Original Article

Critical care medicine in Taiwan from 1997 to 2013 under National Health Insurance

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Background: Monitoring of trends in the use of the intensive care unit (ICU) and the outcomes of ICU patients is essential for the assessment of the effective use of ICU. This study aims to investigate the incidence and outcome of critical care admissions in Taiwan from 1997 to 2013.

Methods: Patients >18 years who had ICU admission between January 1997 and December 2013 were identified from the National Health Insurance Research Database in Taiwan. The main outcomes including ICU mortality and ICU length of stay (LOS) were measured.

Results: A total of 3,451,157 patients with ICU admission were identified during the study period. The mean ICU LOS was 5.9±9.0 days and the overall ICU-mortality rate was 19.8%. The mean age of the patients was 65.4 years old, 58.0% were elderly (≥65 years old), 61.1% were male. Annual incidence of ICU admissions increased from 115,754 in 1997 (age-adjusted incidence: 1,130/100,000 population) to 244,820 in 2013 (incidence: 1,483/100,000 population) (P<0.0001). The admission rate was highest for patients 75–104 years old (8,074 per 100,000 population), and lowest for those 18–44 years old (298 per 100,000 population). Among ICU admission patients, the percentage of patients ≥75 years old significantly increased from 25.2% in 1997 to 38.3% in 2013 (P<0.0001). ICU LOS remained stable during the study period, but the annual mortality rate significantly decreased from 23.0% in 1997 to 16.3% in 2013.

Conclusions: ICU admissions significantly increased from 1997 to 2013, especially for elderly patients, in contrast, the mortality rate of ICU patients significantly declined with time. In addition, the ICU LOS did not change during the study period.

Keywords: Critical care; intensive care unit (ICU); mortality; utilization

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Introduction

The intensive care unit (ICU) is one important component of acute care. Good outcomes rely on a chain of providers and treatment locations (1-5). In the USA, the annual cost of intensive medicine significantly increased (92.2%; $56–108 billion) between 2000 and 2010, and the cost of critical care medicine rose by 32.1% from 0.54% of the

gross domestic product to 0.72% (1). In addition to the increasing ICU use, mortality and length of stay (LOS) of ICU patients are important quality indicators, but these indicators of care quality remain controversial (6-9). Most studies (1,10-15) on these ICU topics were conducted in western countries, and studies on the ICU in Asia are scant or out of date (16,17). Furthermore, most of those studies were short-term cross-sectional analyses (15,18), and only a few were long-term (11,19). Most important, however, is that the availability and use of critical care service varies in different healthcare systems in different countries (12). In 1995, Taiwan's National Health Insurance (NHI) program was implemented. It now covers over 99% of Taiwan's population. Since the introduction of this program, the huge barrier between medical service and patients has been removed, and most the utilization of healthcare services, e.g., outpatient visits to physicians, hospital admissions, ICU admissions, etc., have significantly increased (20,21).

The NHI Research Database (NHIRD), is a running record of encrypted NHI claims information about: outpatient visits, diagnoses, hospital admissions, prescriptions, interventional procedures, medical institutions that provided clinical services, outcomes at hospital discharge, and medical costs incurred. Taking the advantage of this comprehensive database, we can assess the epidemiologic trends of ICU uses of Taiwan adult population with time. In this study, we used the NHIRD to realize the incidence and outcome of critical care admissions in Taiwan from 1997 to 2013.

Methods

Data source

Our data source was NHIRD. The NHI currently enrolls more than 23 million of the country's legal residents with 99.6% coverage (22). The NHIRD provides detailed healthcare services information. The database contains data including all patients' medical care, diagnosis, surgery, medications from 1997 to 2013. The Chi Mei Medical Center Institutional Review Board approved the study and specifically waived informed consent.

Patient selection and definition

The records of adult patients (≥18 years old) who had been admitted to the ICU between January 1, 1997 and December 31, 2013, were retrospectively reviewed. The record of ICU admission was based on the medical expenditure claim applications. The detail medical expenditure applications of ICU were defined by inpatient orders numbers (02011K, 02012A, 02013B, 03010E, 03010K, 03011A, 03011F, 03012B, 03012G, 03013B, 03013H, 03047E, 03048F, 03049G, 03050H) according to the guideline of NHI. Patient's age and gender were recorded. ICU mortality and LOS were the outcomes of interest.

Statistical analysis

The categorical variables—age-group, gender, and mortality—are presented as frequencies and percentages. The continuous variables—age, and length of ICU stay—are presented as means ± standard deviation (SD) and medians with an interquartile range. The crude ICU admission rate for each year was defined as the number of ICU admissions dividing by the total population. The Poisson regression was used to estimate age-adjusted ICU admission rate and age-adjusted ICU mortality rate. The trend tests of ICU admission rate, age admitted to ICU, length of ICU stay, and ICU mortality rates were analyzed by linear regression for the years 1997 to 2013. SAS 9.4 for Windows (SAS Institute, Cary, NC, USA) was used for all analyses.

Results

Demographic characteristics

ICUs in Taiwan admitted 3,451,157 patients between January 1, 1997, and December 31, 2013. The mean age of the patients was 65.4 years old, 58.0% were elderly (≥65 years old), 61.1% were male. The mean LOS in the ICU was 5.9±9.0 days, and 681,706 (19.8%) patients died in the ICU (*Table 1*).

ICU admission trend

During the study period, the annual ICU admissions more than doubled from 115,754 in 1997 to 244,820 in 2013 (P<0.0001), and the crude overall ICU admission rate was 1,149 per 100,000 population. The annual age-adjusted ICU admission rate significantly increased from 1,130 per 100,000 population in 1997 to 1,483 in 2013 (P<0.0001) (*Figure 1*). In the meanwhile, the number of ICU beds also increased from 4,573

Table 1 Characteristics of ICU patients (n=3,451,157 admissions)

Characteristics	Value
Age (years), mean ± SD	65.4±17.6
18–44	507,629 (14.7)
45–54	409,523 (11.9)
55–64	532,666 (15.4)
65–74	770,101 (22.3)
≥75	1,231,238 (35.7)
Gender, n (%)	
Female	1,343,833 (38.9)
Male	2,107,324 (61.1)
Type of hospital, n (%)	
Medical center	1,274,564 (36.9)
Regional hospital	1,613,655 (46.8)
District hospital	562,938 (16.3)
ICU length of stay (days)	
Mean ± SD	5.9±9.0
Median [IQR]	3 [1–6]
ICU mortality, n (%)	681,706 (19.8)

ICU, intensive care unit; IQR, interquartile range; SD, standard deviation.

in 1997 to 7,074 in 2013 (P<0.0001) (*Figure 1*). The admission rate was highest for patients ≥75 years old (8,074 per 100,000 population), and lowest for those 18–44 years old (298 per 100,000 population). For patients 18–44 years old, 45–54 years old, and ≥75 years old, the ICU admission rates significantly increased with time (all P<0.001) (*Table 2*). Among general populations, the percentage of patients ≥75 years old only increased from 3.6% in 1997 to 6.2% in 2013 (P<0.0001). Among ICU admission patients, after adjusting the factor of age, the percentage of patients ≥75 years old significantly increased from 25.2% in 1997 to 38.3% in 2013 (P<0.0001) (*Figure 2*).

ICU LOS trend

The ICU LOS remained stable with time: mean duration =5.4 days in 1997, and =5.6 days in 2013 (*Figure 3*); it was longest for patients ≥75 years old and shortest for patients 18–44 years old.

Mortality trends

The number of deaths significantly increased from 26,566 in 1997 to 40,014 in 2013 (P<0.0001). The annual mortality rate decreased from 23.0% in 1997 to 16.3% in 2013 (P<0.0001) (*Figure 4*). Patients ≥75 years old had the highest mortality rate, but it decreased from 32.9% in 1997 to 22.2% in 2013 (P<0.0001). Mortality rates also significantly decreased in the other age subgroups (P<0.0001) (*Figure 5*). The annual mortality rates significantly decreased for both genders from 1997 to 2013 (both P<0.0001).

Discussion

This large national study is a population-based investigation of secular trends of ICU admission and ICU patient outcomes in Taiwan between 1997 and 2013. We found that adult ICU admissions significantly increased, and that the largest increase was for patient ≥75 years old. The mechanism of increasing admission, especially for the elderly patients can be only partly attributed to the changing population in Taiwan. Although Taiwan has a relatively young population [11.5% are older than 65 years, compared to 16.5% for Organization for Economic Cooperation and Development (OECD) countries on average], but also has low fertility rates, resulting in a relatively accelerated aging of the population (23,24). In this study, the percentage of patient ≥75 years old among general populations only increased from 3.6% in 1997 to 6.2% in 2013. But the percentage of patient ≥75 years old among ICU admission patients significantly increased from 25.2% in 1997 to 38.3% in 2013. Therefore, the patients ≥75 years old may carry the higher risk of ICU admission than the other age group. In this study, the trend in ICU admission significantly increases from 1997 to 2003 and seems to be flattening and even downward since 2009 (*Figure 1*). It is possible due to the change of NHI expenditure and policy. For the expenditure issue, Taiwan's NHI had annual growth in expenditures that outstripped revenues through 2008. Because the government needs to maintain NHI for long time, Taiwan had second generation (G2)-NHI reform in 2013. Therefore, one could speculate that this may have been related to constrain spending, and possibly, ICU utilization. Although the payroll premium changed in 2010 from 4.55% to 5.17% of income, this did not translate into an NHI surplus until 2013—so the effect of the budget shift would not have been felt until even after 2013. For the change of NHI policy, in the first-half

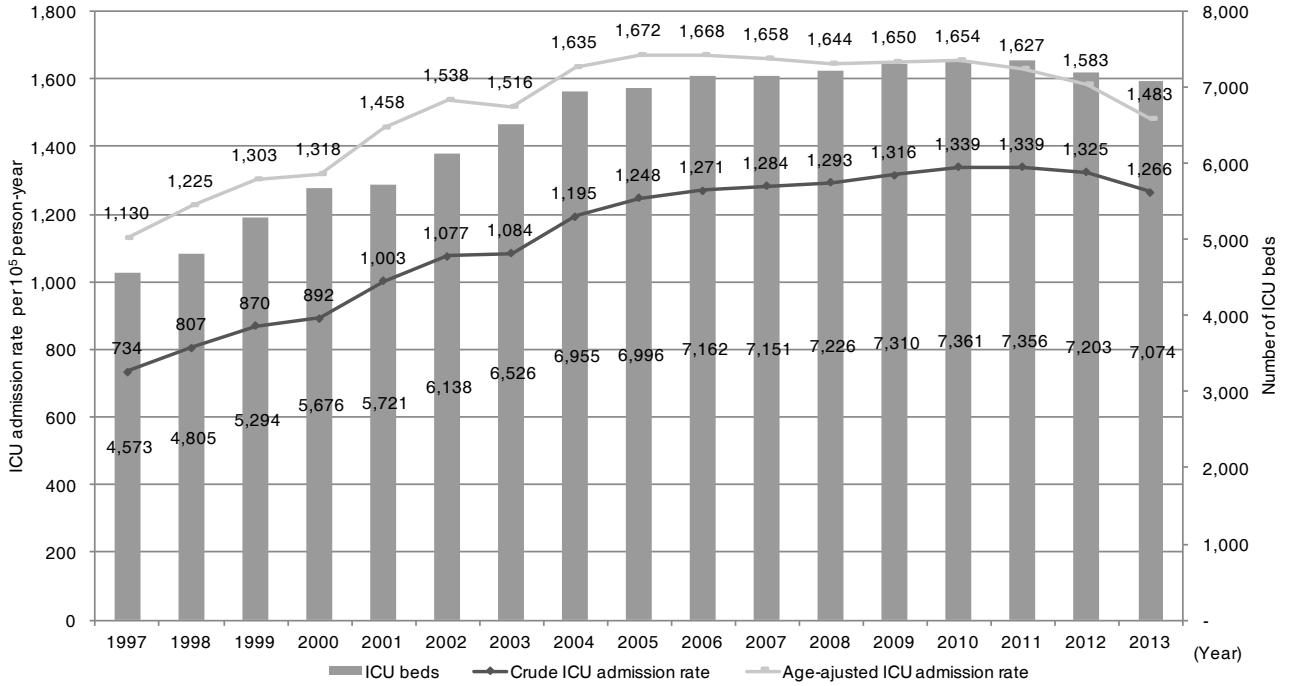

Figure 1 Annual intensive care unit (ICU) crude and age-adjusted admission rate per 100,000 populations in Taiwan, 1997–2013.

Table 2 Annual admission rate of different age group and trend analysis

Year	ICU admission rate of different age groups (per 10^5 person-year)				
	Age of 18–44 years	Age of 45–54 years	Age of 55–64 years	Age of 65–74 years	Age of ≥75 years
1997	212	580	1,304	2,411	5,168
1998	221	599	1,403	2,687	5,763
1999	224	620	1,484	2,868	6,386
2000	227	612	1,499	2,876	6,597
2001	248	676	1,622	3,194	7,435
2002	252	717	1,678	3,360	8,039
2003	262	715	1,607	3,253	7,911
2004	322	759	1,647	3,387	8,474
2005	343	777	1,665	3,378	8,702
2006	347	809	1,603	3,329	8,693
2007	342	790	1,555	3,268	8,879
2008	337	789	1,537	3,211	8,863
2009	338	807	1,532	3,240	8,851
2010	341	806	1,512	3,202	8,995
2011	362	809	1,482	3,054	8,724
2012	364	806	1,473	2,885	8,400
2013	343	793	1,417	2,641	7,766
Test of trend, P value	<0.0001	<0.0001	0.8128	0.3542	0.0002

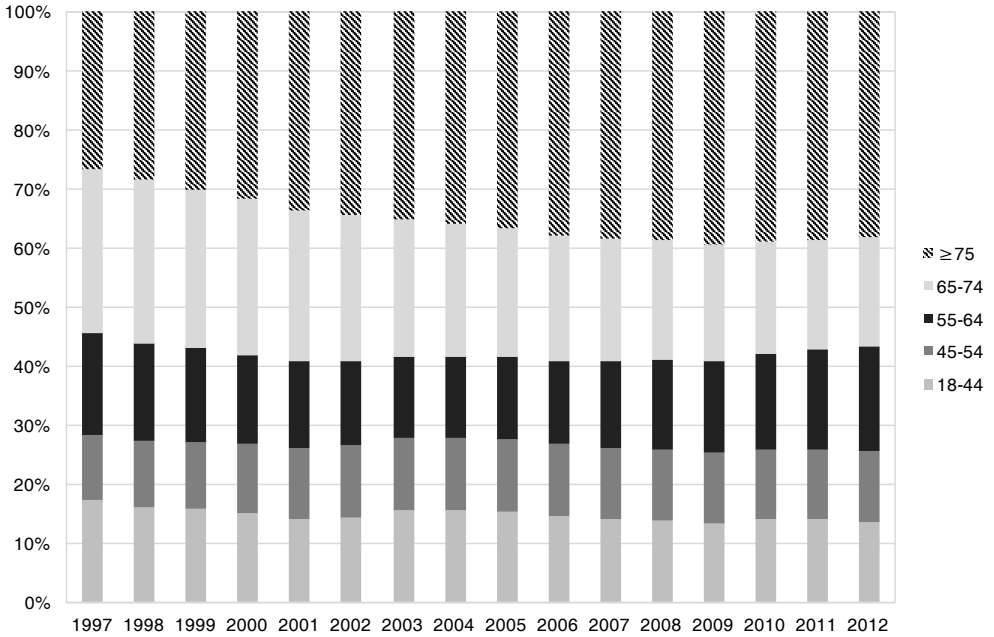

Figure 2 Annual age distribution of ICU admissions and general populations in Taiwan, 1997–2013. ICU, intensive care unit.

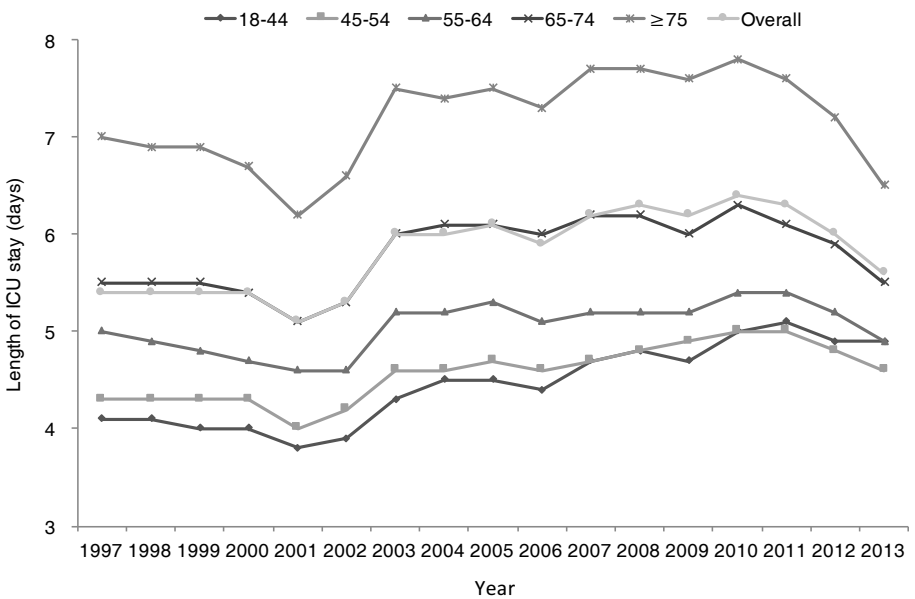

Figure 3 Length of ICU stays by age group in Taiwan, 1997–2013. ICU, intensive care unit.

period of this study, Taiwan was aggressively attempting to reduce long term care and result in inappropriate hospital uses for chronic patients in acute care hospitals (25). This could have contributed to increasing burden on short-term acute care facilities, including ICU admission. However, in 2009, NHI expands to include subacute care and chronic care (26), and thus some patients were shifted from ICU to long-term care facility.

In this study, the mortality declined with time. During these seventeen years, several important medical technologies and critical care measures were developed to

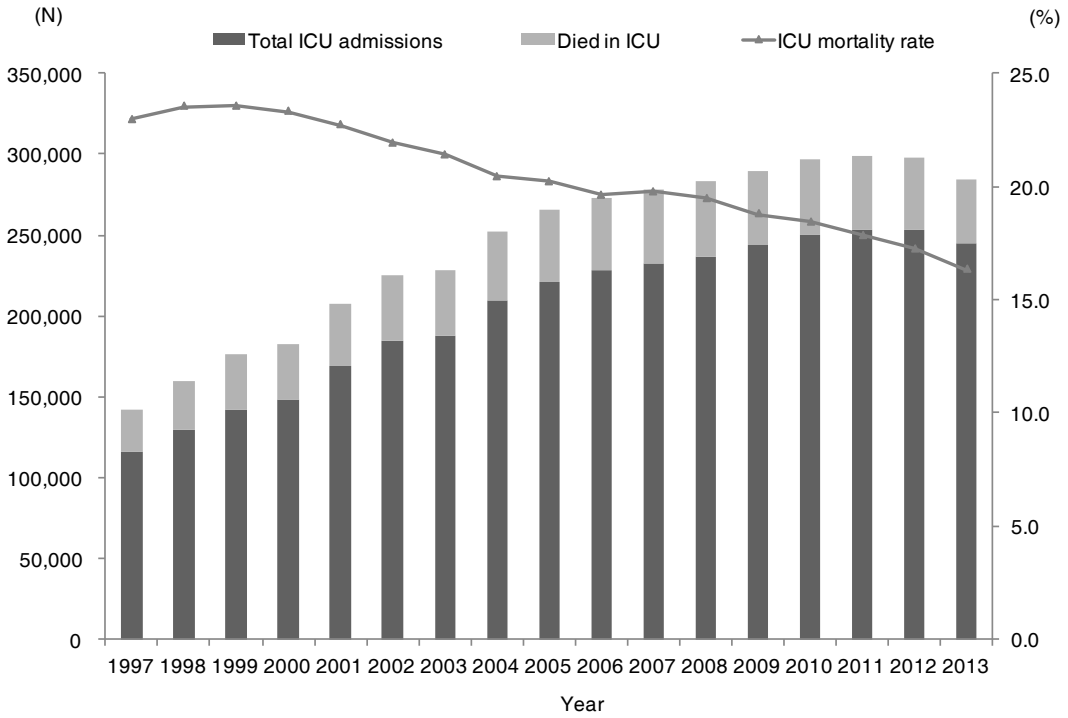

Figure 4 Number of ICU deaths, and ICU mortality rates, in Taiwan, 1997–2013. ICU, intensive care unit.

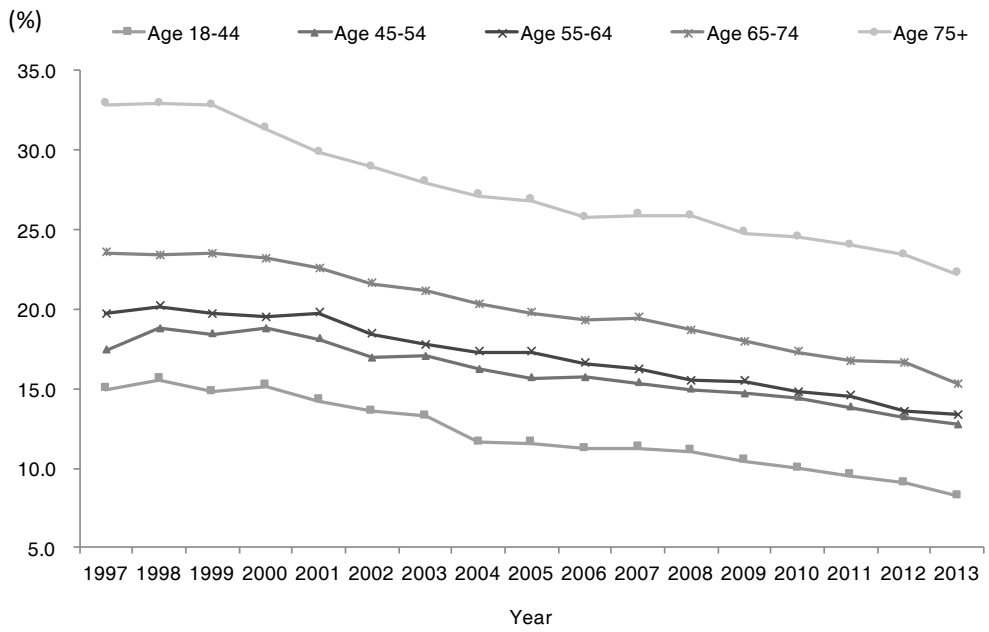

Figure 5 ICU mortality by age group in Taiwan, 1997–2013. ICU, intensive care unit.

improve the outcomes of critically ill patients and the quality of critical care. For example, Amato *et al.* (27) reported that protective-ventilation strategy had reduced 28-day mortality in patients with acute respiratory distress syndrome, for the past eighteen years, this strategy has become a mainstay of ARDS treatment (28). For another common clinical disease—sepsis in ICU, several international organizations enrolling critical care and infectious disease experts initially developed evidence-based management guidelines—Surviving Sepsis Campaign guidelines (29) in 2004 and updated the recommendation with time in 2008 and 2012 (30,31). These guidelines soon became standard management for severe sepsis and septic shock in the ICU, and their efficacy for improving outcomes in patients with sepsis and septic shock has been verified (32). Additionally, key elements of the guidelines were identified and organized into "bundles" of care (e.g., a ventilator bundle, central line-associated bloodstream infection bundle, and catheter-associated urinary tract infection bundle) were developed to prevent common complications in the ICU during this period. In 2009, Taiwan began accrediting the quantity and the quality of intensivists, critical care nurses, and equipment in the ICU to monitor the quality of in-hospital critical care given to patients. These measures might explain our findings of better outcomes in ICU patients.

In this study, we found that the ICU admission rate in Taiwan was higher than in the UK (216 per 100,000 population), Canada [389], France [426], and the Netherlands [466], but lower than in Germany [2,353] in 2005 (12). Additionally, our recent study showed that the number of ICU beds as well as the hospital beds in Taiwan has significantly increased at the same time (27). The total ICU beds increased from 4,573 in 1973 to 7,074 in 2013 and the ratio of ICU beds per 100,000 populations increased from 21.0 in 1997 to 30.3 in 2013, too (33). This ratio in Taiwan is similar as US (20 per 100,000 population), but much higher than Australia, France, Netherlands, Spain, Sweden and UK (all of them less than 10 per 100,000 population) (14). In addition, the number of ICU beds per 100 hospital beds ranged from 3.8% to 4.9% in Taiwan (33), which was similar to Germany (4.1%), and Belgium (14). The ICU occupancy rate also increased from 66.5% to 72.1% during the same period (33). Therefore, all of our findings reflect the rapid expansion and high availability of critical care under the NHI system in Taiwan.

The overall ICU mortality in our study was consistent with the findings of North American, European, Australian, and New Zealand studies on unselected patients (14,19-21,34,35). We also found that ICU mortality was significantly higher in the elderly than in young adults, but not significantly different between genders. Like these other studies, however, we obtained only the raw mortality rate in a heterogeneous population, and mortality is affected by many factors, illness severity, case mix, hospital discharge policies, the hospital setting, and the hospital's administrative policies (19,36,37).

Our study has some limitations. First, because the NHIRD does not provide specific types of clinical data, we were unable to study the disease severity such as SOFA and APACHE II scores, ICU specialty, cause of death and indications that a life-support device was required. Second, although we can obtain the diagnosis according to ICD-9-CM code, we cannot sure which one diagnosis is the primary diagnosis for ICU admission. Therefore, we cannot evaluate this issue. Third, because we did not have data on critical care service before 1997, we cannot know the effect of NHI on intensive care. However, this study could provide useful information regarding the uses of ICU for Taiwan's adults. Additional investigations of the causes and consequences of these trends are required.

Conclusions

Using national population-based data, we found a significant increase in adult ICU admissions between 1997 and 2013, especially for the elderly, but a significant decline in mortality.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The Chi Mei Medical Center Institutional Review Board approved the study and specifically waived informed consent (IRB NO: 10512-E01).

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