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Epidemiology of Sepsis in Australian Public Hospitals:

A Mixed Methods, National Longitudinal Study (2013-2018)

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Preface

The Australian Commission on Safety and Quality in Health Care (the Commission) has commenced a program of work to improve early recognition, treatment and outcomes for patients with sepsis in Australia.

In consultation with internal and external stakeholders, the Commission has identified a series of actions that will be implemented over 2020-22.

The program of work to improve outcomes in patients with sepsis in Australia includes:

- Epidemiological analysis of national inpatient sepsis data to ascertain veracity (this report)
- Conducting a retrospective medical chart audit of records belonging to patients with sepsis. The findings from the audit could inform the development of sepsis coding
- Developing materials relevant to Standard 3 and Standard 8 of the National Safety and Quality Health Service (NSQHS) Standards (2nd edition) to ensure health service organisations are required to demonstrate the use of evidence based practice in the early detection, treatment and monitoring of sepsis
- Revising the *Antimicrobial Stewardship Clinical Care Standard* to strengthen Quality Statement 1 with regard to the role that prompt treatment with intravenous antibiotics has in preventing sepsis in patients who have a suspected severe infection
- Developing national clinical guidance materials to support improvements in the delivery of sepsis care
- Partnering with the Australian Government, states and territories and the George Institute for Global Health to lead a multi-modal public awareness campaign
- Scoping the need to establish a coordinated approach to improving services to address the high rates of disease recurrence and associated morbidity and disability.

Aims and methodology

This report was commissioned as a first step, in the Commission's work to develop a national approach to improving outcomes for patients with sepsis across Australia.

The aims of this report were to:

1. Determine the incidence and mortality of sepsis in public hospitals
2. Investigate variations in incidence and mortality related to patient and hospital stay characteristics.
3. Investigate sepsis-related practice and initiatives across states/territories

A mixed methods approach was used to complete the study including;

a) Epidemiological analysis of national inpatient data from all Australian public hospitals
b) Semi-structured interviews with clinicians, patient safety professionals and sepsis researchers from states and territories

Overview of findings

The report's main findings were:

- An observed 27% increase in the age standardised sepsis incidence between 2013-14 and 2017-18. The timeframe of this reported increase in sepsis incidence correlates with ICD-10-AM coding changes of inpatient data.

- Despite the apparent increase in sepsis incidence, sepsis mortality rates remained relatively stable.
- During the period 2013-14 to 2017-18, there have been multiple prominent sepsis awareness campaigns. These have contributed to improved recognition, treatment and documentation of sepsis.
- The increase in reported incidence and stable mortality rates reflect under reporting of sepsis incidence prior to, changes in coding rules and awareness campaigns

Coding changes and potential impacts

Clinical coders use both lists of ICD-10-AM diagnosis codes and 'rules' for coding contained in an accompanying manual '*The Australian Coding Standard*' (ACS) coding of sepsis in administrative data sets using ICD-10-AM and the information in patients' clinical records is complex and challenging. Changing definitions, diagnostic criteria, treatment pathways[1] and coding rules for sepsis all contribute to the complexity.

There was extensive revision of the *Australian Coding Standard* (ACS 0110) *Sepsis, severe sepsis and septic shock* for ICD-10-AM 9th Edition, which covered the period 01/07/2015 to 30/06/2017, that is, the time period when an increase in the rate of inpatient sepsis was observed in this study. The changes are complex and include the points below which have been provided as preliminary advice to the Commission from several clinical and coding experts (further detail can be provided on request):

- Clinical definitions of SIRS (Systemic inflammatory response syndrome), severe sepsis and septic shock were updated to reflect international expert consensus.
- In ICD-10 AM 9th edition, clinical coders **did not have to verify** the occurrence of sepsis with a clinician in contrast to ICD-10-AM 8th edition where they **did have to do so**. This may have led to potential decrease in 'down-coding' i.e. documented sepsis coded to a localised infection upon clinician review.
- There was also national coding advice for sepsis, which noted that sepsis must be documented to assign a sepsis code. This is irrespective of positive or negative blood cultures. Clinical coders cannot assign a code for sepsis based on a positive blood culture without documentation of sepsis.
- The increased recognition of sepsis due to sepsis clinical pathways may lead to increased coding of A41.9 *Sepsis, unspecified* that may not have been present in the clinical notes before. Small annual increases in non-specific sepsis codes are likely heavily related to increased uptake of sepsis pathways nationally.
- The following sentence was removed in the 9th edition '*Where there is documentation of sepsis, assign a code for the localised and/or generalised infection….if after seeking clarification from the clinician, it is confirmed that sepsis is being used to mean localised infection, refer to the index entry infection rather than Sepsis'*. This reflects clinical advice which indicates that the diagnosis of sepsis is typically a clinical diagnosis based on the early signs of a syndrome, it is a systemic response which cannot be adequately captured by coding a localised infection alone.
- The ACS did not provide specific sequencing guidelines as to which condition should be sequenced first when both sepsis and an associated localised infection were present. The sequencing note means that if a patient is admitted with a localised infection and sepsis, the condition that was chiefly responsible for occasioning the episode of care is to be assigned as the principal diagnosis.

[1] Clinical pathways are standardised, evidence-based multidisciplinary management plans, which identify an appropriate sequence of clinical interventions, timeframes, milestones and expected outcomes for a homogenous patient group.

- In the opinion of an infectious disease expert who reviewed the changes in the ACS from 8th to 9th edition: "*sepsis identified as part of a sepsis pathway may be coded as sepsis despite not clinically eventuating in either an infection nor a sepsis clinical diagnosis due to the insensitivity of the pathway identification process - this may not have occurred in ICD 10-AM 8th edition*". Resulting in an increase of reported sepsis cases with the implementation of 9th edition.

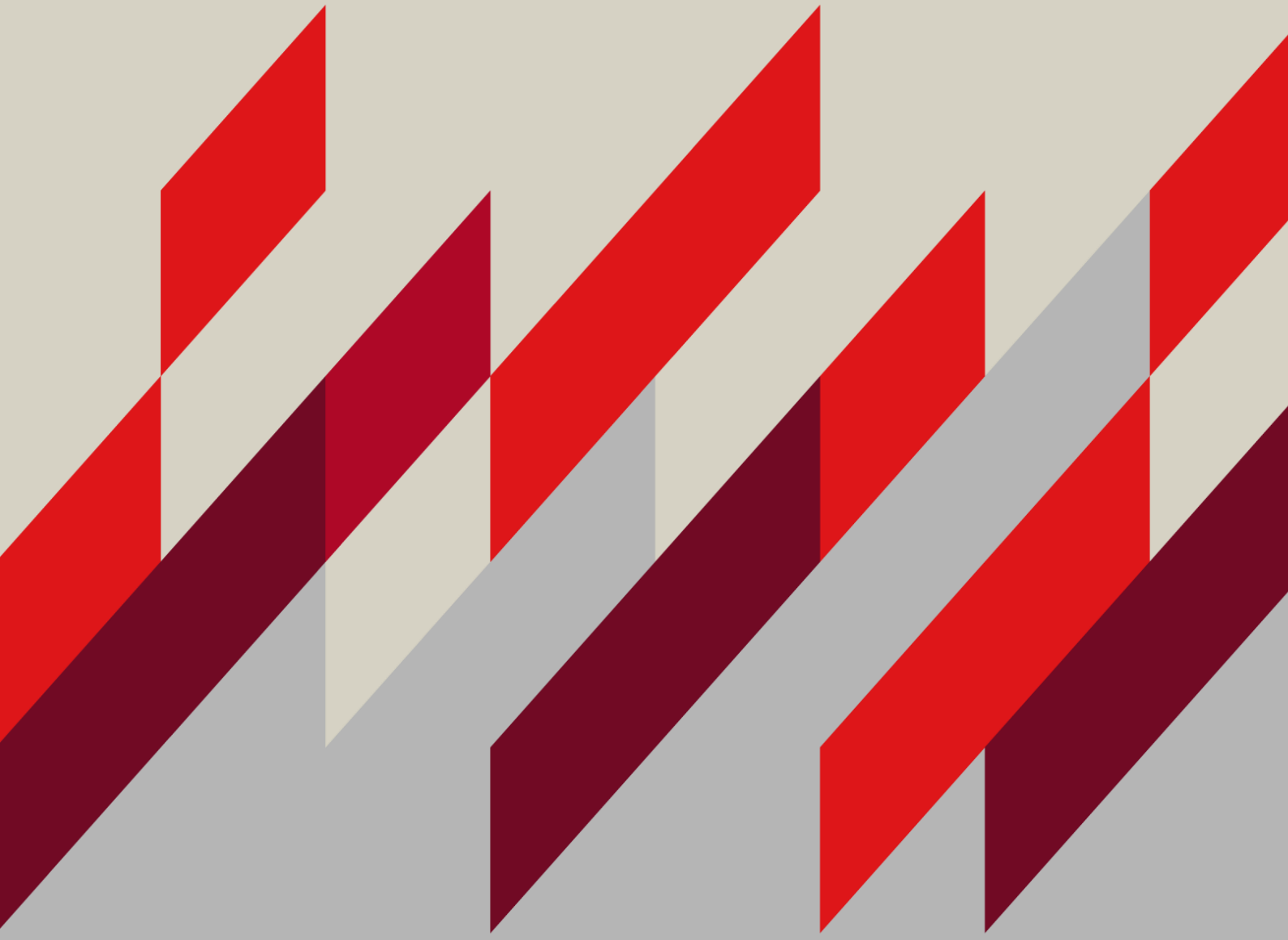
Conclusion and next steps for the Commission

Using hospital administrative data, this epidemiological study shows an increase in the rate of sepsis for the period 2013-14 to 2017-18. Initial exploration with advice from clinical and coding experts suggests that the increase could be explained by a combination of the changes in the Australian Coding Standards used by clinical coders, local level interpretations of the coding standards relevant to sepsis and prominent sepsis awareness campaigns. Encouragingly the study has shown mortality rates of patients with sepsis have been stable.

To obtain a clearer understanding of the key contributing factors of the observed reported increase in rates of sepsis but stable mortality rates, the Commissions will:

- Undertake a medical record audit of sepsis cases and further consultation with clinical experts
- In light of this report, consider if further investigation of available data will provide additional insights

Epidemiology of Sepsis in Australian Public Hospitals: A Mixed Methods, National Longitudinal Study (2013-2018)



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Contents

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Executive summary

Sepsis is a life-threatening condition that contributes considerably to the global burden of disease in the population. This report, commissioned by the Australian Commission on Safety and Quality in Health Care, presents the first national epidemiological snapshot of sepsis and its impact on Australians. **This report aims to** i) determine the incidence and mortality of sepsis in public hospitals, ii) investigate variations in incidence and mortality related to patient and hospital stay characteristics, and iii) investigate sepsis-related practice and initiatives across states/territories.

A mixed methods longitudinal study was conducted. The epidemiological analysis of national longitudinal data included all patients admitted to all Australian public hospitals during the study period, i.e. between 2013-14 and 2017-18. Data related to these hospitalisations were extracted from the Admitted Patient Care National Minimum Data Set specifically isolating the patients with a diagnosis of sepsis using ICD-10-AM codes – defined in the Classification of Hospital Acquired Diagnoses. Sepsis hospitalisations and deaths were analysed in relation to i) patient demographics (e.g., sex, age, remoteness of residence, socioeconomic disadvantage and Indigenous status), ii) patient clinical characteristics (e.g., organ dysfunction, comorbidity, ICU admission, surgical procedure etc.), and iii) hospital characteristics (e.g., remoteness of hospital location, public hospital peer group and state/territory). Age standardised incidence and mortality rates were calculated. An advanced statistical modelling approach was applied to examine changes in mortality with consideration of the cluster effect of hospitals and important risk factors, such as patients' age, sex and comorbidities etc.

Semi-structured interviews with clinicians, patient safety professionals and sepsis researchers around the country were conducted regarding changes in clinical practice, sepsis awareness and clinical initiatives that may have contributed to the observed variations during the study period.

The key findings below highlight the substantial number of hospitalisations of patients with sepsis and related inequalities that exist in the Australian population. This report draws attention to a large increase in sepsis incidence over the study period, which could be explained by coding changes and increased awareness and clinical initiatives.

<u>Burden of disease</u>

Between 2013-14 and 2017-18, a total of 23,827,061 hospitalisations were included in this study. Out of these hospitalisations, 437,354 were recorded with a sepsis diagnosis in 739 public hospitals in Australia. Overall age standardised sepsis incidence was 1,162.8 cases per 100,000 resident population. Of these sepsis hospitalisations, 12.0% (n=52,297) died in hospital, which was 10.9 times higher than non-sepsis patients (1.1%). The median hospital length of stay for sepsis patients was seven times as long as the median LOS for non-sepsis patients (7.0 days vs 1.0 days respectively). About 22.3% of hospitalisations with sepsis had an ICU stay while only 2% of hospitalisations without sepsis with an ICU stay. Nearly half of all sepsis patients had at least one comorbidity recorded with poor clinical prognosis.

<u>Related inequalities</u>

The youngest patients (<1-year-old) experienced the highest number of cases and the highest incidence rate of sepsis. For older groups, sepsis cases and incidence rate rose with age. Age standardised incidence for males was 19% higher than for females. Those living in very remote areas were hospitalised at around 1.7 times the rate for sepsis as those living in major cities. This may be partly explained by the high sepsis incidence rate among Indigenous people, where rates were also

1.7 times higher than among other Australians. Sepsis incidence was 1.2 times higher for those living in the lowest socioeconomic areas compared with the highest socioeconomic areas.

Variation over time

Between 2013-14 and 2017-18, age standardised sepsis incidence increased by 27% - with the sharpest increase of 24% in 2015-16. Despite the large increase in sepsis incidence, sepsis mortality rates remained relatively stable over the study period after adjusting for relevant risk factors and hospital clustering. The death rates for sepsis patients with organ dysfunction and septic shock patients also remained relatively stable over this period.

The reported increased incidence of sepsis, in the context of static mortality rates for the same period, reflects improved reporting and changes to coding guidance made during this period, and not an increase in sepsis. Prior to 2015-16, when changes in coding rules were promulgated together with awareness campaigns, sepsis was being underreported.

The overall increase in sepsis cases between 2013-14 and 2017-18 can be explained by the increase in a small number of ICD-10-AM codes, especially the most frequently used code A419 (Sepsis, unspecified). Further investigation of sepsis coding guidelines and practices may assist in understanding reasons for the increases observed.

Clinical awareness and initiatives

Around the period of 2013-14 to 2017-18, there were multiple prominent sepsis awareness campaigns, such as “Sepsis Kills” in NSW and “Think Sepsis, Act Fast” in Victoria. These campaigns, along with general attention on sepsis in the medical literature and medical education, may have contributed to improved recognition, documentation and subsequently increased coding of sepsis over the time period. Although the availability of electronic record systems was variable across different hospitals, some jurisdictions are currently designing and testing more sophisticated decision support systems to improve early recognition and treatment of sepsis.

Introduction

Sepsis, defined in 2016 as "life-threatening organ dysfunction caused by a dysregulated host response to infection" (1), contributes considerably to the burden of disease in the population. The global incidence of sepsis is conservatively estimated at over 30 million cases and 5.3 million deaths annually (2). It imposes significant economic burdens on healthcare systems (3) and individuals. Sepsis is a significant cause of death and disability, particularly in children (4, 5). The World Health Organisation (WHO) in 2017 adopted a resolution on sepsis urging action to reduce the burden of sepsis worldwide (6).

There is currently no published population-level epidemiologic data for the incidence and mortality of sepsis in Australia. Studies from Australia have focused on the incidence or mortality of sepsis and/or severe sepsis in the Intensive Care Unit (ICU) setting (5, 7-11). These studies indicate that up to around one quarter of all patients in Australian ICUs have sepsis (8); and almost 10% of ICU patients had 'severe sepsis', with a mortality rate over 24% (11). Post-operative sepsis incidence rates in Australia increased over the period 2002-2009, from 12.7 to 15.8 cases per 1000 admissions (12). Although mortality rates decreased (from 27% to 20%), the increase in incidence resulted in no change in the number of post-operative sepsis-related deaths (3.4 vs 3.2 deaths per 1000 admissions) (12).

Indigenous Australians experience sepsis at significantly higher rates than non-Indigenous Australians. In the Northern Territory, the annual population-based incidence of sepsis in 2007-8 was reported at 11.8 admissions per 1000 people, but 40.8 admissions per 1000 Indigenous people (13). In paediatric patients, the incidence of sepsis and septic shock is 4.4 cases per 100, 000 Indigenous children compared with 0.6 cases per 100,000 non-Indigenous children (10).

Sepsis incidence is considered to have traditionally been underreported (6, 14). Sepsis incidence and mortality rates may vary according to the definition used (8); and some authors report a mismatch between clinically diagnosed sepsis and sepsis captured using International Classification of Diseases (ICD) codes (9, 15). There has also been significant variation in the WHO ICD codes used to define sepsis in epidemiological studies using administrative data (16). Adding to the complexity in determining the incidence of sepsis over time are the continually evolving condition definitions, the most recent being the introduction of the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) in 2016 (1).

Aims and scope of this report

This report was commissioned by the Australian Commission on Safety and Quality in Health Care (ACSQHC) as the first strategy in a national program of work to improve patient outcomes from sepsis.

The aims of this report were to

1. Determine the incidence and mortality of sepsis in public hospitals
2. Investigate variations in incidence and mortality related to patient and hospital stay characteristics.
3. Investigate sepsis-related practice and initiatives across states/territories

These aims were achieved through a mixed methods research approach:

- Epidemiological analysis of national inpatient data from all Australian public hospitals (Aims 1 and 2). The analysis included all patients admitted to all Australian public hospitals from 2013-14 to 2017-18. Data related to these hospitalisations were extracted from the

Admitted Patient Care National Minimum Data Set (APC NMDS; (17)), specifically isolating the patients with a diagnosis of sepsis using ICD-10-AM codes – defined in the Classification of Hospital Acquired Diagnoses (CHADx; (18)). Patients with a sepsis ICD code recorded during hospitalisation were referred to as *a sepsis patient* in this report. The same definitions applied to sepsis hospitalisations and deaths in this report.
Sepsis hospitalisations and deaths were analysed in relation to i) patient demographics (e.g., sex, age, remoteness of residence, socioeconomic disadvantage and Indigenous status), ii) patient clinical characteristics (e.g., organ dysfunction, comorbidity, ICU admission, surgical procedure etc.), and iii) hospital characteristics (e.g., public hospital peer group, remoteness of hospital location and state/territory). Age standardised incidence and mortality rates were calculated. Generalised estimating equations were applied to examine the changes in mortality rates over time account for hospital level clustering and to adjust for relevant risk factors.

- Semi-structured interviews with clinicians, patient safety professionals and sepsis researchers around the country (Aim 3) regarding changes in clinical practice, sepsis awareness, promotion and other initiatives that may have contributed to the observed variations during the study period (i.e. between 2013-14 and 2017-18).

Sepsis hospitalisations

The 2013-2018 study cohort included 23,827,061 hospital separations ('hospitalisations') from 739 public hospitals in Australia. There were 437,354 hospitalisations of patients with sepsis (overall crude incidence: 1,835.5 per 100,000 hospitalisations). The demographics and clinical characteristics of these sepsis separations are reported in *Table 1*. For simplicity, 'hospital separations' will be referred to as 'hospitalisations' (see Glossary for definition) in this report but note that as the data are not available at patient level, one patient could have multiple hospitalisations.

The average age of patients hospitalised with sepsis was 60.1 years and 54.7% were males. More than one third (38.9%) had sepsis recorded as the principal diagnosis (see Glossary for definition) for their hospital stays. A similar proportion of these sepsis hospitalisations (37.3%) had a diagnosis of organ dysfunction. Nearly half of them (46.6%) had a comorbidity recorded with more than a quarter (26.7%) having Charlson Comorbidity Index (CCI; (19))≥3, indicating these patients had poor clinical prognosis.

A higher proportion of sepsis hospitalisations were from low socioeconomic status (SES) groups; about a quarter (24.2%) from the lowest SES group, which represents one fifth (20%) of the Australian residential population. Indigenous people accounted for 5.4% of sepsis hospitalisations, yet constitute only 3.3% of Australian residential population (20).

The majority of sepsis hospitalisations (85.3%) were in acute care (see Glossary for definition). Nearly one tenth required ventilatory support with a median duration of 97.0 hours (inter-quartile range [IQR]: 38.0 - 215.0). Overall, 22.3% of sepsis hospitalisations had an ICU admission. Median ICU length of stay (LOS) was 3.3 days (IQR: 1.6-7.7) and median hospital LOS was 7.0 days (IQR: 3.0 - 14.0).

Table 1: Demographics and clinical characteristics of patient hospitalisations with sepsis (n=437,354)

Characteristics		**Patient hospitalisations with sepsis, N (%)**
Total number of hospitalisations with sepsis		**437,354**
Age, years	Mean (SD)	60.1 (27.0)
	Median (IQR)	68.0 (48.0 -80.0)
Sex	Male	239,264 (54.7%)
	Female	198,085 (45.3%)
Diagnosis as@	Principal	170,084 (38.9%)
	Additional	267,270 (61.1%)
With organ dysfunction^	Yes	163,138 (37.3%)
	No	274,216 (62.7%)
Remoteness (patients) @	Major cities	285,167 (65.2%)
	Inner regional	92,293 (21.1%)
	Outer regional	43,058 (9.8%)
	Remote	6,276 (1.4%)
	Very remote	7,557 (1.7%)
	Unknown	3,003 (0.7%)
Socioeconomic group@	Group 1 (lowest SES)	105,768 (24.2%)
	Group 2	89,569 (20.5%)
	Group 3	91,809 (21.0%)

Characteristics		Patient hospitalisations with sepsis, N (%)
	Group 4	74,932 (17.1%)
	Group 5 (highest SES)	72,235 (16.5%)
Aboriginal and Torres Strait Islander Status	Indigenous	23,621 (5.4%)
	Other Australians	413,733 (94.6%)
Acute care[@]		372,894 (85.3%)
Ventilation required		41,787 (9.6%)
Duration of ventilatory support, total hours (for those with ventilation)	Mean (SD)	189.4 (325.6)
	Median (IQR)	97.0 (38.0 - 215.0)
Involved a surgical procedure[@] during hospital stay		78,657 (18.0%)
With a comorbidity[#]		203,694 (46.6%)
Charlson Comorbidity Index (CCI)	Mean (SD)	1.9 (2.5)
	Median (IQR)	1 (0-3)
CCI groups	CCI=0	192,630 (44.0%)
	CCI=1, 2	127,994 (29.3%)
	CCI≥3	116,757 (26.7%)
ICU admission		97,494 (22.3%)
ICU length of stay, days	Mean (SD)	7.5 (14.0)
	Median (IQR)	3.3 (1.6-7.7)
Hospital length of stay, days	Mean (SD)	12.4 (21.7)
	Median (IQR)	7.0 (3.0 - 14.0)
In-hospital mortality		52,297 (12.0%)
State/territory (hospitals)	South Australia (SA)	21,422 (4.9%)
	Tasmania (TAS)	9,701 (2.2%)
	Northern Territory (NT)	7,742 (1.8%)
	New South Wales (NSW)	150,796 (34.5%)
	Queensland (QLD)	80,783 (18.5%)
	Victoria (VIC)	122,377 (28.0%)
	Western Australia (WA)	35,820 (8.2%)
	Australian Capital Territory (ACT)	8,713 (2.0%)
Remoteness (hospitals) [@]	Major cities	319,095 (73.0%)
	Inner regional	78,046 (17.8%)
	Outer regional	32,100 (7.3%)
	Remote	6,300 (1.4%)
	Very remote	1,813 (0.4%)
Hospital peer group[@]	Principal referral	173,283(39.6%)
	Public acute group A	158,101(36.2%)
	Public acute group B	48,285(11.0%)
	Public acute group C	25,619(5.9%)
	Women's and/or children's	16,418(3.8%)

Characteristics		Patient hospitalisations with sepsis, N (%)
	Public acute group D	6,833(1.6%)
	Non-acute/subacute	5,051(1.2%)
	Other*	3,764(0.9%)

^ organ dysfunction includes following conditions: cardiovascular (R570, I509), respiratory (J80, J95, J960), renal (N17, N990), Hematologic (D65, D69), hepatic (K72), and metabolic (E872).

 # Comorbidity includes: pulmonary disease (J40- J47, J60-J67), cancer (C0-C3, C40, C41, C43, C45-C49, C5, C6, C70- C76, C80-C85, C883, C887, C889, C900, C901, C91-C93, C940-C943, C9451, C947, C95, C96), diabetes (E109, E119, E139, E149, E101, E111, E131, E141, E105, E115, E135, E14, E102, E112, E132, E142 E103, E113, E133, E143 E104, E114, E134, E144), HIV/AIDS (B20-B24), liver disease (K702, K703, K73, K717, K740, K742, K746, K743, K744, K745) and renal disease (N03, N052-N056, N072- N074, N01, N18, N19, N25).

@ definition see Glossary.

***Other includes: Very small, Psychiatric, Outpatient hospital, and Other hospital peer groups, and hospitals with no peer group information)**

Sepsis incidence

Age and sex

The number of sepsis hospitalisations and incidence were highest for the youngest (<1 year of age) and the oldest age groups (≥85 years; *Figure 1*). The overall age standardised incidence was 1162.8 cases per 100,000 population (95% CI:1158.4-1167.0).

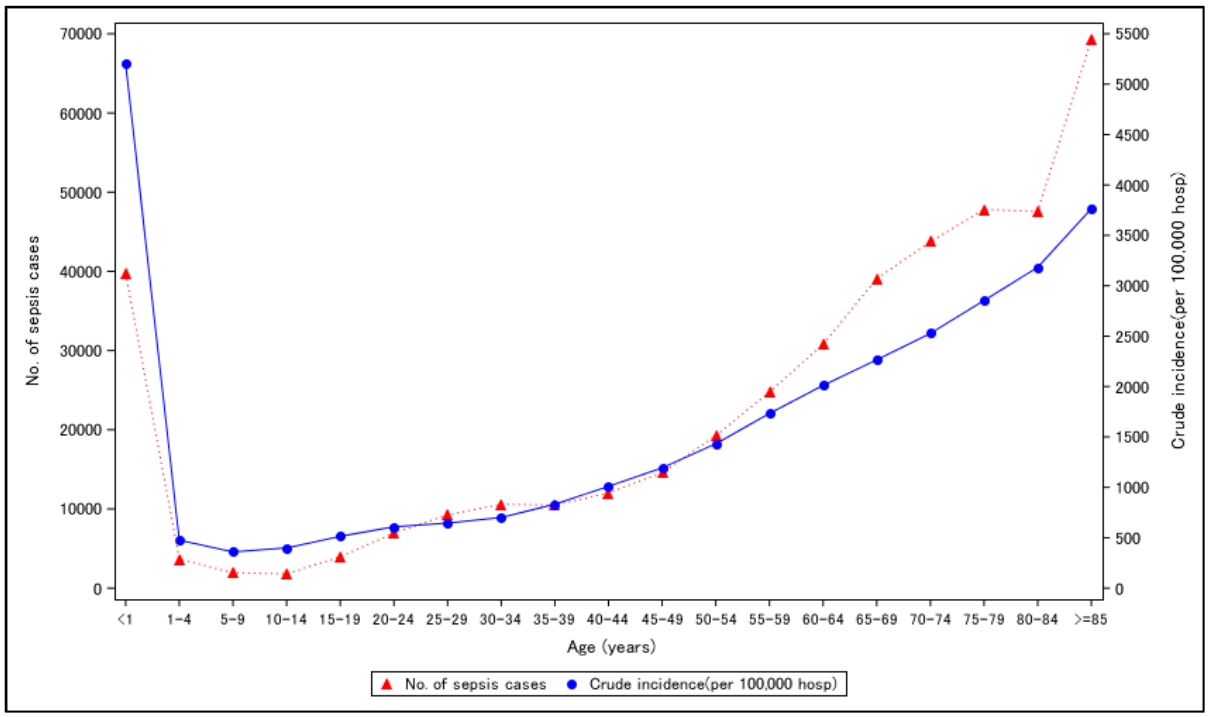


Figure 1: Age-specific number of sepsis cases and incidence

Overall, males were 19% more likely to have sepsis than females (Rate ratio: 1.19 [95% CI: 1.18-1.20]); age standardised incidence for males: 1,266.1 per 100,000 population (95% CI:1,259.3-1272.9), for females: 1,064.7 per 100,000 population (95% CI: 1,058.8-1,070.7).

Males had substantially higher rates of sepsis hospitalisations than females among those younger than 1-year and for those in the older age groups. The gap between males and females for sepsis incidences widened with increasing age (*Figure 2*).

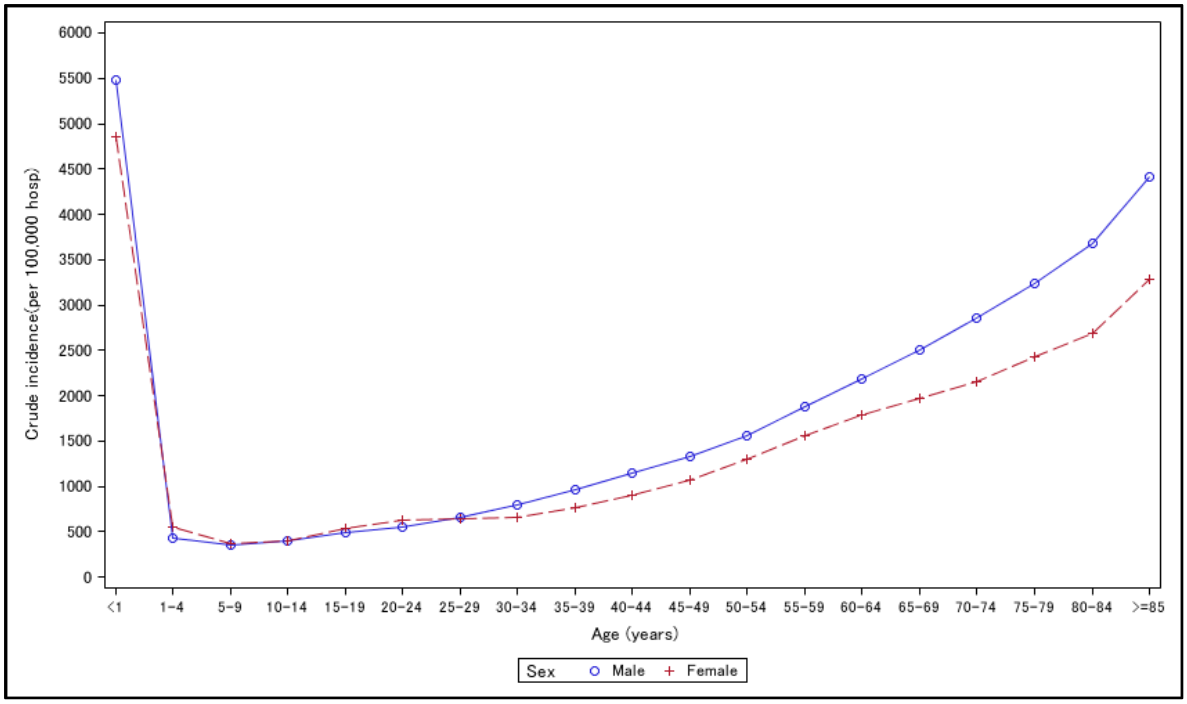


Figure 2: Age specific sepsis incidence by sex

Change over time

Overall trend

Between 2013-14 and 2017-18, there was a considerable increase in the number and rate of hospitalisations where sepsis was recorded as a diagnosis (*Table 2*). The number of sepsis cases recorded increased 59%, from 66,062 to 104,912, an average increase of around 9,712 hospitalisations (or 15%) per year over this period. The largest increase occurred in 2015-16, 23,144 more cases recorded than that in 2014-15 (a 33% increase).

Similarly, the age standardised incidence increased over the same period – by 27% (from 994.1 to 1,260.5 per 100,000 population), an average annual increase of 7% (*Table 2*). A sharp increase also happened from 2014-15 to 2015-16 (24% increase). The sepsis incidence stabilised after 2015-16, with only a 2% increase from 2015-16 to 2016-17.

Table 2: Sepsis cases and age standardised incidence over time

Year	Number of sepsis cases recorded	Age standardised incidence, per 100,000 pop (95% CI)
2013-14	66,062	994.1 (984.5 – 1,003.8)
2014-15	70,383	1,007.3 (997.7 – 1,016.8)
2015-16	93,527	1,246.2 (1,236.0 – 1,256.4)
2016-17	102,470	1,272.2 (1,262.2 – 1,282.1)
2017-18	104,912	1,260.5 (1,250.8 – 1,270.3)

Trends in sepsis hospitalisations by Age and sex

Sepsis hospitalisation rate increased every year among the youngest patients (<1 year) while the rates increased after 2015-16 among the older age groups (aged 35 years and over; *Figure 3*). Age

standardised incidence was consistently higher among males than females over the whole study period (*Figure 4*).

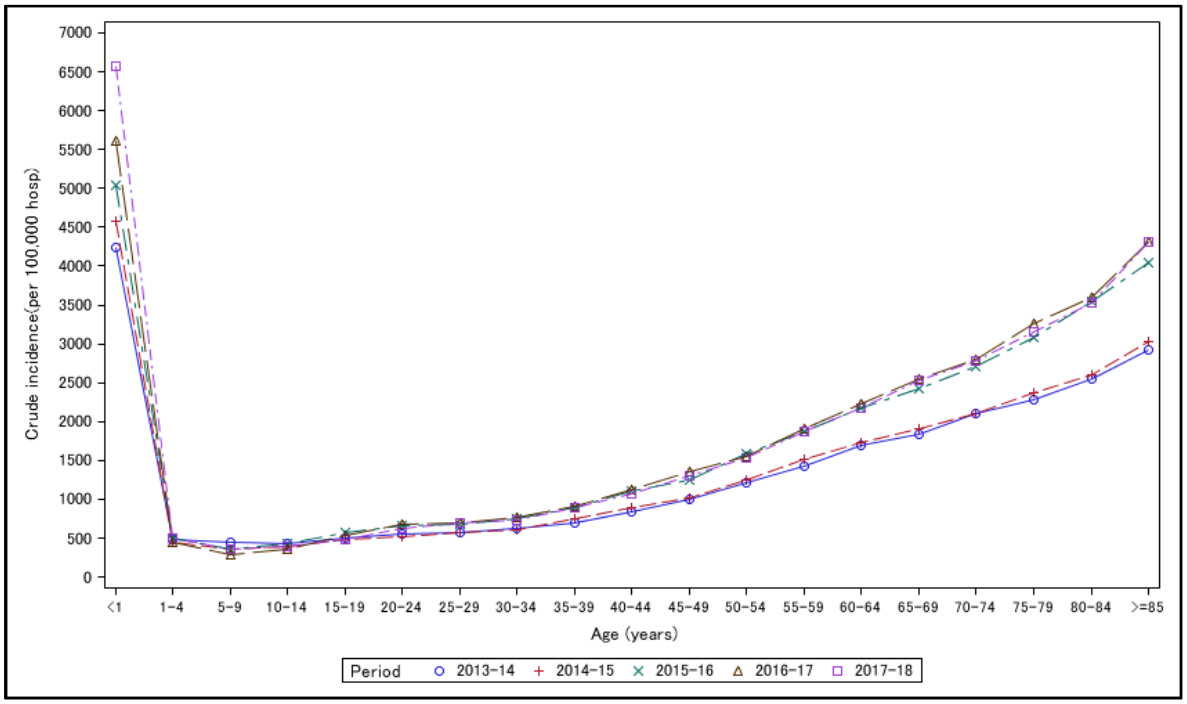


Figure 3: Age-specific sepsis incidence by year

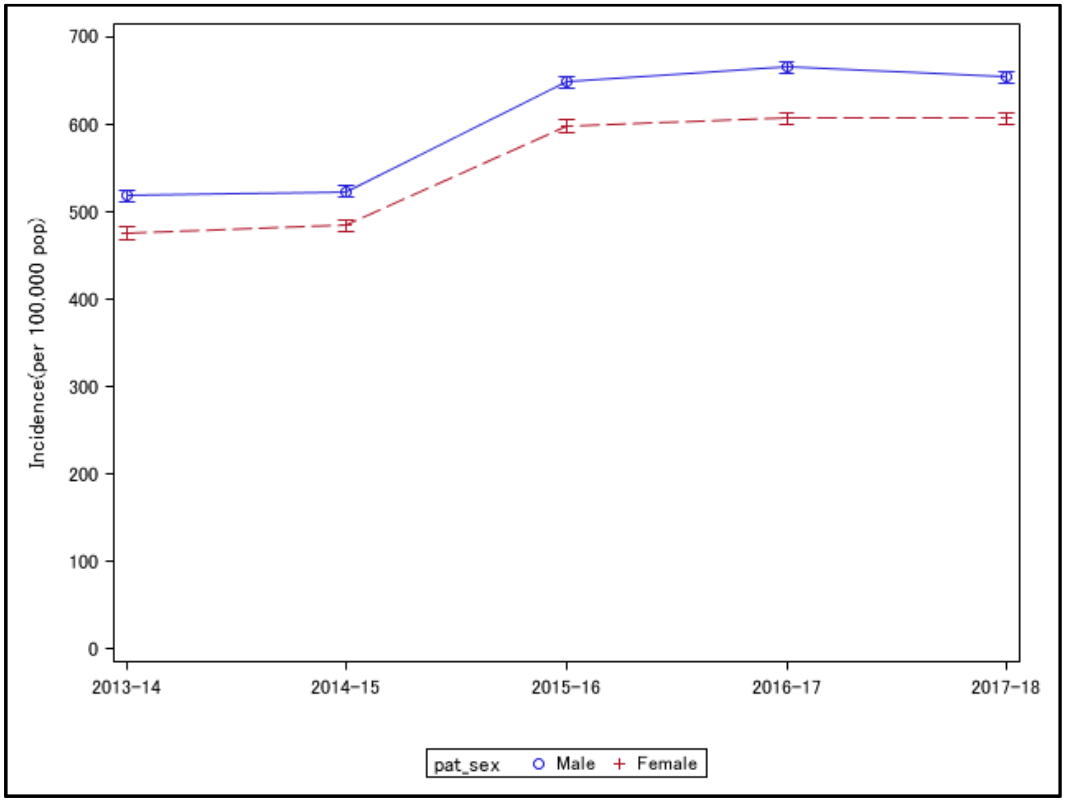


Figure 4: Change over time – age and sex standardised sepsis incidence by year, including the 95% CI for each year and sex

Sepsis ICD-10-AM coding changes over time

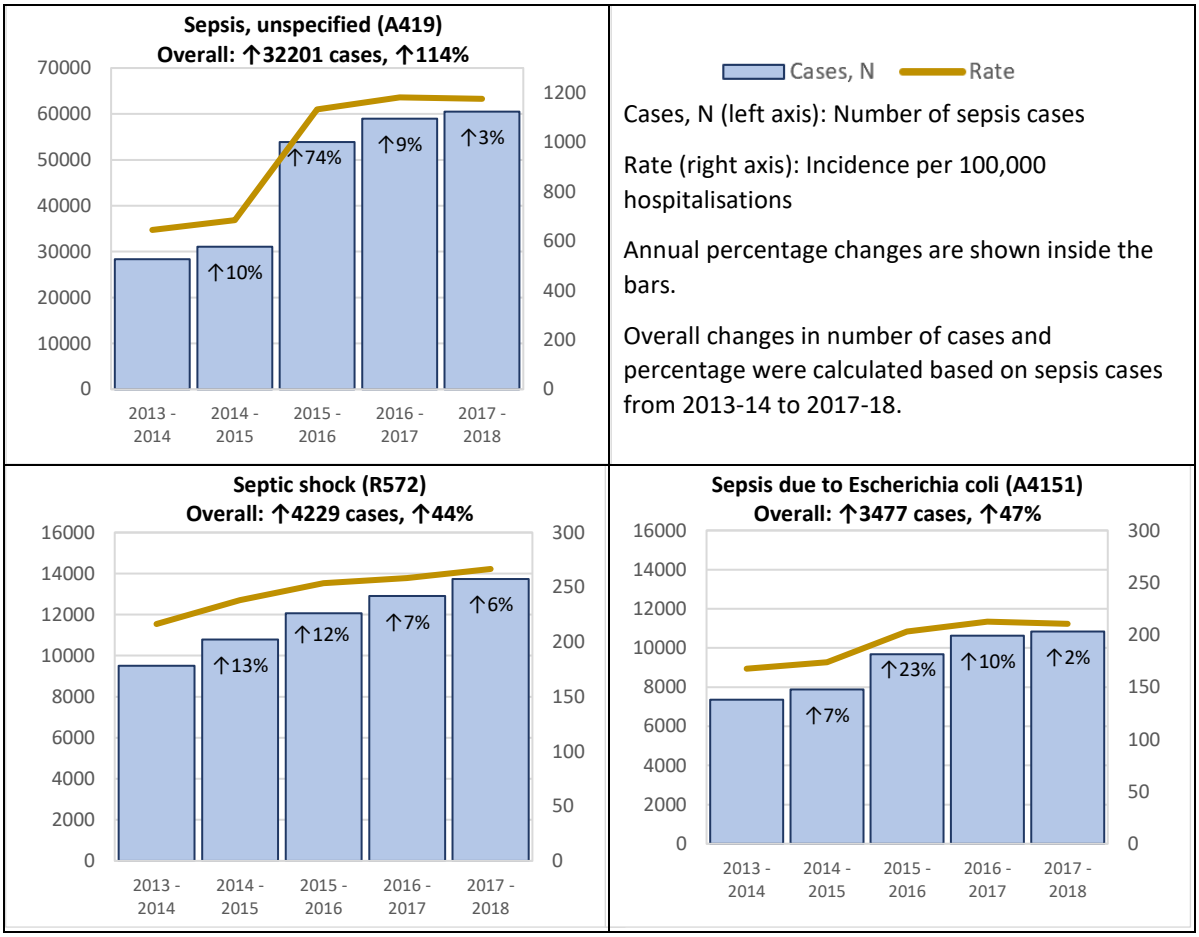
A set of 43 sepsis ICD-10-AM codes, from the Classification of Hospital Acquired Diagnoses (CHADx), were used to identify sepsis diagnosis (Appendix Table 7). The number of sepsis cases recorded increased by 38,850 over 5 years, from 66,062 in 2013-14 to 104,912 in 2017-18 (see *Table 2*).

Sepsis cases identified by each individual ICD code were investigated and changes in these different diagnosis codes over time were presented in Appendix Table 7. The top seven most common sepsis ICD codes accounted for 96% (n=419,758) of all sepsis cases recorded. *Figure 5* shows sepsis cases recorded in these seven codes have increased since 2013-14, ranging from 24% to 114%.

ICD code A419 (sepsis, unspecified) was the most common sepsis code recorded – 232,757 cases (53% of all 437,354 sepsis cases; *Figure 5*). It accounted for 83% of the increase over 5-year study period – an increase of 32,201 cases. The sharpest increase of this code occurred from 2014-15 to 2015-16 (31,032 cases vs 53,885, respectively; a 74% increase). These 22,853 cases increase of A419 coded sepsis from 2014-15 to 2015-16 accounted for almost all sepsis cases increase (99%) over this time period (70,383 compared with 93,527, respectively).

There were 19 ICD codes (44% of all 43 codes) with less than 1000 sepsis cases recorded for each code over 5-year period in all study hospitals, including four codes that were never used at all (Appendix Table 7).

The use of two sepsis codes have reduced dramatically in the period from 2013-14 to 2017-18 (Appendix Table 7): 1) Systemic inflammatory response syndrome (SIRS) of infectious origin without acute organ failure (R650) – from 2625 to 0 cases (100% decrease); and 2) Severe sepsis (R651) – from 2365 to 942 (60% decrease). The sharpest reductions for both codes occurred in 2015-16.



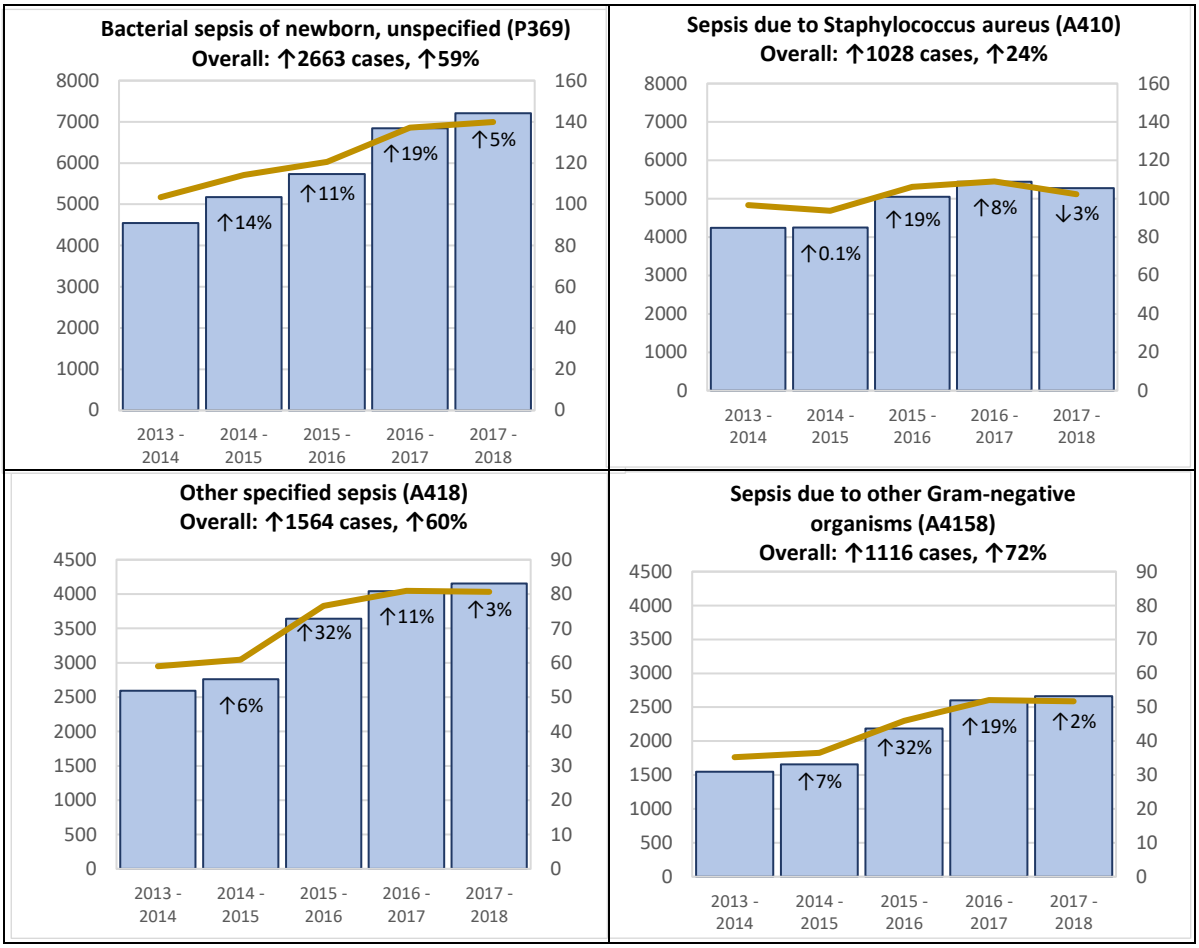


Figure 5: Top seven most common sepsis codes, accounting for 96% of all recorded sepsis cases

Sepsis recorded as the principal or an additional diagnosis

Age standardised incidence for sepsis recorded as the principal diagnosis for patients' hospital stays was 438.4 per 100,000 population (95% CI: 435.7 – 441.1) and it was 724.4 as an additional diagnosis (95% CI: 720.9 – 727.8). Sepsis incidence recorded as an additional diagnosis was 65% higher than that recorded as the principal diagnosis (rate ratio: 1.65, 95% CI: 1.64-1.67).

Sepsis diagnoses were more likely to be coded as an additional diagnosis than the principal diagnosis, especially for the youngest patients (<1 year) and older patients (*Figure 6*).

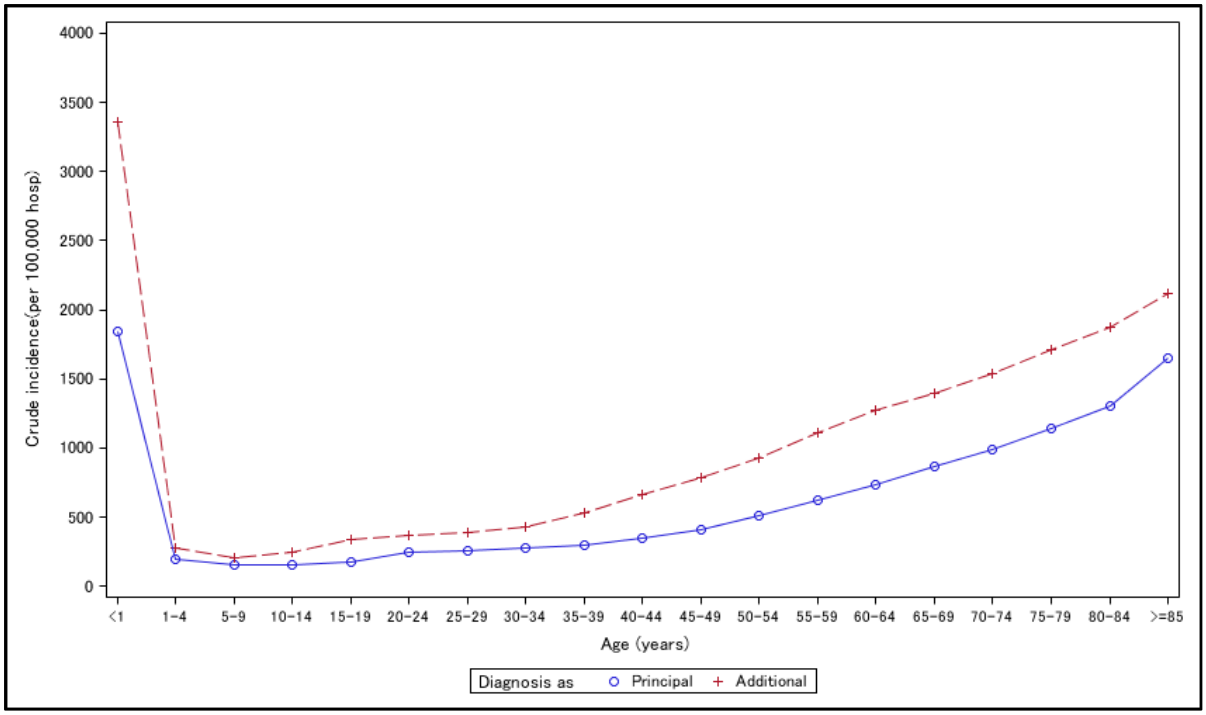


Figure 6: Age specific sepsis incidence by diagnosis recording as the principal or additional diagnosis

For each study year age standardised sepsis incidence was consistently higher for those hospitalisations with sepsis recorded as an additional diagnosis than for those with a principal diagnosis of sepsis (*Figure 7*). However, the age standardised incidence of sepsis as a principal diagnosis increased by 39% during the study period (average annual increase of 10%) while the increase in sepsis as an additional diagnosis was 20% (average annual increase of 5%).

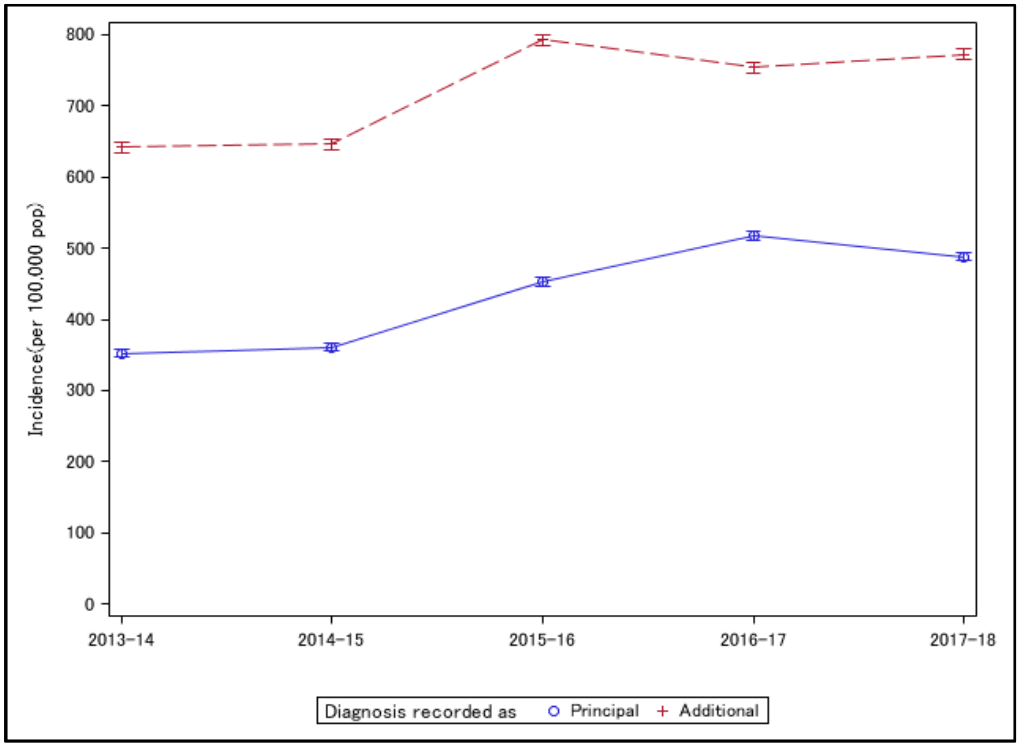


Figure 7: Change over time – age standardised sepsis incidence by diagnosis recording as the principal or additional diagnosis (errors bars indicate 95% CIs)

Sepsis with organ dysfunction

A total of 163,138 sepsis hospitalisations had an organ dysfunction also coded. Renal disease was the most common type of organ dysfunction (80.1%; *Figure 8* -Note: as patients may have multiple organ dysfunctions, total percentage for type of organ dysfunction is higher than 100%). A total of 26.2% of these patient hospitalisations had more than one organ dysfunctions.

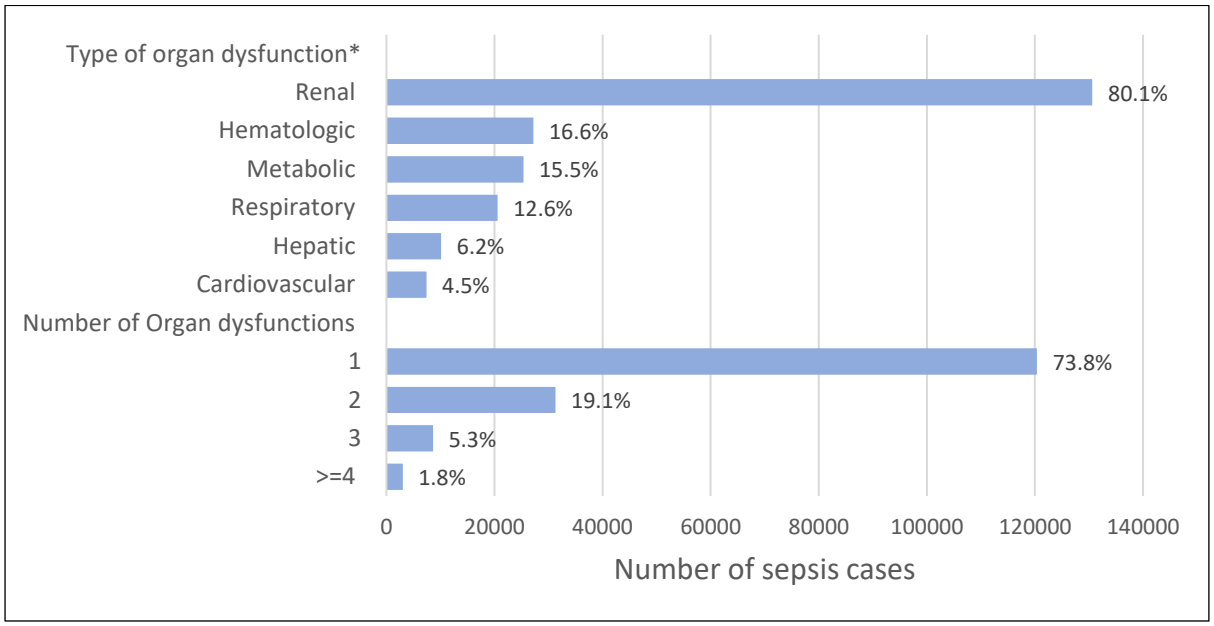


Figure 8: Sepsis with organ dysfunction

Age standardised incidence for sepsis with an organ dysfunction was 403.2 per 100,000 population (95% CI: 400.7 – 405.7). Age standardised incidence for sepsis without an organ dysfunction was 88% higher (incidence: 759.6 per 100,000 populations, 95% CI: 756.0 – 763.2).

The youngest patients (<1 year) had the highest rate of sepsis hospitalisations without an organ dysfunction among all age groups (*Figure 9*). The rates of sepsis hospitalisations both with and without an organ dysfunction increased with age.

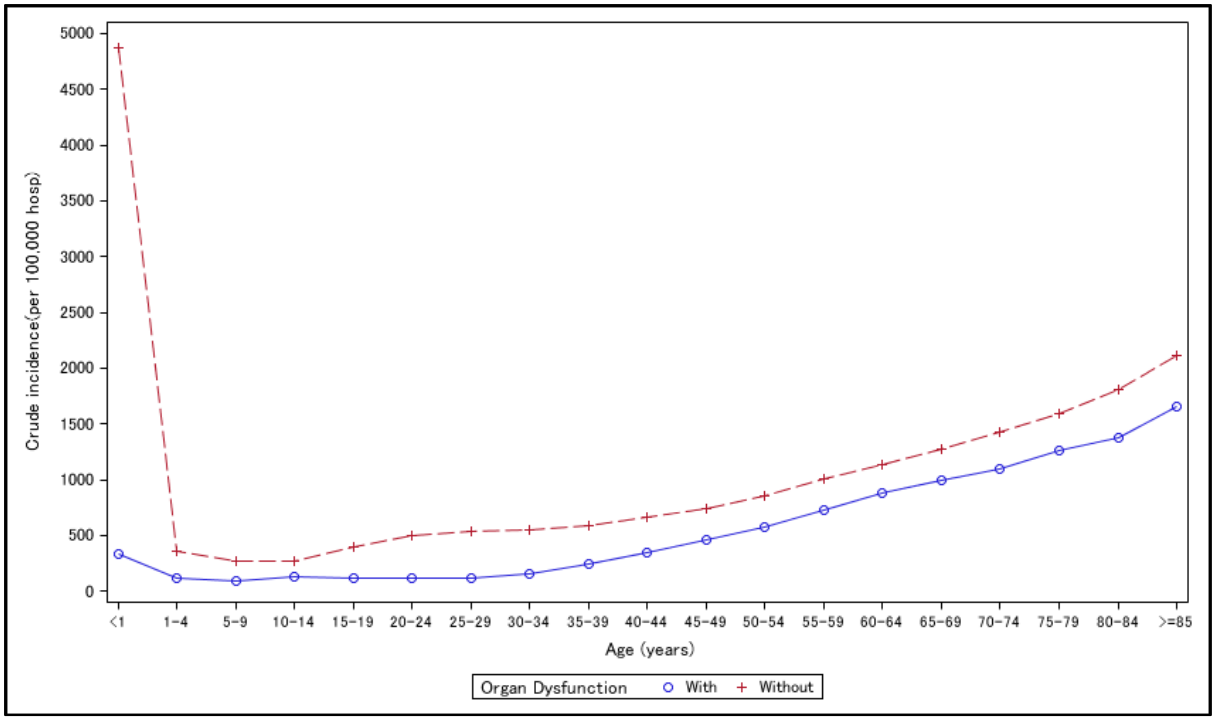


Figure 9: Age specific sepsis incidence for those with and without organ dysfunction

Age standardised sepsis incidences increased for both groups, i.e. those with and without organ dysfunction, from 2013-14 to 2017-18 (a 28% increase for sepsis with an organ dysfunction and a 26% for those without), at similar annual increase rates (7% for those with an organ dysfunction and 6% for those without; *Figure 10*). The sharpest annual increase occurred in 2015-16 for both groups (a 21% increase for those with an organ dysfunction and a 25% increase for those without).

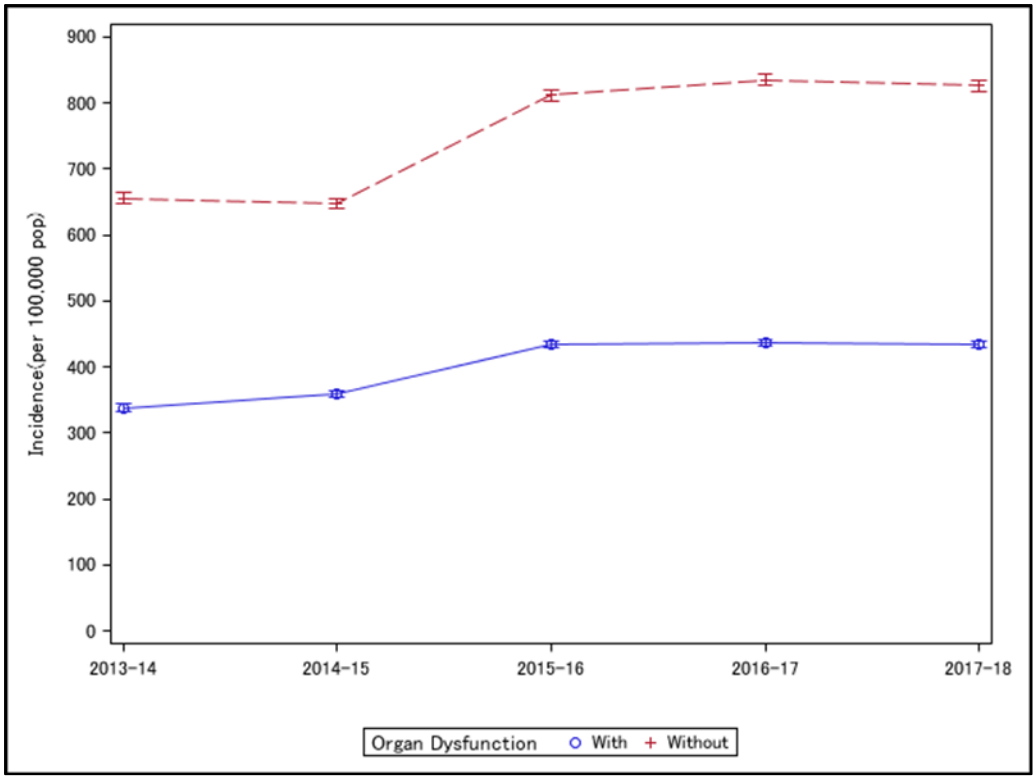


Figure 10: Change over time – age standardised sepsis incidence for those with and without organ dysfunction (errors bars indicate 95% CIs)

Septic shock

Between 2013-14 and 2017-18, 59,011 septic shock (ICD-10-AM: R572) hospitalisations were identified (Appendix *Table 7*). The youngest patients (<1 year) had the highest crude incidence rate compared to other young patients (aged 29 and less). The incidence increased with age among patients aged 30 and over (*Figure 11*).

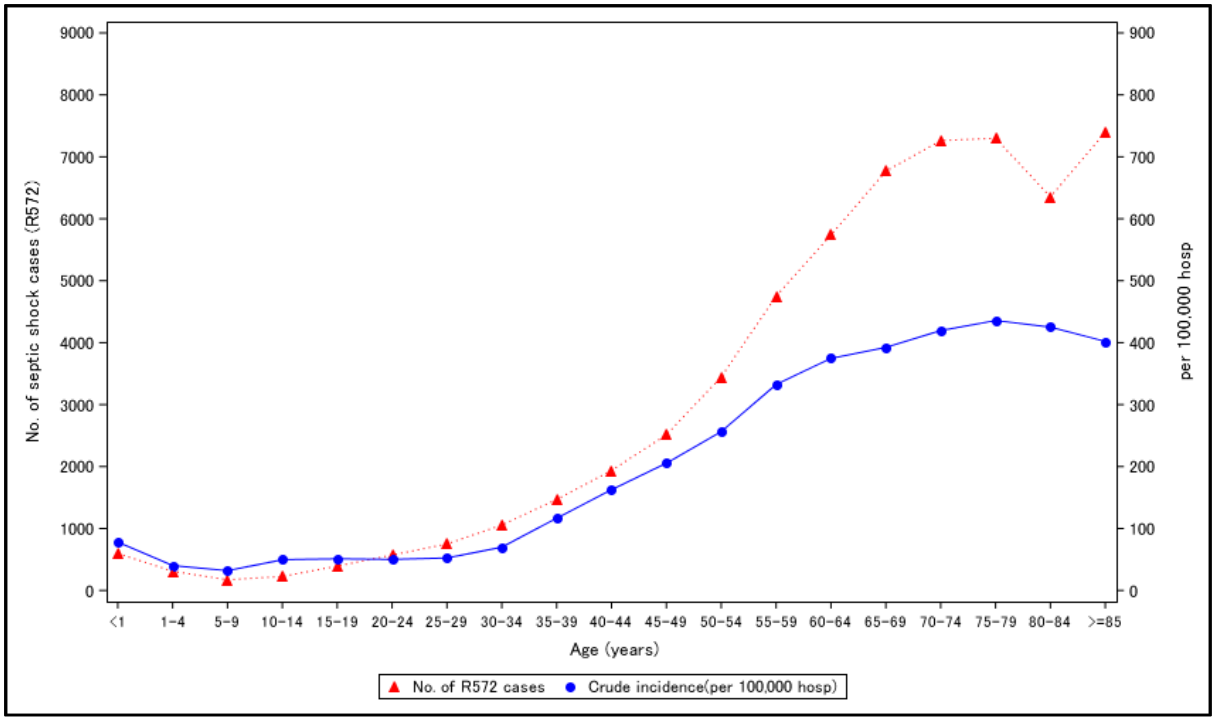


Figure 11: Number of septic hospitalisations and crude incidence of septic shock (R572) by age group

Age standardised incidence for septic shock was 162.9 per 100,000 population (95% CI: 161.2-164.5) and it was 999.9 for all other sepsis (95% CI: 995.8-1,004.0). Sepsis incidence recorded as a non-septic shock diagnosis was 6.1 times higher than that recorded as a septic shock diagnosis (rate ratio: 6.1, 95% CI: 6.1-6.2).

Age standardised septic shock incidence increased 19% from 2013-14 to 2017-18 while the incidence for other sepsis increased 28% (*Figure 12* and *Table 3*). The patterns of increases were different. There was a small increase every year for septic shock incidence – annual increase of 8%, 6%, 1% and 4% over the five-year period. For all other sepsis, a sharpest increase occurred in 2015-2016 – a 27% increase relative to 2014-2015 – then 2% increase in 2016-17 and followed by 2% decrease in 2017-18.

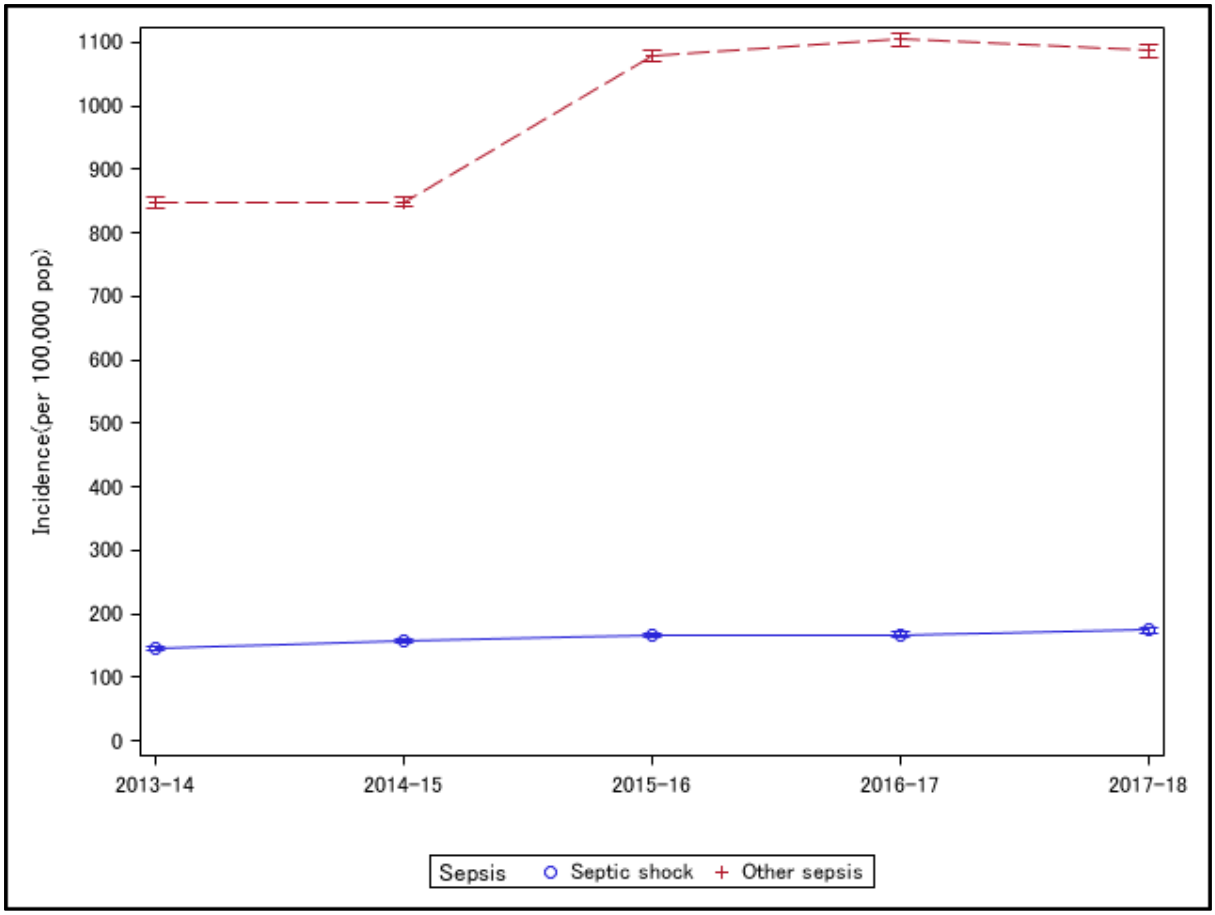


Figure 12: Change over time – age standardised sepsis incidence rates for septic shock and other sepsis (errors bars indicate 95% CIs)

Table 3: Age standardised sepsis incidence rates for septic shock and other sepsis over 5-year period

Year	Septic shock*	Annual change	Other sepsis*	Annual change
2013-14	145.8 (142.2 - 149.4)	-	848.3 (839.3 - 857.3)	-
2014-15	157.7 (154.0 - 161.4)	+8%	849.5 (840.7 - 858.3)	0%
2015-16	166.6 (162.9 - 170.3)	+6%	1,079.7 (1070.1 - 1089.2)	+27%
2016-17	167.5 (163.9 - 171.1)	+1%	1,104.7 (1095.4 - 1113.9)	+2%
2017-18	173.9 (170.3 - 177.6)	+4%	1,086.6 (1077.6 - 1095.7)	-2%

* Age standardised incidence (per 100,000 population; with 95% CI)

Population groups

Remoteness

People living in inner/outer regional area had the lowest age standardised incidence rate compared to those living elsewhere (*Figure 13* and Appendix *Table 8*). Those living in very remote areas had sepsis hospitalisations 1.7 times higher than those living in major cities. Hospitalisation rates for people living in very remote areas were highest across all age groups <80 years (*Figure 14*).

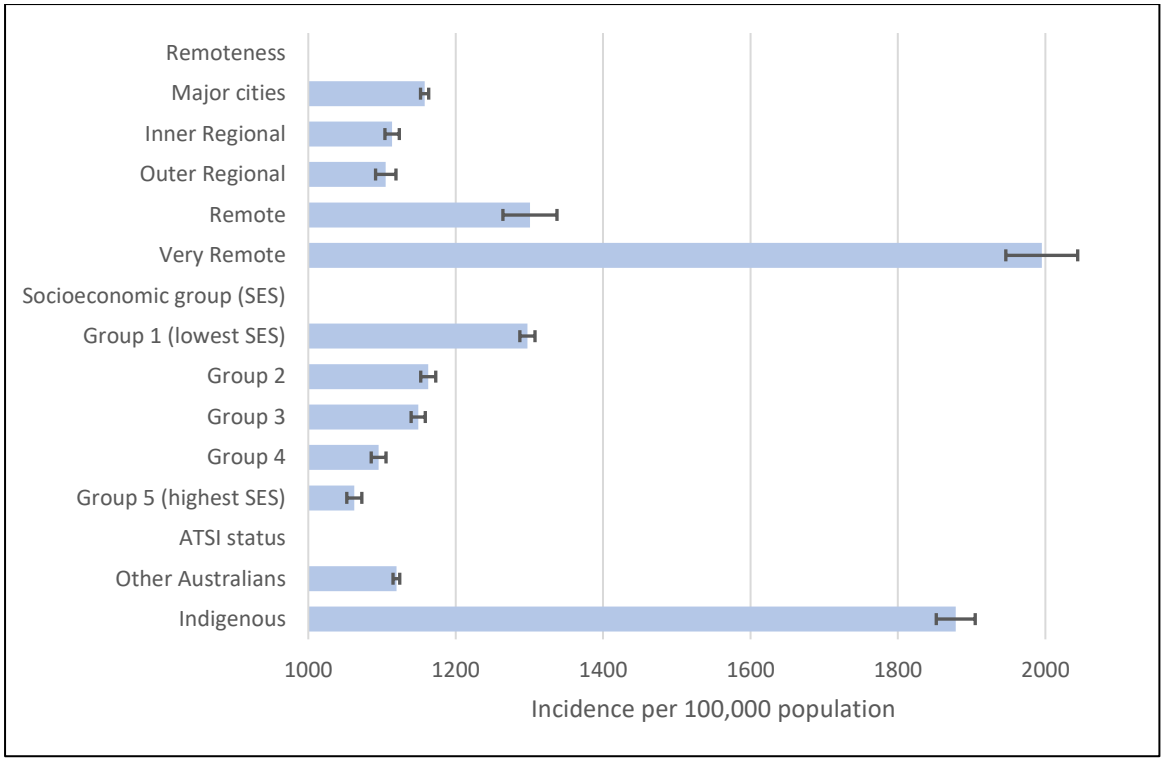


Figure 13: Age standardised incidence rates and 95% CIs by selected population characteristics

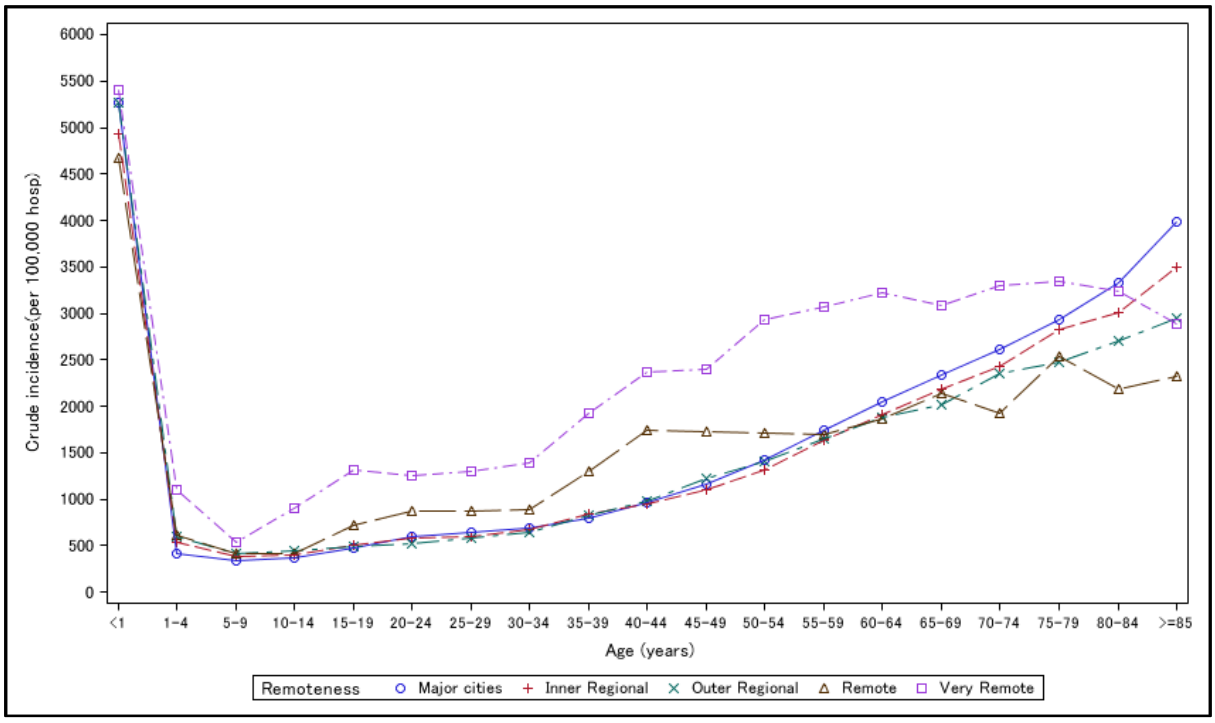


Figure 14: Age specific sepsis incidence by remoteness of patients' place of residence

Socioeconomic status (SES)

Living in an area with socioeconomic disadvantage (see Glossary) was associated with higher hospitalisation rates for sepsis (*Figure 13* and Appendix Table 8). The age standardised sepsis incidence rate based on the area of usual residence was 1.2 times as high in the lowest SES group compared with the highest SES group. The difference in sepsis incidence between lowest SES group and the other SES groups was greatest for those patients aged 40-59 (*Figure 15*).

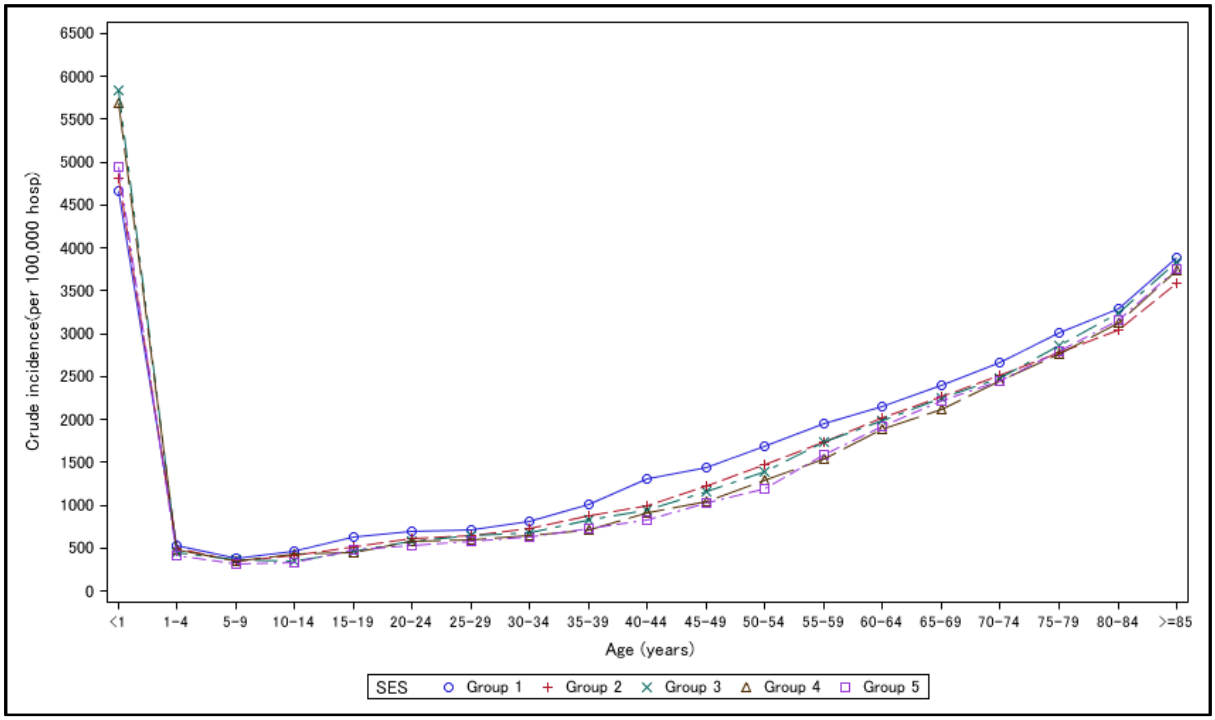


Figure 15: Age specific sepsis incidence by patient SES (Group 1 – lowest)

Aboriginal and Torres Strait Islander (ATSI)

Indigenous people accounted for 5.4% (n=23,621) of all sepsis hospitalisations. However, age standardised incidence rate was 1.7 times higher among indigenous people than other Australians (1,878.4 compared with 1,119.5 per 100,000 population, respectively; *Figure 13* and Appendix *Table 8*). The rates were higher among Indigenous people for all age groups apart from the youngest patients (<1 year; *Figure 16*).

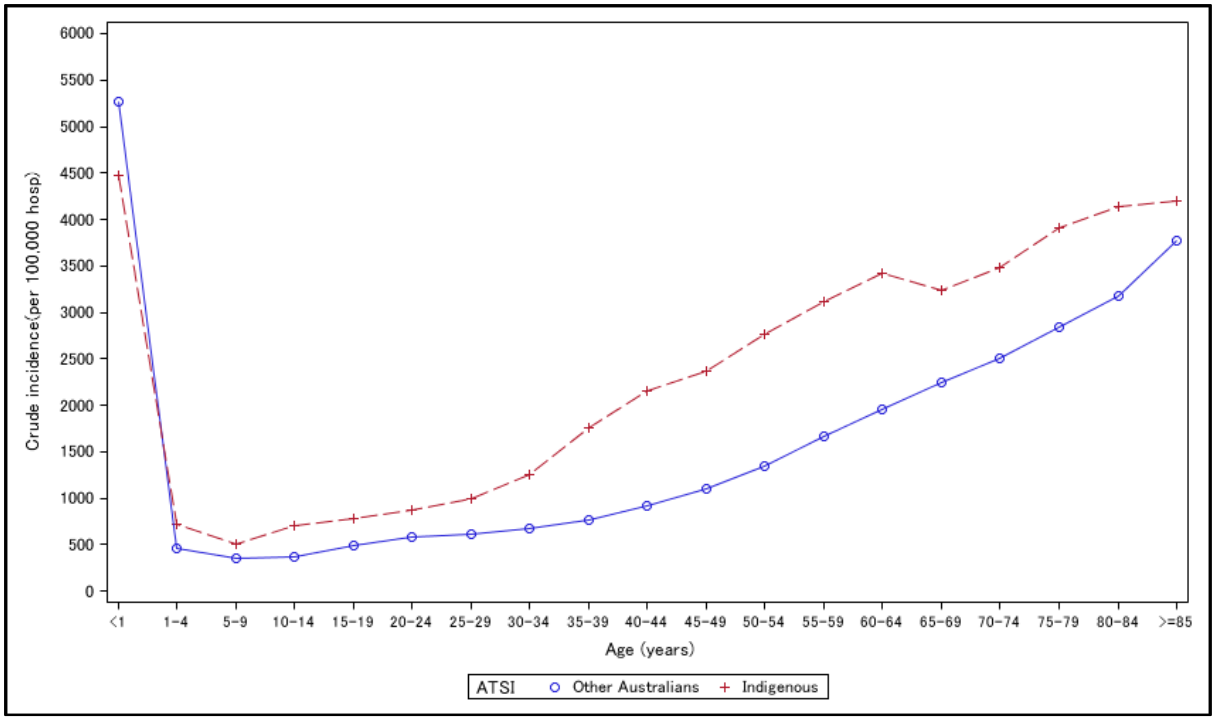


Figure 16: Age specific sepsis incidence by ATSI status

Clinical characteristics

Hospitalisations with an ICU admission

Age standardised incidence rate of sepsis was 14.9 times higher for hospitalisations with an ICU admission (Defined in https://meteor.aihw.gov.au/content/index.phtml/itemId/327234) during their stay than those without an ICU admission (13,241.0 sepsis hospitalisations per 100,000 population compared with 885.9 per 100,000 population, respectively). The rates were higher for all age groups among patients with an ICU stay than those without (*Figure 17*).

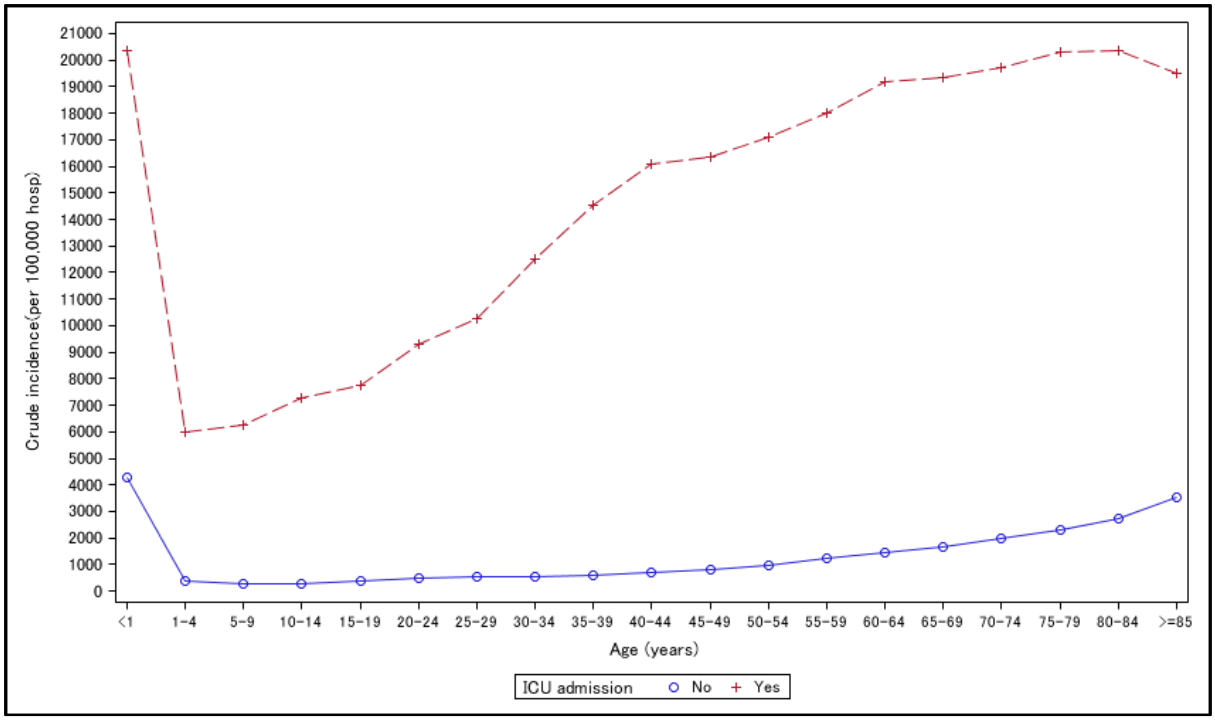


Figure 17: Age specific sepsis incidence for those with and without an ICU admission

Ventilation

Similarly, the age standardised incidence rate of sepsis was 16.5 times higher among patients who received ventilation than those who did not (17,081.2 compared with 1037.3 per 100,000 population, respectively). The rates were higher for those who had ventilation than who did not for all age groups (*Figure 17*).

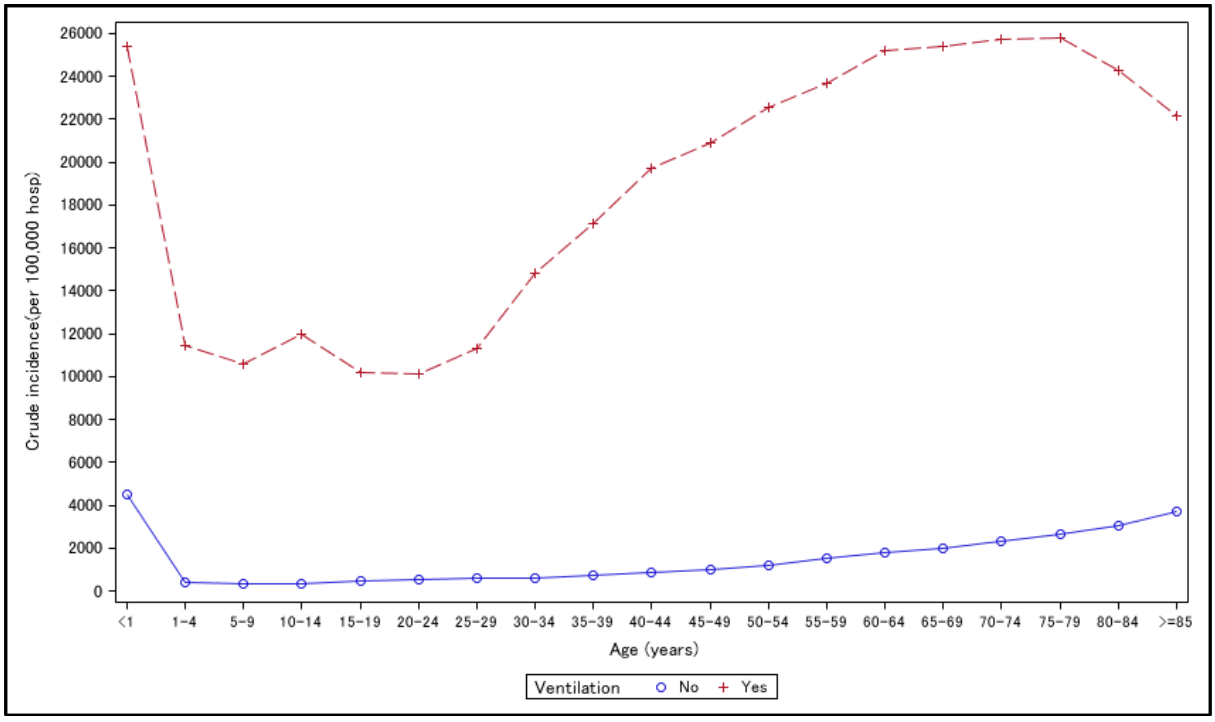


Figure 18: Age specific sepsis incidence by ventilation usage during hospital stay

Acute care

The majority of sepsis hospitalisations were recorded as acute care (85.3%, n=372,984; see Glossary for definition). Age standardised incidence rates were similar between those in acute care and non-acute care – 1,122.0 per 100,000 population (95% CI: 1,117.5 – 1,126.5) versus 1101.3 (95% CI: 1,073.9 – 1,128.7), respectively; rate ratio: 1.02, 95% CI (0.99-1.04). The highest hospitalisation sepsis rate for non-acute care was among the youngest age group (<1 year; *Figure 19*).

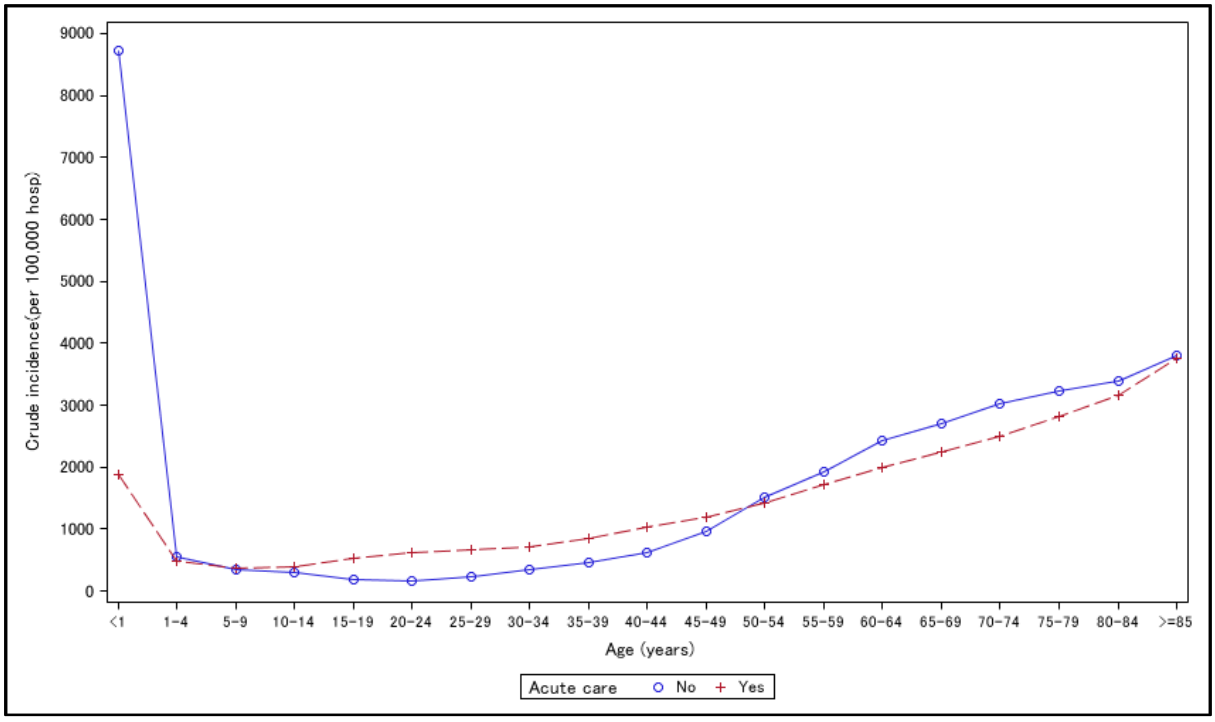


Figure 19: Age specific sepsis incidence by care type

Surgical procedure

Age standardised sepsis incidence was 3% higher among patients who did not have a surgery (see Glossary for definition) during their hospitalisation compared to those who had a surgical procedure – 1,177.4 per 100,000 population (95% CI: 1,172.3 – 1,182.5) versus 1,142.0 (95% CI: 1,132.7 – 1,151.4) respectively; rate ratio: 1.03, 95% CI: 1.02-1.04. The highest sepsis incidence rate was experienced by the youngest age group who had surgery (<1 year; *Figure 19*).

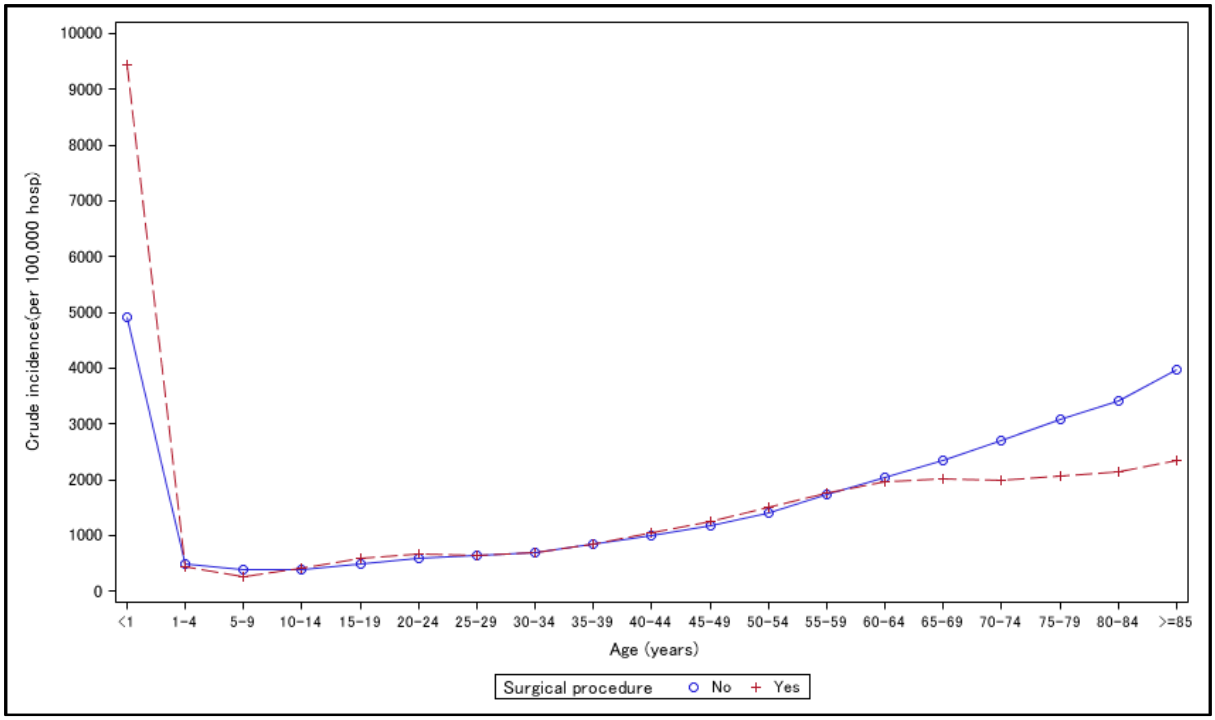


Figure 20: Age specific sepsis incidence for patients with and without a surgical procedure during their hospital stays

With a comorbidity

Five common comorbidities in sepsis patients were examined in this report (Table 4). Of 203,694 hospitalisations of patients who had a comorbidity, more than half had diabetes and one third had renal disease.

Table 4: Number of sepsis patients with comorbidities

Comorbidity	N (% of all 203,694 patients with a comorbidity)
Diabetes	104,656(51.4%)
Renal disease	68,262 (33.5%)
Cancer	57,736 (28.3%)
Chronic pulmonary disease	35,81(17.6%)
Liver disease	8,404 (4.1%)
HIV or AIDS	627(0.3%)

Age standardised sepsis incidence was 5.5 times higher among those with a comorbidity than those without – 6,279.3 per 100,000 population (95% CI: 5,942 – 6,616.6) versus 1,139.3 (95% CI: 1,134.8 – 1,143.8) respectively; rate ratio: 5.5, 95% CI: 5.2-5.8. The sepsis incidence rate among those with a comorbidity was consistently higher than those without for all age groups (*Figure 21*. Note: only 10 under 1-year old patients were recorded with a comorbidity during their hospital stays and 4 of them were diagnosed with sepsis. Age groups <1 and 1-4 were combined).

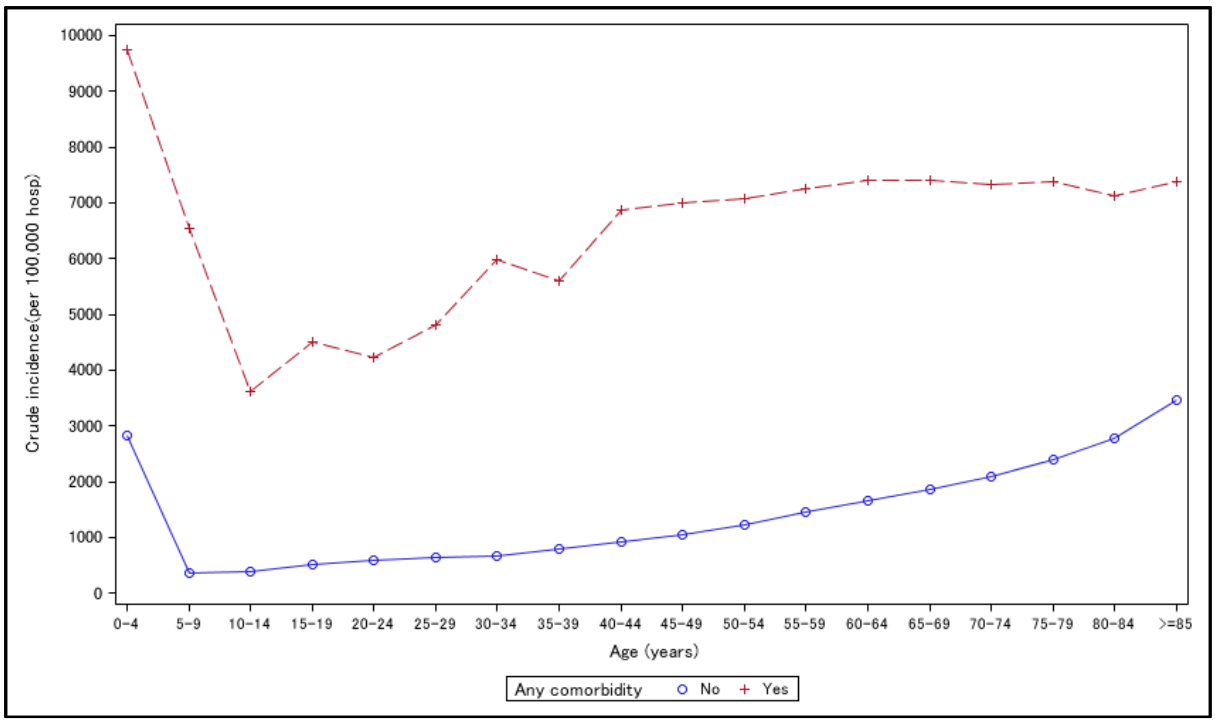


Figure 21: Age specific sepsis incidence with/without a comorbidity

Hospital characteristics

Between 2013-14 and 2017-18, hospitalisations from a total of 739 public hospitals were included in this study. More than two-thirds of hospitalisations were from principal referral and public acute group A hospitals in 2017-18 (*Table 6*).

Table 5: Number of hospitals and hospitalisation by peer group in 2017-18

Peer group	Number of hospitals	Number of hospitalisations
Principal referral	31 (4.5%)	1,868,660 (36.3%)
Public acute group A	62 (9.0%)	1,722,931 (33.4%)
Public acute group B	43 (6.2%)	601,370 (11.7%)
Public acute group C	141 (20.5%)	427,467 (8.3%)
Women's and/or children's	12 (1.7%)	268,738 (5.2%)
Public acute group D	188 (27.3%)	92,750 (1.8%)
Other	21 (3.0%)	89,329 (1.7%)
Non-acute/subacute	37 (5.4%)	46,771 (0.9%)
Psychiatric	29 (4.2%)	14,946 (0.3%)
Very small	110 (16%)	9,194 (0.2%)
Outpatient hospital	2 (0.3%)	226 (<0.1%)
Missing	13 (1.9%)	10,266 (0.2%)
Total	**689 (100.0%)**	**5,152,648 (100.0%)**

State/territory (hospital)

Sepsis incidence rates by hospitals in each state/territory were examined. Age standardised sepsis incidence rates ranged from 748.1 per 100,000 population (SA) to 1,805.5 (NT) during the study

period (*Figure 22* and Appendix *Table 9*). Sepsis hospitalisation rate for the youngest patients varied dramatically between states/territories - the highest sepsis rate occurred for VIC (*Figure 23*). SA was consistently lower for all age groups and NT experienced the highest sepsis incidence rates for patients aged 10-59 years.

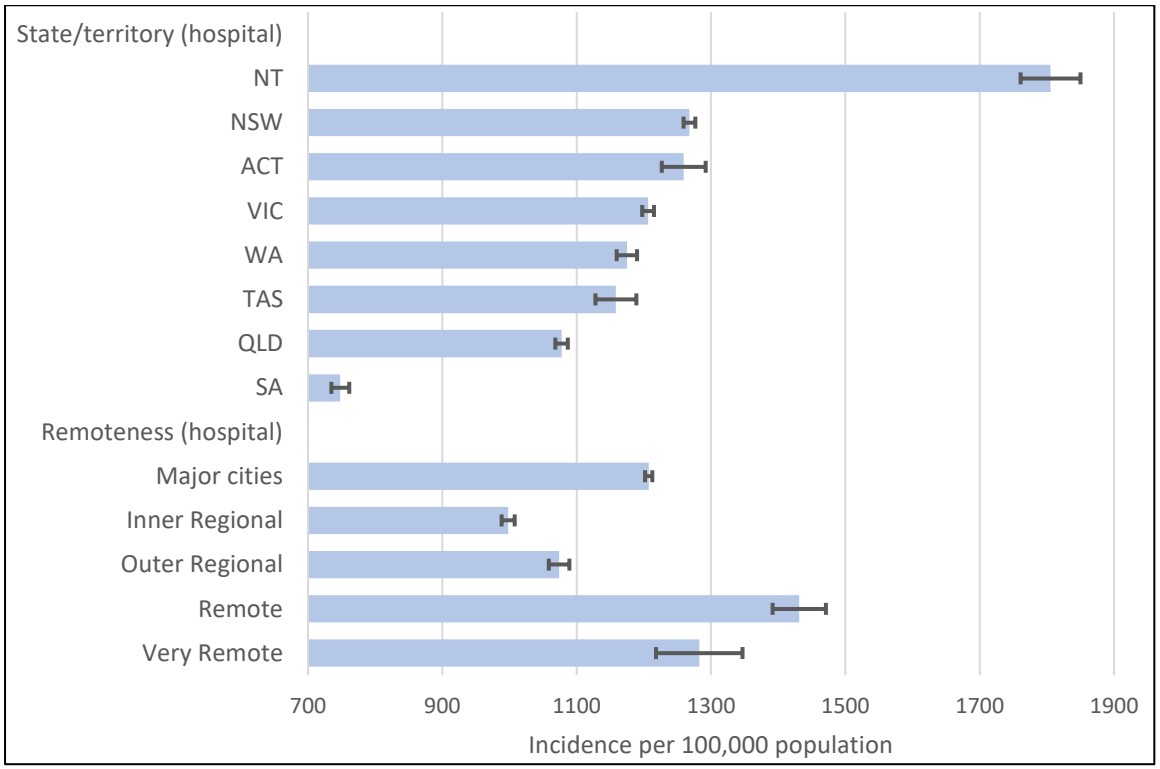


Figure 22: Age standardised incidence rates and 95% CIs by selected hospital characteristics

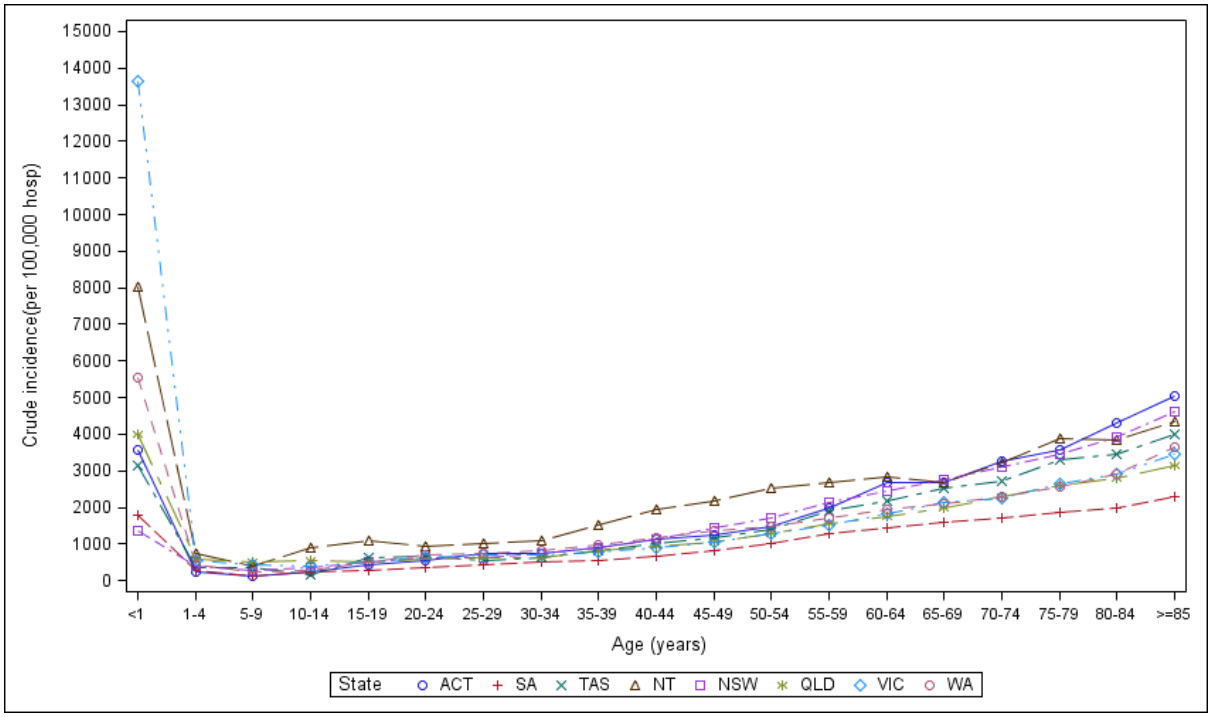


Figure 23: Age specific sepsis incidence by states/territories

Remoteness (hospital)

Age standardised incidence was 1.4 times higher for patients admitted to a remote hospital than for those patients in an inner regional hospital – 1,431.4 per 100,000 population compared with 998.0 (*Figure 22* and Appendix *Table 9*). The sepsis rate was 1.2 times higher among patients admitted to a major city hospital than those in an inner regional hospital. For those patients aged 75 and over, the sepsis incidence rate was higher for those who were admitted to a major city hospital compared to those patients in other hospitals (*Figure 24*).

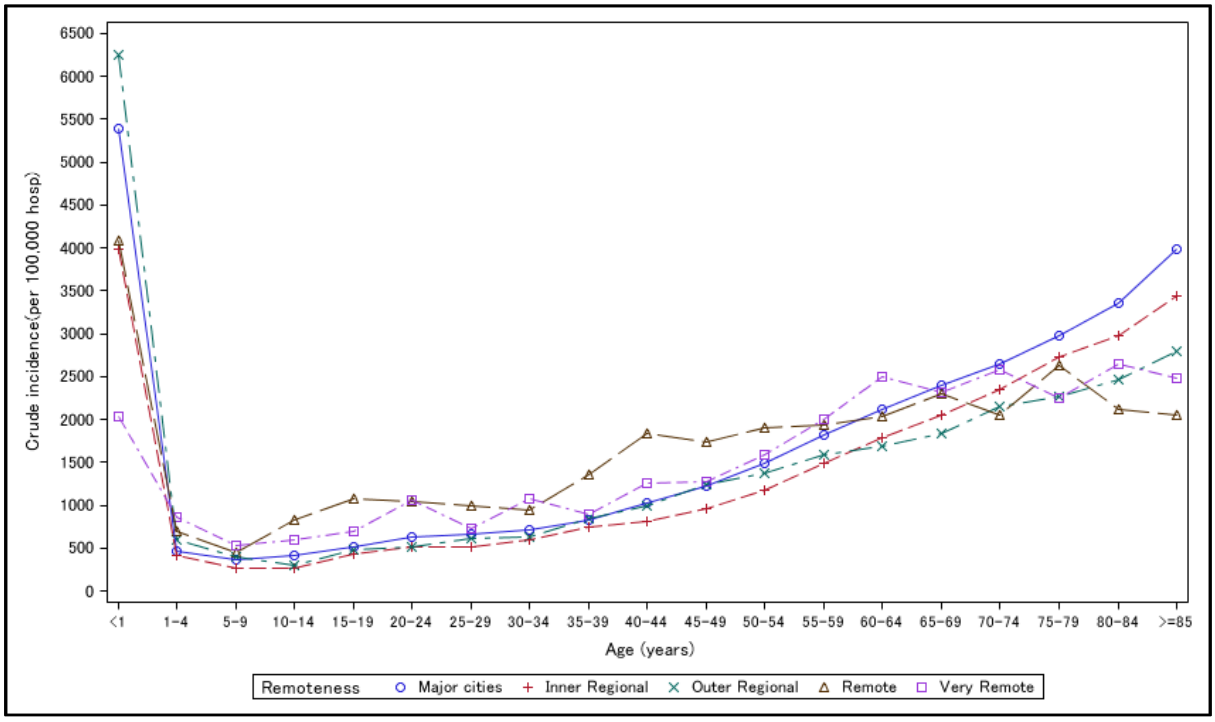


Figure 24: Age specific sepsis incidence by geographical remoteness of hospitals

Sepsis patient outcomes

Overall sepsis mortality rates

A total 305,368 patients died out of all 23,827,061 hospitalisations between 2013-14 and 2017-18. Of 437,354 hospitalisations of patients with sepsis, 52,297 patients died in hospital. In this report, mortality was calculated based on in-hospital deaths. Two types of mortality rates are presented:

- **Case mortality rate** (also referred as **case fatality rate**) is the proportion of *deaths of sepsis patients* within *all sepsis hospitalisations*.
  Crude case mortality was 119.6 per 1000 sepsis hospitalisations, i.e. 52,297 deaths of sepsis patients out of 437,354 patients in hospital with sepsis. Sepsis case mortality was much higher than case mortality for non-sepsis conditions, which was 10.8 per 1000 non-sepsis hospitalisations. Age standardised case mortality was 57.7 per 1000 population, 95% CI: 56.5-58.8.
- **Mortality rate** is the proportion of *deaths of sepsis patients* relative to *all hospitalised patients.*
  Crude hospital sepsis mortality was 219.5 per 100,000 hospitalisations, i.e. 52,297 deaths of sepsis patients out of 23,827,061 hospitalisations. Age standardised mortality was 98.7 deaths per 100,000 population, 95% CI: 97.6-99.7.

Although those in the youngest age group (<1-year-old) experienced the highest number of sepsis hospitalisations, the case mortality was similar to other young patients (≤29 years). Mortality rates of all hospitalisations was still the highest among young patients (*Figure 25* and *Figure 26*). For older patients (≥30 years), both mortality rates increased with age.

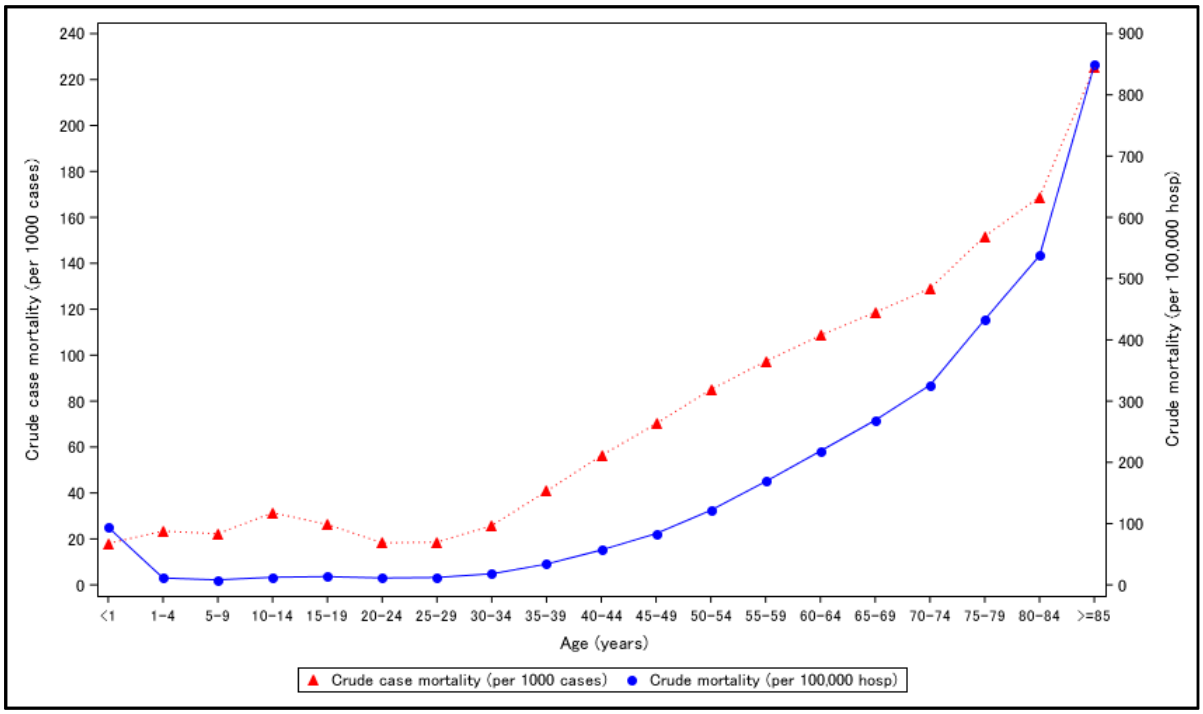


Figure 25: Age specific case mortality and hospital mortality rates

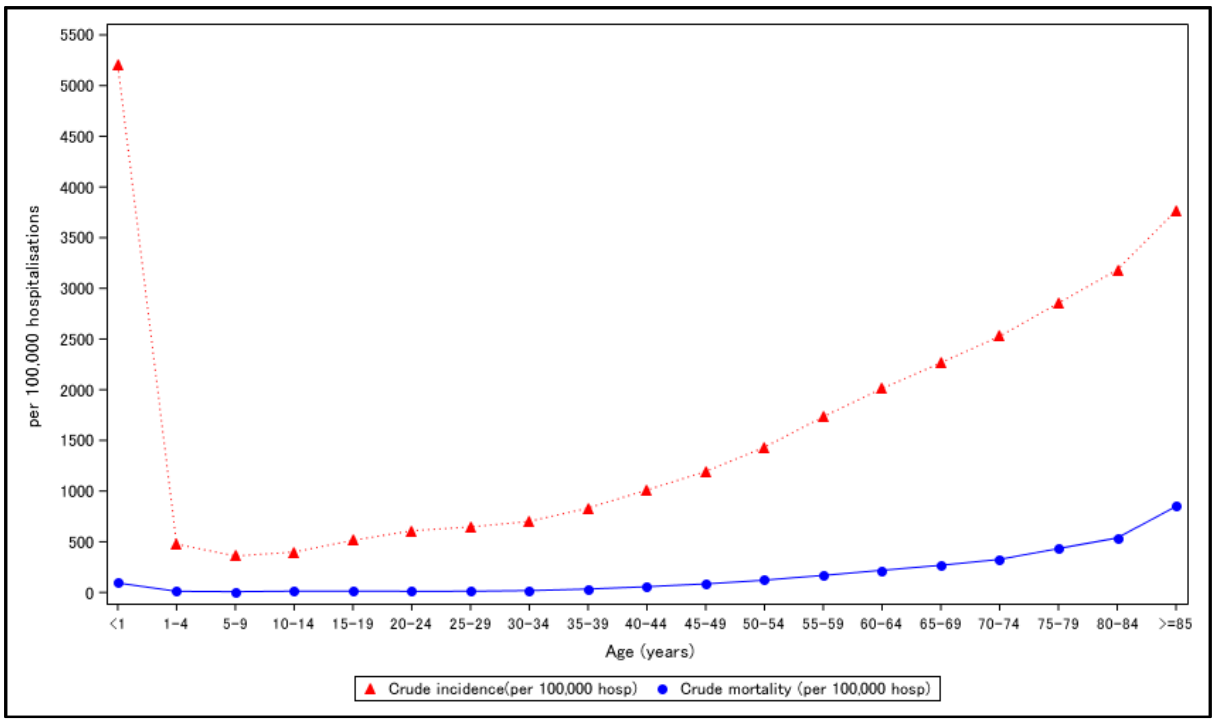


Figure 26: Age specific incidence and morality

Changes in mortality over time

Deaths of sepsis patients increased by 39% from 8,628 in 2013-14 to 11,993 in 2017-18 – an average annual increase of 10% (*Table 6*). During the same time period, overall hospitalisations increased by 17% (an average annual increase of 4%) and hospitalisations with sepsis increased by 59% (an average annual increase of 15%).

Age standardised sepsis case mortality rate (i.e. the proportion of sepsis deaths relative to all sepsis hospitalisations) decreased over time. This can be partly explained by the relatively large increase in the number of sepsis hospitalisations (i.e. the denominator) over the time period, especially after 2015-16. On the other hand, age standardised mortality rates (i.e. the proportion of sepsis deaths out of all hospitalisations) increased. This may also be due to the large increase in the number of sepsis hospitalisations coded, increasing the proportion of hospitalised patients who had sepsis and subsequently die (i.e., the numerator). Although the two mortality rates indicated potentially different trends, both can be largely explained by the overall increase in sepsis hospitalisations coded.

Table 6: Age standardised mortality rates over time

Year	Hospitalisations	Sepsis hospitalisations	Deaths of sepsis patients	Case mortality*	Mortality^
2013-14	4,393,539	66,062	8,628	63.2(60.5 – 65.9)	91.6(89.2 – 94.0)
2014-15	4,531,488	70,383	9,308	65.0(62.2 – 67.9)	94.7(92.2 – 97.1)
2015-16	4,757,601	93,527	10,856	55.1(52.7 – 57.5)	102.1(99.6 – 104.5)
2016-17	4,993,249	102,470	11,512	53.8(51.2 – 56.4)	101.6(99.2 – 104.0)
2017-18	5,151,184	104,912	11,993	55.9(53.3 – 58.5)	102.0(99.7 – 104.4)
Total	**23,827,061**	**437,354**	**52,297**	**57.7(56.5 – 58.8)**	**98.7(97.6 – 99.7)**

* Age standardised case mortality per 1,000 population and ^age standardised mortality per 100,000 population. Their 95% CIs are in brackets.

To interpret the changes in mortality rates over time, other relevant risk factors must be considered. Generalised estimating equations were applied to account for hospital level clustering and to adjust for hospital characteristics (state/territory, availability of 24-hour emergency department [yes/no], and hospital geographical remoteness) and patient case mix (median age, proportion of ICU vs total hospitalisations, average Charlson Comorbidity Index, proportion of males, and proportion of Indigenous people).

Adjusted overall sepsis mortality rates

There was an average annual decrease of 3% in case mortality from 2013-14 to 2017-18, with adjusted sepsis case mortality 61.8 deaths per 1000 sepsis hospitalisations (95% CI: 49.4-77.2) and 53.9 (95% CI: 44.1-65.8), respectively (*Figure 27* and Appendix *Table 10*). The adjusted mortality rates over time were very similar with overlapping confidence intervals.

The adjusted mortality rate of sepsis deaths relative to all hospitalisations increased from 130.4 per 100,000 hospitalisations (95% CI: 110.1 - 154.4) in 2013-14 to 155.1 (95% CI: 130.5 - 184.4) – an average annual increase of 5% (*Figure 27* and Appendix *Table 10*). The sharpest increase of 13% occurred in 2015-16 compared with the previous year. Similar to the changes in case mortality, the rates over time were very similar with overlapping confidence intervals as shown in Figure 27 and Appendix Table 10.

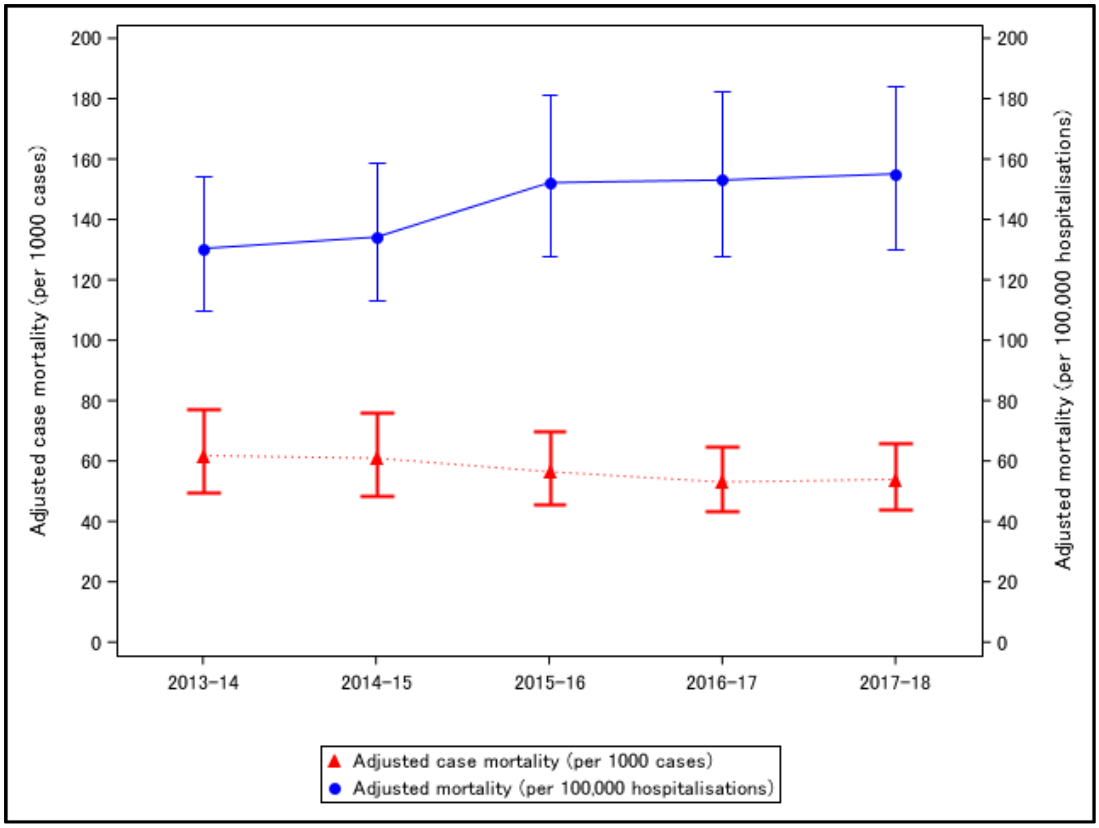


Figure 27: Change over time – adjusted mortality rates (error bars indicate 95% CIs)

Mortality for sepsis patients with organ dysfunction

Of all 163,138 sepsis patient hospitalisations with organ dysfunction also coded, 19.7% died, i.e. 197.0 deaths per 1000 hospitalisations.

After adjusting for patient and hospital risk factors, there was an average annual decrease of 4% in case mortality for these sepsis patients with organ dysfunction from 2013-14 to 2017-18, with adjusted sepsis case mortality 53.5 deaths per 1000 sepsis hospitalisations with an organ dysfunction (95% CI: 39.2 – 73.0) and 45.0 (95% CI: 34.9-58.1), respectively (Figure 28 and Appendix Table 11). The rates over time were very similar with overlapping confidence intervals.

Relative to all hospitalisations, the adjusted mortality rate of sepsis patients with organ dysfunction increased from 45.1 per 100,000 hospitalisations (95% CI: 33.2-61.2) in 2013-14 to 53.3 (95% CI: 38.8-73.1) – an average annual increase of 5% (*Figure 28* and Appendix *Table 11*). The sharpest increase of 12% occurred in 2015-16 compared with the previous year. Similar to the changes in case mortality, the rates over time were very similar with overlapping confidence intervals, as shown in Figure 28 and Appendix Table 11.

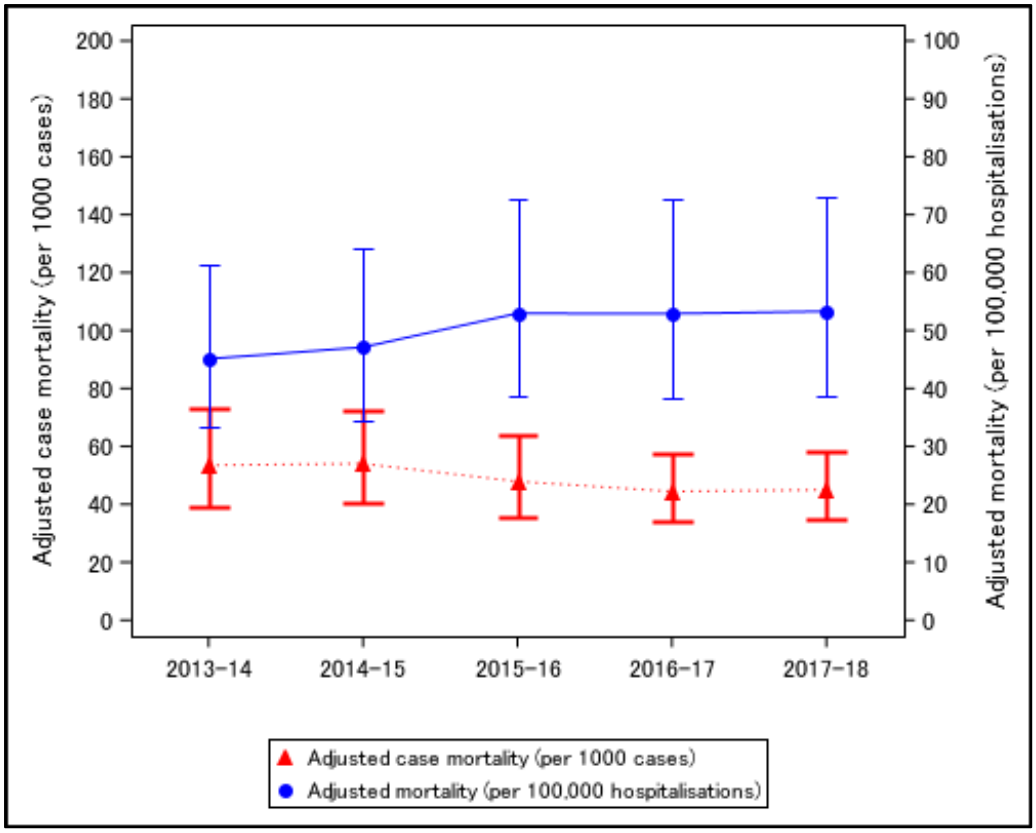


Figure 28: Change over time – adjusted mortality rates for sepsis patients with organ dysfunction (error bars indicate 95% CIs)

Mortality for septic shock patients

Of all 59,011 septic shock patients, 23.9% (n=14,126) died, i.e. 239.4 deaths per 1000 hospitalisations. After adjusting for the patient and hospital risk factors, there was an average annual decrease of 4% in case mortality for these septic shock patients from 2013-14 to 2017-18, with adjusted septic shock case mortality 62.6 deaths per 1000 septic shock hospitalisations (95% CI: 42.9-91.5) and 55.3 (95% CI: 38.6-79.2), respectively (*Figure 29* and Appendix Table 12). The rates over time were very similar with overlapping confidence intervals.

Relative to all hospitalisations, the mortality rate of septic shock patients after adjusting for the patient and hospital risk factors increased from 18.1 per 100,000 hospitalisations (95% CI: 11.7-28.0) in 2013-14 to 20.9 (95% CI: 13.3-32.9) – an average annual increase of 4% (*Figure 29* and Appendix Table 12). The sharpest increase of 9% occurred in 2014-15 compared with the previous year. Similar to the changes in case mortality, the rates over time were very similar with overlapping confidence intervals, as shown in *Figure 29* and Appendix Table 12.

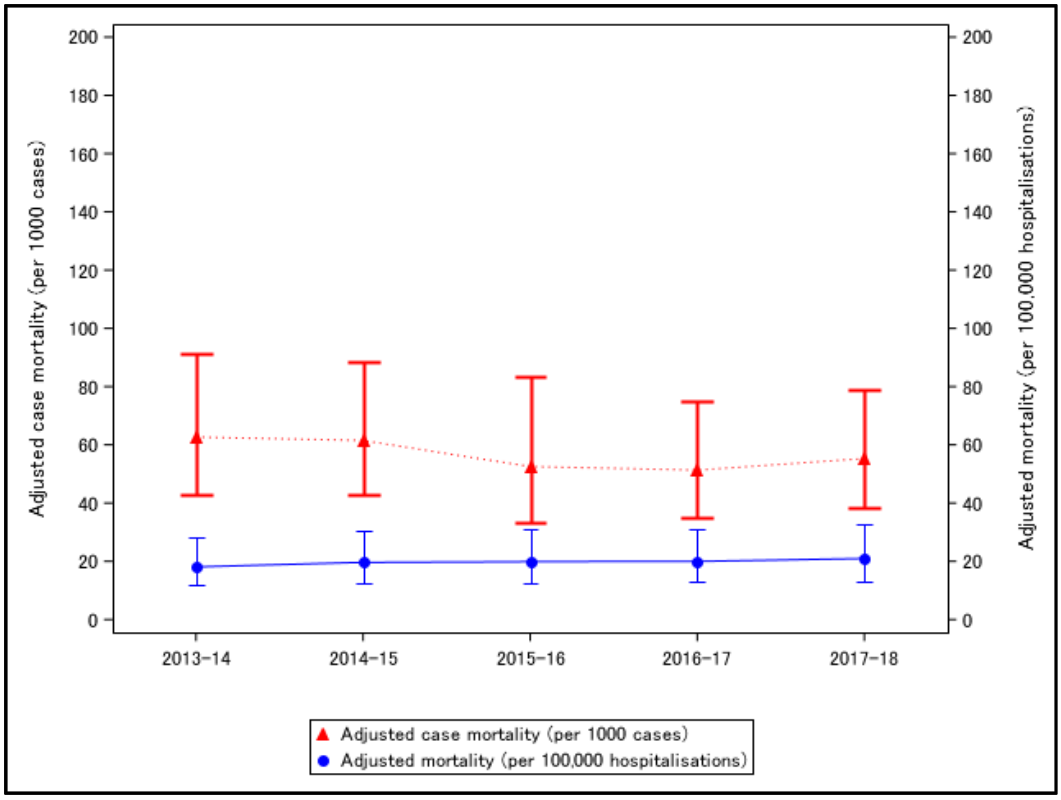


Figure 29: Change over time – adjusted mortality rates for septic shock patients (error bars indicate 95% CIs)

Length of stay (LOS)

ICU LOS

About 22.3% of patients with sepsis were admitted to ICU during their stay while only 2% of patients without sepsis were admitted to ICU during their stay. Median ICU LOS for sepsis patients was double that of non-sepsis patients in ICU- 3.3 days (IQR: 1.6-7.7) vs 1.6 days (IQR: 0.8-3.1) respectively.

The median ICU LOS for non-sepsis patient hospitalisations remained the same over the 2013-14 to 2017-18 period. However, the median ICU LOS for sepsis hospitalisations reduced from 3.5 days (IQR: 1.5-8.3) in 2013-14 to 3.2 days (IQR: 1.5-7.2) in 2017-18 – about an 11% (or 9 hours from 85 hours to 76 hours) reduction in the median and 14% (or 28 hours from 200 hours to 172 hours) in the 75th percentile (*Figure 30*).

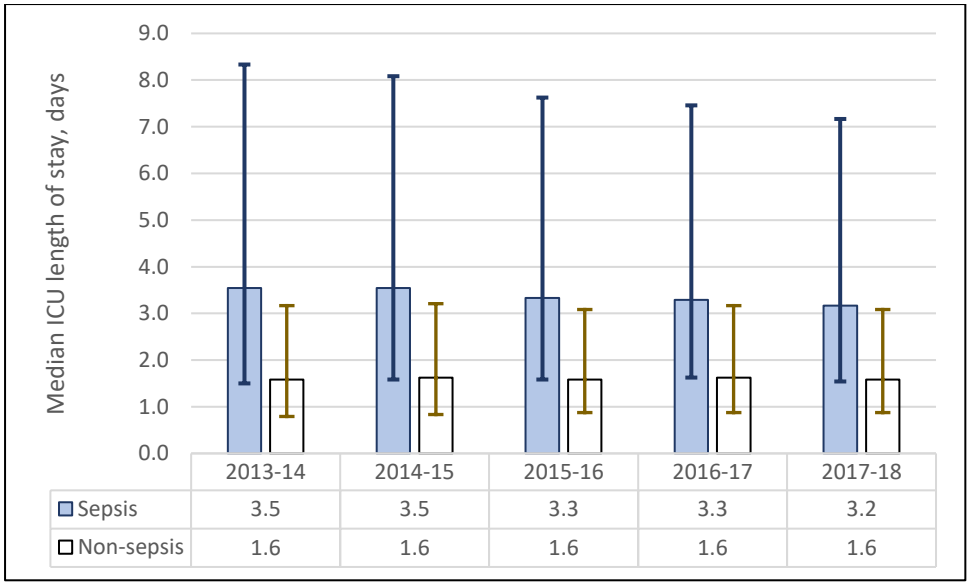


Figure 30: Change over time – median ICU length of stay for sepsis and non-sepsis patients (error bars indicate the 25th and 75th percentiles)

Hospital LOS

Median hospital LOS was 7 days (IQR: 3 - 14) for sepsis hospitalisations, which was seven times as long as the median LOS for non-sepsis hospitalisations, 1 days (IQR: 1-3). In this case, it is possible that patients with longer stay were more likely to develop sepsis.

The median hospital LOS for non-sepsis hospitalisations remained the same from 2013-14 to 2017-18 period. However, the median hospital LOS for non-sepsis hospitalisations reduced from 7 days (IQR: 3-16) in 2013-14 to 6 days in 2017-18 (IQR: 3-13) – about a 14% (or 1 day) reduction in the median and 19% (or 3 days) in the 75th percentile (*Figure 31*).

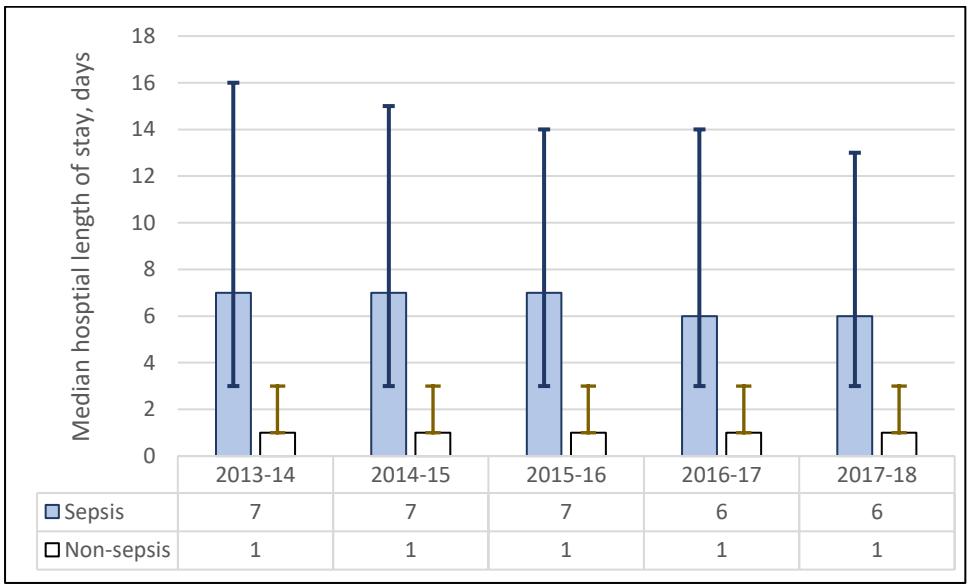


Figure 31: Change over time – median hospital length of stay for sepsis and non-sepsis patients (error bars indicate the 25th and 75th percentiles)

Sepsis related practice and initiatives

Representatives with expertise in sepsis from all Australian states and territories were invited to participated in semi-structured interviews in order to identify contextual factors that may be important in the interpretation of the epidemiological data. Interviews with 10 people were conducted with representatives of various hospitals and health departments from six states and territories. Participants in the consultation interviews came from a variety of clinical and health policy backgrounds, including specialists in Intensive Care, Infectious Disease, Microbiology, Emergency Medicine, and leaders/policy maker in patient safety and quality improvement. The interview guide is available as an Appendix (page 55).

Themes identified from interviews:

- Variability in the presence of sepsis clinical practice guidelines and pathways, sepsis education and promotion campaigns

  The availability of clinical practice guidelines or pathways for sepsis varied between hospitals and health districts. Some jurisdictions had sepsis pathways or clinical guidelines introduced during the period 2013-2018. Education and sepsis pathways tended to be focused on Emergency Departments (ED) in the first instance, given the importance of early recognition and the high proportion of cases that develop outside of hospital. Participants from jurisdictions where sepsis guidelines and pathways were in place thought that in addition to increasing the recognition of potential sepsis patients, this would have increased the coding of sepsis hospitalisations due to increased documentation in patients' medical records.

  In conjunction with the introduction of sepsis guidelines and pathways, many hospitals participated in sepsis awareness and promotion campaigns. Examples of the most prominent sepsis campaigns include:

  - "Sepsis Kills" – NSW Clinical Excellence Commission (CEC), commenced in May 2011; phased implemented in 180 NSW public hospital emergency departments. Inpatient phase commenced in 2014. Some uptake by other jurisdictions also (e.g. ACT, Queensland). http://www.cec.health.nsw.gov.au/patient-safety-programs/adult-patient-safety/sepsis-kills
  - "Think Sepsis, Act Fast" – Better Care Victoria, sepsis pathway developed at Peter MacCallum Cancer Centre in 2013, subsequently adapted and scaled up over 2016-17. https://www.bettercare.vic.gov.au/our-work/innovation-fund/scaling-projects/sepsis-scaling
  - World Sepsis Day – Global Sepsis Alliance, first held 2012. Promoted by some hospitals/health organisations, with some years more heavily promoted than others. https://www.worldsepsisday.org/

  However, in most states/territories, sepsis campaigns were most actively rolled out in the latter part of the time period (around 2017-18) or are currently underway/planned, and would not account for changes seen earlier in the study time period. The CEC's "Between the Flags" initiative for identifying and managing the acutely deteriorating patient, introduced in NSW in 2010 and subsequently adopted in other jurisdictions, was also thought to have improved detection of sepsis patients even though it was not sepsis specific.

  Participants were asked about the presence of electronic health record systems in their jurisdictions during the time period of interest, to identify whether the rollout of systems with clinical decision support may have contributed to increased identification or documentation of sepsis. The electronic capabilities varied widely, with some hospitals still

using paper systems while others had electronic systems with limited decision support features. Although some participants indicated that more sophisticated clinical decision support related to sepsis was currently being designed and tested in some jurisdictions, this was not available during the time period between 2013-14 and 2017-18.

- Steadily increasing awareness and recognition of sepsis as a distinct condition
  Participants commonly asserted that patients with sepsis were increasingly likely over the past 5-10 years to have their illness documented as 'sepsis' rather than 'infection', 'unwell after surgery' or other less-specific terms. In some jurisdictions, this was attributed to increased clinician awareness of sepsis due to campaigns and education programs within hospitals. However, even in jurisdictions without promotional campaigns in the time period (between 2013-2018), participants felt there had been increasing awareness of sepsis as a distinct condition, and of the importance of early recognition. Prominent medical literature about the likely under-reporting of sepsis and the importance of early recognition and treatment over the past decade was thought to have played a role in this increase in clinician awareness. Additionally, more focus and explicit teaching in medical schools on sepsis means that junior doctors have generally good awareness. Given junior doctors are commonly tasked with documentation, some participants suggested that this has increased the likelihood that 'sepsis' is noted in the medical record and will then be coded.

- "Catch up" in under-reporting or under-recognition
  Several participants suggested that the increase in the reported number of hospitalisations of sepsis was a 'catch up' in historical underreporting of sepsis, and was possibly still less than the true incidence. However, others suggested that there may now be some over-coding of patients with 'potential sepsis' as 'sepsis' even though they would not meet the clinical definition – for example patients with infections, and possibly in neonates who may be presumed to have sepsis until proven otherwise. Several participants perceived a mismatch between the ICD-codes for sepsis and the clinical definition, and were not convinced that ICD-codes were accurately capturing the true incidence.

- An increase in clinical cases, in certain populations
  There was general consensus that there has been a steady increase in the population of certain vulnerable patient groups, which may contribute to an increase in the total number of cases. These include the elderly, patients with chronic and complex disease, and immunocompromised patients. Participants felt that increased rates of surgery and other interventions in more vulnerable patients may be contributing to an increase in hospital-acquired and post-operative sepsis. Some participants who work in clinical areas expressed that they saw a generally decreasingly healthy population, with more sedentary lifestyles and increasing chronic disease burden, as a potential explanation for increasing rates of sepsis. However, other participants did not agree that there had been a real increase in clinical cases at all, instead attributing the increase completely to a change in the way sepsis is coded.

  Consistent with published data, participants identified Indigenous patients as experiencing particularly high rates of sepsis and poor outcomes. Neonates were another patient group that was highlighted specifically by participants, as sepsis is a well-recognised and frequently used differential diagnosis for a sick baby.

Discussion

The primary aim of this report was to conduct an epidemiological investigation of sepsis hospitalisations and deaths in Australian public hospitals. The findings are based on information recorded in hospital records, using a defined set of ICD-10-AM codes to identify sepsis cases. Our analyses show that sepsis accounted for many hospitalisations and deaths, and the burden of this condition was not equally distributed across the Australian population. These inequalities are seen in relation to all population characteristics examined, i.e. age, sex, remoteness of residence and socioeconomic disadvantage and Indigenous status.

Temporal variations in sepsis hospitalisations and patient deaths were apparent. These were likely to have been influenced particularly by both changes in sepsis coding and increased clinical awareness. Age standardised sepsis incidence rates, including by sex, principal/additional diagnoses, organ dysfunction, septic shock status, and mortality rates (relative to sepsis cases and all hospitalisations) were investigated to provide a more complete picture of these variations over time. An advanced statistical modelling approach was applied to examine changes in mortality with consideration of the cluster effect of hospitals and important risk factors, such as patients' age, sex and comorbidities etc. In addition, sepsis cases identified using 43 specific sepsis ICD codes were examined separately over the 5-year period.

The burden of sepsis

The median hospital length of stay for sepsis patients was seven times as long as the median LOS for non-sepsis patients (7.0 days vs 1.0 days respectively). Sepsis patients were 11.2 times more likely to have an ICU than non-sepsis patients (22.3% compared with 2.0% respectively). Their median ICU length of stay was double that of non-sepsis patients (3.3 days vs 1.6 days, respectively). Nearly half of all sepsis patients had a comorbidity recorded, with more than a quarter having a Charlson Comorbidity Index ≥3, indicating these patients had poor clinical prognoses. Nearly one tenth of sepsis patients required ventilation with a median duration of ventilatory support of 97 hours (more than 4 days). Overall, 12.0% of sepsis patients died in hospital, which was 10.9 times higher than non-sepsis patients (1.1%).

The youngest patients (<1-year-old) experienced the highest number and incident of sepsis. For older groups, sepsis cases and incidence rate rose with age. Age standardised incidence for males was 19% higher than for females. The differences in age standardised incidence rates between males and females remained similar from 2013-14 to 2017-18.

After age standardisation, those living in very remote areas were hospitalised for sepsis at around 1.7 times the rate as those living in major cities. This may be partly explained by the high age standardised sepsis incidence rate among Indigenous people, where rates were 1.7 times higher than among other Australians. Age standardised sepsis incidence was 1.2 times higher for those living in the lowest socioeconomic areas compared with the highest socioeconomic areas.

Variation in incidence and mortality over time

Between 2013-14 and 2017-18, age standardised sepsis incidence increased by 27% - an average annual increase of 7%. Two mortality rates, i.e. case mortality relative to sepsis cases and hospital mortality relative to hospitalisations, were reported in this report to reflect the changes in deaths relative to increases in sepsis cases and overall hospitalisations, respectively, between 2013-14 and 2017-18. These two different mortality rates indicated potentially different trends. Case mortality rates relative to sepsis cases decreased over this time period while mortality rate relative to overall hospitalisations increased. These trends can be in part explained by the relatively high increase in coded sepsis cases over this time period. However, other important risk factors and the cluster

effect of hospitals should be considered to correctly interpret the changes in mortality rates observed. Despite the large increase in sepsis incidence, sepsis mortality rates remained relatively stable over the study period after adjusting for relevant risk factors and hospital clustering. The death rates for sepsis patients with organ dysfunction and septic shock patients also remained relatively stable over this period. The reported increased incidence of sepsis, in the context of static mortality rates for the same period, reflects improved reporting and changes to coding guidance made during this period, and not an increase in sepsis. Prior to 2015-16, when changes in coding rules were promulgated together with awareness campaigns, sepsis was being underreported.

The use of the seven most frequently applied sepsis ICD codes, covering 96% of all sepsis cases, were examined. Sepsis cases recorded under each of these seven codes increased by between 24% and 114% since 2013-2014. In particular, there was a 114% increase between 2013-14 and 2017-18 in the most common sepsis code, i.e. A419 (Sepsis, unspecified) constituting 53% of all sepsis cases. This huge increase in A419 coded sepsis accounted for 83% of the increase in all sepsis cases over this time period. It is worth noting that the sharpest increase of all sepsis cases occurred in 2015-16, and this was mainly due to the increase in A419 coded sepsis.

Septic shock, a severe sepsis condition, was the second most frequently used sepsis code. It had a very different annual increase pattern from all other sepsis codes. Age standardised incidence for septic shock increased by 19% with a relatively steady increase every year between 2013-14 and 2017-18. In contrast, there was a 28% increase in all other sepsis codes, with the sharpest annual increase of 27% occurred in 2015-16 compared to a +/- 2% change in all the other years.

Reductions in both ICU length of stay and overall hospital stay for patients with sepsis were observed between 2013-14 and 2017-18, while ICU length of stay and overall hospital stay were unchanged for non-sepsis patients over the same period. Further investigation may be warranted to better understand the factors contributing to these reductions, e.g., better recognition and/or early treatment of sepsis patients.

Variation in practice and health initiatives

Several variations in sepsis policy and practice were identified both between jurisdictions, and within jurisdictions over time. Around the period of 2013-14 and 2017-18, there were multiple prominent sepsis awareness campaigns (especially “Sepsis Kills” in NSW and “Think Sepsis, Act Fast” in Victoria), the introduction of sepsis pathways and other localised initiatives aimed at improving the early recognition, diagnosis and treatment of sepsis patients in some, but not in all jurisdictions. These campaigns, along with general attention on sepsis in the medical literature and medical education, may have contributed to improved recognition, documentation and subsequently increased coding of sepsis over the time period. Although the availability of electronic record systems was variable across different hospitals, some jurisdictions are currently designing and testing more sophisticated decision support systems to improve early recognition and treatment of sepsis.

Interpretation of findings and way forward

Administrative health data are widely collected, and are a generally cost-effective way of studying multiple outcomes, health service usage and resource allocation in large populations (21). The findings were based on the information recorded in hospital records and sepsis cases were identified using a defined set of ICD-10-AM codes. However, this may not fully capture all cases of sepsis in Australia. A recent systematic review concluded that sepsis cases were under-recognised or under recorded in administrative data (16).

The overall increase in sepsis hospitalisations between 2013-14 and 2017-18 can be largely explained by the increase in a small number of ICD-10-AM codes, especially the code A419. The

sharp increase in this code in a 2015-16 suggests a change in coding practice at around this time, rather than a true increase in sepsis epidemiology. However, the steadier increase in the incidence of other sepsis codes, such as septic shock (R572), may be explained by improved clinician awareness of sepsis and/or documentation of sepsis in patients' medical records, increased vigilance by coding staff, or an increasing number of clinical presentations of sepsis.

Further investigation of sepsis coding practices may assist in understanding reasons for the increases observed. Chart review could be a useful first step to cross validate the accuracy of sepsis coded in the administrative data. Another option would be the design of developing automatic algorithms to detect sepsis cases. As electronic medical record systems have been rolled out in many Australian hospitals, rich dynamic clinical data routinely collected from these systems, including patients' vital signs and laboratory testing results etc., provide a unique opportunity to conduct sepsis surveillance using embedded electronic algorithms. This presents a new, highly efficient method for monitoring this important clinical condition. Preliminary results suggest that this is a highly feasible option (22, 23).

Our findings provide the basis for further investigation to determine the causes of sepsis burden on healthcare systems, e.g. longer stay patients may be more likely to develop sepsis and to be admitted to ICU. As the coding quality on the condition onset flag improves, it would be beneficial to investigate sepsis as a hospital acquired complication. The Australian Commission on Safety and Quality in Health Care and the Independent Hospital Pricing Authority established a Joint Working Party in 2012 to consider potential approaches to pricing for safety and quality in public hospital services in Australia. The Joint Working Party initiated a clinician-driven process and developed a national list of high-priority hospital acquired complications (24). The implantation of this list may have also contributed to improved sepsis recognition and diagnosis.

The findings highlight the inequalities in sepsis incidence by age, sex, remoteness of residence and socioeconomic disadvantage and Indigenous status. These at-risk groups should be the target for interventions to reduce sepsis hospitalisations and increased clinical guidance for early recognition and treatment. However, our results cannot explain why these inequalities exist or how these factors interact to influence inequality. Further exploration and analysis of the social determinants of health are required to assist in understanding these relationships.

All-cause in-hospital-mortality was used in this report as a patient's cause of death was unavailable in the Admitted Patient Care National Minimum Data Set used in this study. Data linkage, e.g. with National Mortality Database, could be conducted to better understand the cause of deaths of patients with sepsis diagnoses.

Data records of multiple hospitalisations from the same person could not be linked at the national level. Therefore, it is not possible to count the number of individuals being hospitalised nationally and their patterns of hospitalisations, e.g. readmissions and hospital transfers.

Patient outcomes of sepsis patients, such as mortality and length of stay in ICU and hospital, were examined in this report. The financial cost and burden of sepsis on individuals, the community, and the health system should be explored. In particular, the short- and long-term impact of sepsis on sepsis survivors and how to best support them and their families.

Conclusion

This is the first national report on hospitalisations and in-hospital deaths associated with sepsis in all Australian public hospitals. It gives an epidemiological and statistical reference for policy makers, service providers, planners, clinicians and researchers. Despite an increase in awareness and clinical

initiatives related to sepsis, it remains a growing health problem that affects certain groups in the population more than others. Ongoing monitoring, taking advantage of the new capabilities that electronic health record data present, will be critical to build our understanding of this important condition and to develop and implement effective interventions.

Appendix: Data and additional results

Data source and exclusions

The data used in this report were extracted from the Admitted Patient Care National Minimum Data Set (APC NMDS; (17)), which includes information on demographic characteristics, administrative and length of stay data, as well as data on the diagnoses of the patients and the procedures they underwent in hospital. It included all hospitalisations in all public hospitals in Australia from 2013/14- 2017/18 (financial year). Hospitalisations/separations were excluded if 1) Information for calculating patient age were unavailable (n=523), 2) the diagnosis related group (DRG) of hospitalisation was dialysis or chemotherapy, and 3) care type was recorded as organ procurement or hospital boarder.

Sepsis coding over time

Sepsis hospitalisations were identified using International Statistical Classification of Disease and Related Conditions, 10th Revision, Australian Modification (ICD-10-AM) codes (*Table 7*).

Table 7: Number of sepsis hospitalisations and incidence by 43 ICD-10-AM codes overtime

Note: Sepsis codes are in the descending order of total number of sepsis hospitalisations identified by each code. Sepsis hospitalisation rates are presented as number sepsis hospitalisations per 100,000 hospitalisations. ^Difference and change were calculated based on the number of sepsis hospitalisations in 2013-14 and 2017-18 (negative values indicating decreases in sepsis case from 2013-14 to 2017-18). Note: Cells shaded with light orange colour indicate an annual increase of ≥10% in sepsis hospitalisations; those shaded with light orange colour and in bold indicate an increase of ≥ 20%. Cells shaded with light grey colour indicate an annual decrease of ≥10% in sepsis hospitalisations, those shaded with light grey colour and in bold indicate a decrease of ≥ 20%.)

Financial Year (ICD edition)		**2013 -14 (8th)**	**2014-15 (8th)**	**2015-16 (9th)**	**2016-17 (9th)**	**2017-18 (10th)**	**Total**	**Difference^**	**Change^, %**
Total number of admissions		4,393,539	4,531,488	4,757,601	4,993,249	5,151,184	23,827,061		
Sepsis, unspecified (A419)	N	28,330	31,032	**53,885**	58,979	60,531	232,757	32,201	114%
	Rate	644.8	684.8	**1,132.6**	1,181.2	1,175.1	976.9		
Septic shock (R572)	N	9,509	10,790	12,072	12,902	13,738	59,011	4,229	44%
	Rate	216.4	238.1	253.7	258.4	266.7	247.7		
Sepsis due to Escherichia coli [E. Coli] (A4151)	N	7,365	7,883	**9,673**	10,619	10,842	46,382	3,477	47%
	Rate	167.6	174.0	**203.3**	212.7	210.5	194.7		
Bacterial sepsis of newborn, unspecified (P369)	N	4,544	5,172	5,734	6,846	7,207	29,503	2,663	59%
	Rate	103.4	114.1	120.5	137.1	139.9	123.8		
Sepsis due to Staphylococcus aureus (A410)	N	4,244	4,246	5,050	5,443	5,272	24,255	1,028	24%
	Rate	96.6	93.7	106.2	109.0	102.4	101.8		
Other specified sepsis (A418)	N	2,592	2,759	**3,642**	4,042	4,156	17,191	1,564	60%
	Rate	59.0	60.9	**76.6**	81.0	80.7	72.2		
Sepsis due to other Gram-negative organisms (A4158)	N	1,549	1,656	**2,187**	2,602	2,665	10,659	1,116	72%
	Rate	35.3	36.5	**46.0**	52.1	51.7	44.7		
Puerperal sepsis (O85)	N	2,032	1,856	2,122	2,192	2,163	10,365	131	6%
	Rate	46.3	41.0	44.6	43.9	42.0	43.5		
Sepsis due to streptococcus, group D (A402)	N	1,665	1,714	**2,117**	2,278	2,298	10,072	633	38%
	Rate	37.9	37.8	**44.5**	45.6	44.6	42.3		
Sepsis due to other specified staphylococcus (A411)	N	1,846	1,796	2,143	2,071	2,172	10,028	326	18%
	Rate	42.0	39.6	45.0	41.5	42.2	42.1		

Financial Year (ICD edition)		2013 -14 (8th)	2014-15 (8th)	2015-16 (9th)	2016-17 (9th)	2017-18 (10th)	Total	Difference^	Change^, %
Sepsis due to Pseudomonas (A4152)	N	1,312	1,343	**1,847**	1,877	1,961	8,340	649	49%
	Rate	29.9	29.6	**38.8**	37.6	38.1	35.0		
Severe sepsis (R651)	N	2,365	2,283	**1,330**	1,083	942	8,003	-1,423	-60%
	Rate	53.8	50.4	**28.0**	21.7	18.3	33.6		
Other streptococcal sepsis (A408)	N	1,315	1,338	1,585	1,837	1,918	7,993	603	46%
	Rate	29.9	29.5	33.3	36.8	37.2	33.6		
Systemic inflammatory response syndrome [SIRS] of infectious origin without acute organ failure (R650)	N	2,625	2,694	**5**	**1**	**0**	5,325	-2,625	-100%
	Rate	59.8	59.5	**0.1**	**0.0**	**0.0**	22.4		
Sepsis due to Streptococcus pneumoniae (A403)	N	611	600	717	842	938	3,708	327	54%
	Rate	13.9	13.2	15.1	16.9	18.2	15.6		
Sepsis due to streptococcus, group A (A400)	N	553	537	613	**772**	**937**	3,412	384	69%
	Rate	12.6	11.9	12.9	**15.5**	**18.2**	14.3		
Sepsis due to streptococcus, group B (A401)	N	475	**574**	685	764	780	3,278	305	64%
	Rate	10.8	**12.7**	14.4	15.3	15.1	13.8		
Candidal sepsis (B377)	N	448	532	587	653	693	2,913	245	55%
	Rate	10.2	11.7	12.3	13.1	13.5	12.2		
Sepsis due to unspecified Gram-negative organisms (A4150)	N	552	456	539	543	576	2,666	24	4%
	Rate	12.6	10.1	11.3	10.9	11.2	11.2		
Sepsis due to anaerobes (A414)	N	179	202	**304**	317	**394**	1,396	215	120%
	Rate	4.1	4.5	**6.4**	6.4	**7.7**	5.9		
Sepsis of newborn due to other and unspecified staphylococci (P363)	N	290	280	246	253	215	1,284	-75	-26%
	Rate	6.6	6.2	5.2	5.1	4.2	5.4		
Other bacterial sepsis of newborn (P368)	N	222	224	245	244	**307**	1,242	85	38%
	Rate	5.1	4.9	5.2	4.9	**6.0**	5.2		
Sepsis due to unspecified staphylococcus (A412)	N	257	238	270	235	235	1,235	-22	-9%
	Rate	5.9	5.3	5.7	4.7	4.6	5.2		
Salmonella sepsis (A021)	N	198	202	233	263	223	1,119	25	13%

Financial Year (ICD edition)		2013 -14 (8th)	2014-15 (8th)	2015-16 (9th)	2016-17 (9th)	2017-18 (10th)	Total	Difference^	Change^, %
	Rate	4.5	4.5	4.9	5.3	4.3	4.7		
Streptococcal sepsis, unspecified (A409)	N	174	174	193	199	206	946	32	18%
	Rate	4.0	3.8	4.1	4.0	4.0	4.0		
Sepsis of newborn due to streptococcus, group B (P360)	N	130	154	**198**	163	**197**	842	67	52%
	Rate	3.0	3.4	**4.2**	3.3	**3.8**	3.5		
Sepsis due to Haemophilus influenzae (A413)	N	93	**127**	**158**	173	**136**	687	43	46%
	Rate	2.1	**2.8**	**3.3**	3.5	**2.6**	2.9		
Sepsis of newborn due to Escherichia coli (P364)	N	90	**119**	111	**140**	157	617	67	74%
	Rate	2.1	**2.6**	2.3	**2.8**	3.1	2.6		
Acute and fulminating melioidosis (A241)	N	89	**125**	112	**137**	**89**	552	0	0%
	Rate	2.0	**2.8**	2.4	**2.7**	**1.7**	2.3		
Sepsis of newborn due to other and unspecified streptococci (P361)	N	85	76	82	91	78	412	-7	-8%
	Rate	1.9	1.7	1.7	1.8	1.5	1.7		
Sepsis of newborn due to Staphylococcus aureus (P362)	N	79	73	74	78	72	376	-7	-9%
	Rate	1.8	1.6	1.6	1.6	1.4	1.6		
Disseminated herpesviral disease, herpesviral sepsis (B007)	N	25	**34**	28	**40**	**26**	153	1	4%
	Rate	0.6	**0.8**	0.6	**0.8**	**0.5**	0.6		
Listerial sepsis (A327)	N	33	30	27	31	30	151	-3	-9%
	Rate	0.8	0.7	0.6	0.6	0.6	0.6		
Actinomycotic sepsis (A427)	N	9	**7**	**17**	**13**	15	61	6	67%
	Rate	0.2	**0.2**	**0.4**	**0.3**	0.3	0.3		
Obstetric pyaemic and septic embolism (O883)	N	3	**2**	**4**	**2**	2	13	-1	-33%
	Rate	0.1	**0.0**	**0.1**	**0.0**	0.0	0.1		
Sepsis of newborn due to anaerobes (P365)	N	1	**2**	**3**	**4**	**3**	13	2	200%
	Rate	0.0	**0.0**	**0.1**	**0.1**	**0.1**	0.1		
Erysipelothrix sepsis (A267)	N	4	**1**	1	**2**	**3**	11	-1	-25%
	Rate	0.1	**0.0**	0.0	**0.0**	**0.1**	0.1		
Anthrax sepsis (A227)	N	1	0	0	0	1	2		

Financial Year (ICD edition)		2013 -14 (8th)	2014-15 (8th)	2015-16 (9th)	2016-17 (9th)	2017-18 (10th)	Total	Difference^	Change^, %
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		
Septicaemic plague (A207)	N	0	0	0	1	0	1		
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		
Streptococcal sepsis (A40)	N	0	0	0	0	0	0		
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		
Other sepsis (A41)	N	0	0	0	0	0	0		
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		
Sepsis due to other Gram-negative organisms (A415)	N	0	0	0	0	0	0		
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		
Bacterial sepsis of newborn (P36)	N	0	0	0	0	0	0		
	Rate	0.0	0.0	0.0	0.0	0.0	0.0		

Population group

Table 8: Sepsis hospitalisations and age standardised incidence rates by selected population characteristics

Patient characteristics	Number of sepsis hospitalisations (%)	Incidence*, per 100,000pop (95% CI)
Remoteness		
Major cities	285,167 (65.2%)	1,157.8(1,152.4 – 1,163.3)
Inner Regional	92,293 (21.1%)	1,113.7(1,104.1 – 1,123.2)
Outer Regional	43,058 (9.8%)	1,105.1(1,091.5 – 1,118.6)
Remote	6,276 (1.4%)	1,300.7(1,264.7 – 1,336.6)
Very Remote	7,557 (1.7%)	1,995.1(1,947.3 – 2,042.9)
Socioeconomic group^ (SES)		
Group 1 (lowest SES)	105,768 (24.2%)	1,297.3(1,287.2 – 1,307.3)
Group 2	89,569 (20.5%)	1,162.7(1,152.7 – 1,172.7)
Group 3	91,809 (21.0%)	1,149.1(1,139.7 – 1,158.5)
Group 4	74,932 (17.1%)	1,095.4(1,085.5 – 1,105.2)
Group 5 (highest SES)	72,235 (16.5%)	1,062.4(1,052.4 – 1,072.4)
Aboriginal and Torres Strait Islander (ATSI) status		
Indigenous	23,621 (5.4%)	1,878.4(1,852.5 – 1,904.3)
Other Australians#	413,733 (94.6%)	1,119.5(1,115.0 – 1,123.9)

*Age standardised incidence ^ the Socioeconomic Index for Areas (SEIFA) Index of Relative Socioeconomic Disadvantage (IRSD) is used. Five SES groups with roughly equal populations (each around 20% of the total) based on the level of disadvantage of the statistical local area of their usual residence. #Other Australians includes people who did not identify as being of ATSI origin, and people for whom information on their Indigenous status was not available.

Hospital characteristics

Table 9: Sepsis hospitalisations and age standardised incidence rates by selected hospital characteristics

Hospital characteristics	Number of sepsis hospitalisations (%)	Incidence*, per 100,000pop (95% CI)
State/territory (hospital)		
NSW	150,796 (34.5%)	1,267.9(1,259.3 – 1,276.5)
VIC	122,377 (28.0%)	1,206.3(1,197.7 – 1,214.9)
QLD	80,783 (18.5%)	1,077.5(1,068.4 – 1,086.6)
WA	35,820 (8.2%)	1,174.7(1,159.8 – 1,189.6)
SA	21,422 (4.9%)	748.1(735.1 – 761.1)
TAS	9,701 (2.2%)	1,158.4(1,128.5 – 1,188.2)
ACT	8,713 (2.0%)	1,259.4(1,227.3 – 1,291.4)
NT	7,742 (1.8%)	1,805.5(1,761.8 – 1,849.2)
Remoteness (hospital)		
Major cities	319,095 (73.0%)	1,207.2(1,201.9 – 1,212.5)
Inner Regional	78,046 (17.8%)	998.0(988.4 – 1,007.5)
Outer Regional	32,100 (7.3%)	1,073.8(1,058.8 – 1,088.8)
Remote	6,300 (1.4%)	1,431.4(1,392.5 – 1,470.3)
Very Remote	1,813 (0.4%)	1,282.5(1,219.4 – 1,345.6)

*Age standardised incidence

Mortality

Age standardised rate over time

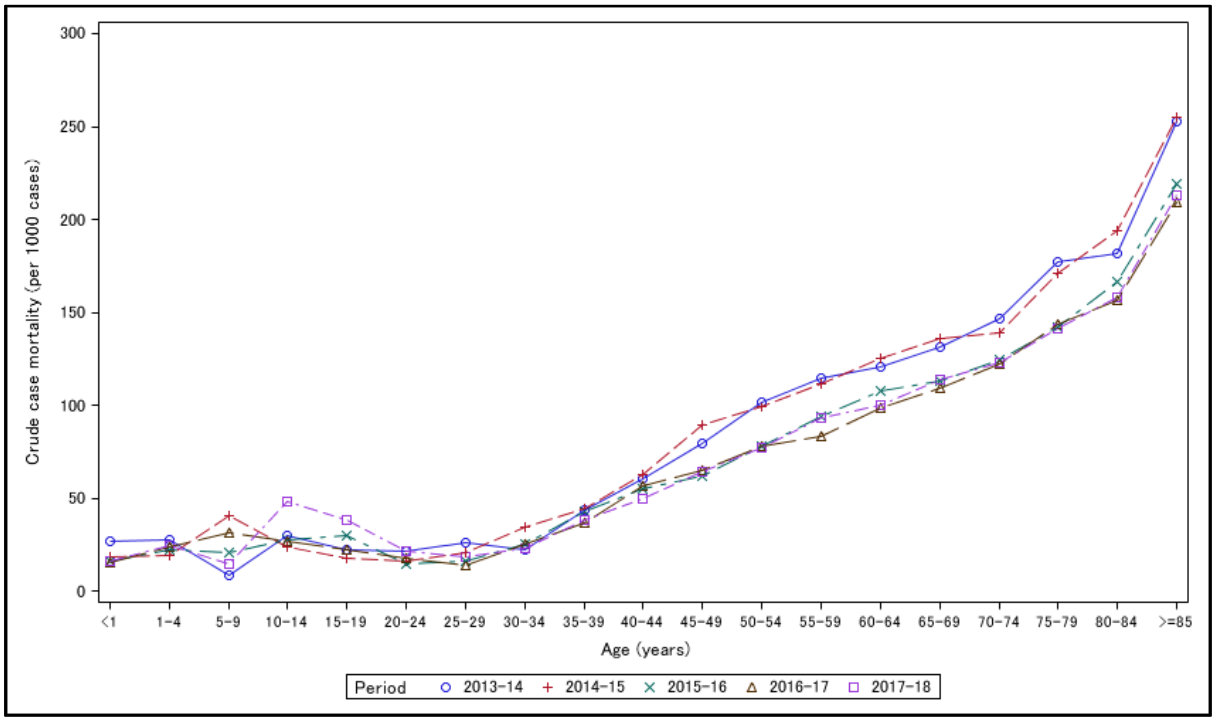


Figure 32: Age specific case mortality over time

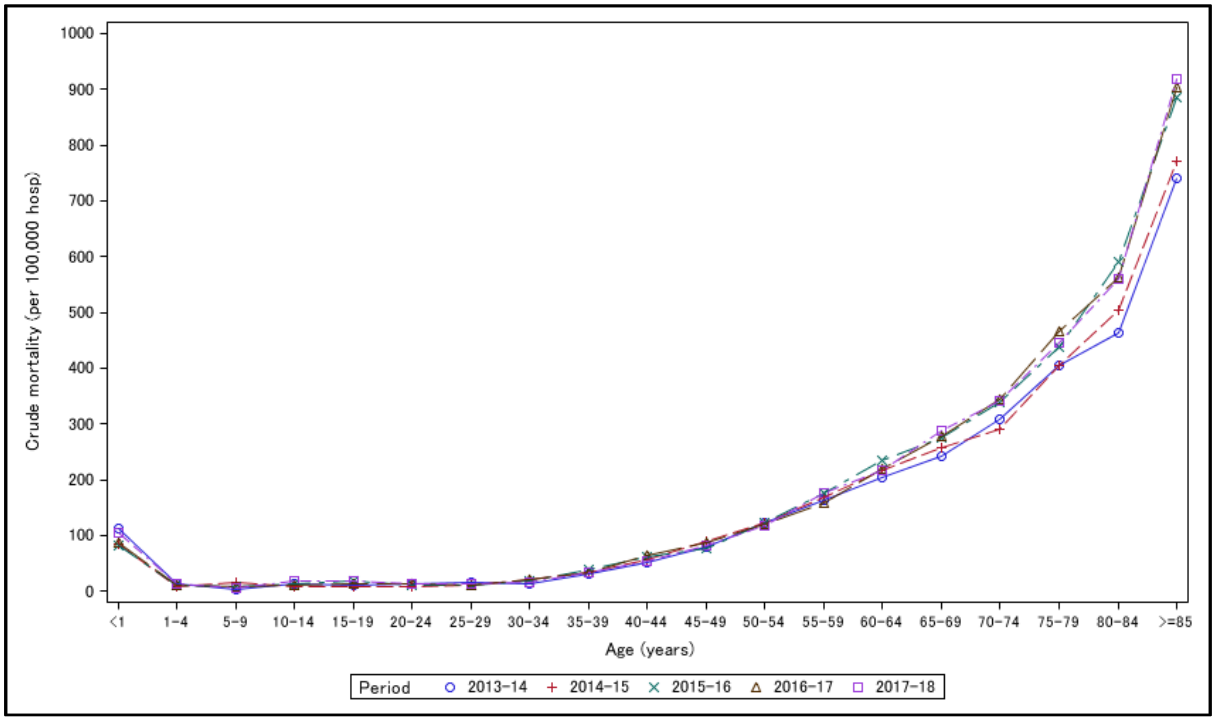


Figure 33: Age specific mortality over time

Adjusted rates for all sepsis hospitalisations over time

Table 10: Adjusted rates over time

Year	Case mortality, per 1,000 sepsis hospitalisations (95% CI)	Mortality, per 100,000 hospitalisations (95% CI)
2013-14	61.8 (49.4 - 77.2)	130.4 (110.1 - 154.4)
2014-15	60.9 (48.7 - 76.2)	134.1 (113.2 - 158.9)
2015-16	56.5 (45.7 - 69.7)	152.2 (127.8 - 181.2)
2016-17	53.0 (43.4 - 64.8)	153.1 (128.2 - 182.8)
2017-18	53.9 (44.1 - 65.8)	155.1 (130.5 - 184.4)

Adjusted rates for sepsis hospitalisations with an organ dysfunction over time

Table 11: Adjusted rates for sepsis hospitalisations with an organ dysfunction

Year	Case mortality, per 1,000 sepsis hospitalisations (95% CI)	Mortality, per 100,000 hospitalisations (95% CI)
2013-14	53.5 (39.2 - 73.0)	45.1 (33.2 - 61.2)
2014-15	54.0 (40.5 - 72.1)	47.1 (34.6 - 64.1)
2015-16	47.9 (35.9 - 64.0)	53.0 (38.6 - 72.6)
2016-17	44.5 (34.3 - 57.7)	52.9 (38.5 - 72.9)
2017-18	45.0 (34.9 - 58.1)	53.3 (38.8 - 73.1)

Adjusted rates for septic shock patients

Table 12: Adjusted rates for septic shock hospitalisations

Year	Case mortality, per 1,000 sepsis hospitalisations (95% CI)	Mortality, per 100,000 hospitalisations (95% CI)
2013-14	62.6 (42.9 - 91.5)	18.1 (11.7 – 28.0)
2014-15	61.5 (42.7 - 88.5)	19.6 (12.7 - 30.3)
2015-16	52.5 (33.1 - 83.5)	19.9 (12.7 - 31.1)
2016-17	51.3 (35.2 - 74.8)	20.0 (12.8 - 31.2)
2017-18	55.3 (38.6 - 79.2)	20.9 (13.3 - 32.9)

Guide for interviews on sepsis related practice and health initiatives

Proposed topic areas (as relevant)

1) Health promotion and sepsis awareness at hospitals
    a. Campaigns
    b. Promotional materials
    c. Education programmes
2) Clinical hospital practice and guidelines
    a. Any clinical process/guidelines for sepsis on
        i. early recognition
        ii. diagnosis
        iii. treatment
        iv. documentation, medical record keeping (e.g. paper/electronic)
    b. Any clinician training programs, online modules
3) Hospital administrative practice
    a. Coding process and practice
    b. Training
    c. Management involvement
    d. Financial implications (incentives or disincentives) related to sepsis
4) Any other sepsis-related health initiatives in the community
    a. Patients/consumers
    b. Health professionals, especially GP

Questions for each topic area (as relevant):

- What? – any specific initiatives, policies, guidelines, financial incentives, etc.
- When? – particularly any changes over the time, especially before/after July 2015
- Who? – any specifically targeted clinical or patients/consumer groups (e.g. neonates/infants, ICU clinicians, etc)
- What were the outcomes? – e.g. increased number of referrals, increased documentation in medical records
- Any other plans – past, present and future?

If any specific sepsis-related health policy documents are provided by the jurisdictions or by the Commission before the interviews, some related questions may be asked in the interviews.

Abbreviations

APC NMDS	**Admitted Patient Care National Minimum Data Set**
ATSI	Aboriginal and Torres Strait Islander
CCI	Charlson Comorbidity Index
CEC	Clinical Excellence Commission
CHADx	Classification of Hospital Acquired Diagnoses
CI	Confidence interval
ED	Emergency department
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, 10th revision, Australian modification
ICU	Intensive care unit
IQR	Inter-quartile range
LOS	Length of stay
SD	Standard deviation
SES	Socioeconomic status

Glossary

Acute care	**Care provided to patients admitted to hospital that is intended to cure illness, alleviate symptoms of illness or manage. Error! Hyperlink reference not valid.** **https://meteor.aihw.gov.au/content/index.phtml/itemId/584408**
Age standardisation	Age standardisation is used to enhance the comparability of data from different populations by adjusting for the confounding effects of compositional differences in age structure between the populations or sub-populations being compared (25). Direct age standardisation method was used to standardise to the 2001 Australian Standard Population. Rates in the report are expressed per 100,000 population.
Hospital^	All public acute and psychiatric hospitals, freestanding day hospital facilities, and alcohol and drug treatment centres. Includes hospitals specialising in dentistry, ophthalmology, and other acute medical or surgical care. May also include hospitals run by the Australian Defence Force and correctional authorities, and those in Australia's offshore territories. Excludes outpatient clinics and emergency departments.
Hospitalisation^	An episode of admitted patient care, which can be a total hospital stay (from admission to discharge, transfer or death), or a portion of a hospital stay beginning or ending in a change in type of care (for example, from acute care to rehabilitation).
Peer group	Public hospital peer groups are defined by Australian Institute of Health and Welfare, see https://www.aihw.gov.au/reports/hospitals/australian-hospital-peer-groups/contents/table-of-contents. Please note that peer groups: Principal referral, Public acute group A, and Public acute group B, have 24-hour emergency departments.
Population	Estimated Resident Population (ERP) in Australia. The ERP for each year has been used as the denominator in time series analyses. https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3101.0Explanatory%20Notes1Mar%202019?OpenDocument
Principal diagnosis	The diagnosis established after study to be chiefly responsible for occasioning an episode of admitted patient care, an episode of residential care or an attendance at the health care establishment, as represented by a code. https://meteor.aihw.gov.au/content/index.phtml/itemId/680976 Please note that 1) qualified newborns can have the principal diagnosis of sepsis, but this would be treated and coded as hospital-acquired; 2) sepsis could be recorded as the principal diagnosis for patients transferred from rural and/or small facilities.

Remoteness categories^	Categories of geographical remoteness are based on the ABS Australian Statistical Geography Standard (ASGS) 2016. The ABS ASGS 2016 remoteness categories divide Australia into broad geographic regions that share common characteristics of remoteness for statistical purposes.
Socioeconomic disadvantage^	Local areas are grouped into socioeconomic quintiles based on the 2016 Index of Relative Socio-Economic Disadvantage (IRSD) at the Statistical Area Level 1 (SA1) level. The IRSD is derived from census variables relating to disadvantage, such as low income, low educational attainment, unemployment and dwellings without motor vehicles. Information from the ABS Socio-Economic Indexes for Areas (SEIFA) and the IRSD was used to calculate the socioeconomic status at the SA3 level in the Atlas. SEIFA includes four summary measures created from 2016 Census information. The indexes can be used to explore different aspects of socioeconomic conditions by geographic areas. For each index, every geographic area in Australia is given a SEIFA number that shows how disadvantaged that area is compared with other areas. Each index summarises a different aspect of the socioeconomic conditions of people living in an area. For example, they provide more general measures of socioeconomic status than are given by measuring income or unemployment alone.
Surgery (surgical procedure)	Separations for which the AR-DRG belonged to the Surgical partition of the AR-DRG classification (Categories based on associated AR-DRG V7 and V8), https://www.aihw.gov.au/reports/hospitals/ar-drg-data-cubes/contents/user-guide.

^Source: the Australian Atlas of Healthcare Variation series published by the Australian Commission on Safety and Quality in Health Care (https://www.safetyandquality.gov.au/our-work/healthcare-variation).

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