons of critical care bed capacity allow governments and policy makers to benchmark their resources with others (1, 2). Although an over-supply of critical care beds may lead to unnecessary admissions, prolonged death for the terminally ill, and high costs, a lack may result in delayed or refused admissions to ICUs for appropriate patients and increased preventable mortality (11, 29–31). The discrepancy in bed numbers across countries and regions suggests differences in patterns of referrals, triage, rationing, and admissions, with many critically ill patients being treated outside of ICUs and IMCUs in resource-limited settings. This should trigger debate on what degree of investments in critical care is appropriate in countries which continue to struggle with more basic healthcare (11, 15, 31). Second, such heterogeneity points toward the need for caution in extrapolating findings from studies conducted in high-income (and often Western) countries to low- and middle-income

ones. For example, fluid resuscitation protocols, long considered standard of care in the West, has been associated with increased mortality in African countries, presumably related at least partly to the lack of ICUs for mechanical ventilation in patients who developed hypervolemia and/or acute respiratory distress syndrome (32, 33). To this end, clinical practice guidelines which specifically target resource-limited settings will prove valuable (31). Third, this exercise is an important first step toward the creation of national and international registries of ICUs and IMCUs which are crucial for a better understanding of the epidemiology and burden of critical illness and preparation for pandemics (1, 2).

The limitations of our study must be acknowledged. First, although we reached out as widely as possible, 21 countries did not participate. Second, exact definitions of—and the quality of care provided in (34)—ICU and IMCU beds differ across Asia, and there is often a lack of a clear distinction between IMCU and general wards beds used for more intensive monitoring and treatment in low- and middle-income countries. To deal with this heterogeneity, we used the WFSICCM task force's definition as a reference, and found that all countries but Laos and the Philippines have a similar basic understanding of what ICUs and IMCUs are (eTables 4 and 5, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). Third, most countries and regions did not have official up-to-date numbers of critical care beds, and we had to use multiple methods to obtain as accurate an estimate of true capacity as possible, including extrapolation of data for India, Laos, Malaysia, and the Philippines (eTable 6, Supplemental Digital Content 1, http://links.lww.com/CCM/F287). eTable 7 (Supplemental Digital Content 1, http://links.lww.com/CCM/F287) details the limitations of the information sources such as the absence of data on IMCU beds in seven countries. Fourth, critical care capacity is not uniform throughout each country, with beds being concentrated in urban areas.

CONCLUSIONS

In conclusion, critical care bed capacity varies widely across Asia and is significantly lower in low- and lower-middle–income economies than in upper-middle–income economies and high-income economies.

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