Counting the cost of major infection and sepsis in New Zealand: an exploratory study using the National Minimum Data Set

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ABSTRACT

AIM: To explore the population-at-risk and potential cost of a sepsis episode in New Zealand.

METHOD: Retrospective analysis of the National Minimum Data Set using two code-based algorithms selecting (i) an inclusive cohort of hospitalised patients diagnosed with a 'major infection' with the potential to cause sepsis and (ii) a restricted subset of these patients with a high likelihood of clinical sepsis based on the presence of both a primary admission diagnosis of infection and at least one sepsis-associated organ failure.

RESULTS: In 2016, 24% of all inpatient episodes were associated with diagnosis of a major infection. The sepsis coding algorithm identified a subset of 1,868 discharges. The median (IQR) reimbursement associated with these episodes was $10,381 ($6,093–$10,964). In both groups, 30-day readmission was common (26.7% and 11% respectively).

CONCLUSIONS: Infectious diseases with the potential to cause sepsis are common among hospital inpatients. Direct treatment costs are high for those who present with or progress to sepsis due to these infections.

Sepsis is defined as "life-threatening organ dysfunction due to a dysregulated immune response to infection."[1] Sepsis is a major health challenge globally, with incidence stratified by geography and national income.[2] In high-income countries, sepsis-associated mortality remains high, with a wide variation based on the age and underlying health status of the individual.[3] A proportion of patients with sepsis require treatment in an intensive care unit (ICU), survivors often require long stays in hospital and hospital readmission is common.[4,5] Unsurprisingly perhaps, sepsis is a leading cause of healthcare spending. In the US in 2018, USD$22,000,000,000 was charged to the Medicare and Medicaid budgets for inpatient sepsis management.[6]

Sepsis is a complication of infection. In New Zealand, infection-related public-hospital admissions have increased significantly over time, particularly among Māori and Pacific people and those facing high levels of socioeconomic deprivation.[7–11] Presentations with infectious diseases and sepsis are therefore a major barrier to population health equity, and their prevention, mitigation and treatment are deserving of investment. Investment requires an understanding of the scale of the underlying problem and its associated cost. There are no studies reporting the cost of infection and sepsis to the New Zealand public health system. We used routine data to estimate (i) the number of inpatients with infections that can cause sepsis and (ii) the potential cost of a sepsis episode.

Methods

This study was registered as a quality improvement activity with the Clinical Audit Support Unit at Waikato District Health Board (WDHB). It was considered a low-risk observational study and therefore out of scope for New Zealand Health and Disability Ethics Committee review. Funding for an independent health-economist (IS) was provided by the Accident Compensation Corporation (ACC).

Defining infection and sepsis using routine data

This was a retrospective analysis of the National Minimum Data Set (NMDS). The analysis made use of codes derived from the International Classification of Disease, Tenth Edition, Australian Modification (ICD-10-AM). The *a priori* design of this explorative study addressed several problems known to impact studies of sepsis epidemiology and cost.

Firstly, we had to identify a source of data from which to derive estimates of prevalence and cost. Although prospective databases are maintained to identify sepsis within intensive care unit admissions, limiting studies to ICU-treated populations is highly problematic.[4] The NMDS is the only resource available to judge the total number of infectious disease and sepsis-associated hospital admissions in New Zealand. It has been the preferred data source for national reporting of infection-related hospital admissions and is linked to hospital reimbursement data.[7] The NMDS was therefore chosen as the data source for this study.

Secondly, we needed a method to identify sepsis within the NMDS. Significant controversy and debate surround the contemporary clinical definition of sepsis, and the limitations associated with defining it within routine data, are well described.[4,12–14] Briefly, the clinical definition of sepsis has changed over time, as have the International Classification of Disease versions from which sepsis coding algorithms are constructed.[1,12] Multiple code-based definitions of sepsis exist, and their accuracy has been reported against different populations in different health systems.[3,12] The only published study of sepsis incidence in New Zealand was based on an approach subsequently adopted by the Global Burden of Disease study, and which is reported to exhibit 50% sensitivity and 94% specificity against the 2001 consensus definition of 'severe sepsis'.[2,8,13] This method was therefore selected to define sepsis within the NMDS and from then on was referred to as the 'New Zealand Sepsis' indicator (NZS, see Appendix).

Due to the syndromic nature of sepsis (as opposed to the binary presence or absence of infections with specific ICD-10-AM codes), clinical validation of the NZS algorithm was undertaken by reviewing a sample of clinical records at WDHB. We retrospectively identified 100 NZS discharges from WDHB facilities in each of two one-year time periods (July to June 2008/09 and 2012/13). These adult patients were found to have confirmed sepsis if their presentations were both consistent with infection and associated with a new increase of two or more in the modified-Sequential Organ Failure Assessment (mSOFA).[15] Use of the original Sequential Organ Failure Assessment (SOFA) score is required to satisfy the current clinical definition of sepsis.[1] mSOFA replaces the cardiovascular and respiratory requirements of the original score to make use of information typically entered into the clinical record.

Thirdly, we recognised the limited sensitivity of the NZS algorithm and, therefore, our inability to identify all patients with sepsis from the NMDS. Instead, we sought to identify the hospitalised population-at-risk of sepsis. This approach is in routine use in the UK and is used to identify trends in the presentation and outcome of specific infectious diseases in NHS hospitals. The so-called 'suspicion of sepsis' approach was first developed by Inada-Kim et al.[14] These authors conducted a consensus review of the International Classification of Disease to extract all infectious disease diagnoses commonly complicated by sepsis. To these codes we added 14 that were part of the sepsis coding strategy developed by Huggan et al.[4] From then on we labelled this algorithm as the 'New Zealand Major Infection' (NZMI) indicator.

In summary, to estimate the population-at-risk of sepsis, we identified all patients admitted to New Zealand hospitals with infections known to cause this condition (NZMI). From within this cohort,

we identified a subpopulation with a high likelihood of having true clinical sepsis (NZS) and validated this assumption by conducting a clinical record review.

Data extraction and hospital reimbursement

The National Minimum Data Set (NMDS) was used to identify discharges meeting NZS and NZMI criteria for the 2016 calendar year (see Appendix). We extracted 30-day readmissions for any reason through to 31 January 2017. The NMDS was accessed under a pre-existing memorandum of understanding between the Ministry of Health and ACC. This limited the information provided to the patient's age, district health board and discharge diagnosis codes. Mortality and ethnicity data were not available.

Data were entered into Microsoft Excel (2016) and further analysed in SAS Enterprise Guide (version 7.1). Public-hospital reimbursement for each case was derived from the New Zealand Casemix System for Publicly Funded Hospitals (WEISNZ16v1.0, NCCP Casemix—Cost Weights Project Group, 2016).[16] This system uses case-weights to estimate average costs for cases of varying complexity, as determined by Diagnosis Related Groups (DRGs) linked to ICD-10-AM codes. For cases not covered by the Casemix System (namely those paid by Crown agencies such as ACC), we used the average inlier costs for relevant DRGs. We had no data relating to reimbursements for private hospitals or facilities run by community trusts. To compare case-weighted reimbursement with true inpatient costs at Waikato District Health Board, we used i.Patient Manager (DXC Technology, Tysons Corner, US) to describe the actual costs of care for patients included in the NZS clinical validation cohort.

Results

Regarding validation of the NZS algorithm, 192 sets of clinical records were available for review. Clinical sepsis was identified in 165 (86%); 125 (76%) of these satisfied the clinical sepsis definition (mSOFA score of two or more) at first presentation to hospital, 43 (26%) identified as Māori, 36 (22%) were admitted to ICU and 30 (18%) died in hospital.

Table 1 shows the number of cases identified using the NZMI and NZS indicators in 2016, stratified by age group.

Table 1: Hospital discharges identified by the New Zealand Major Infection (NZMI) and New Zealand Sepsis (NZS) indicators, 2016.

Age group (years)	N	%	N	%
	NZMI		NZS	
0–2	13,255	8	18	1
3–19	14,136	8	35	2
20–29	15,053	9	28	2
30–39	11,449	6	41	2
40–49	11,950	7	86	5
50–59	16,337	9	202	11
60–69	22,832	13	330	18
70–79	29,471	17	472	25
80 and over	40,136	23	656	35
Total	174,619	100	1,868	100

In the 2016 calendar year, we estimated that there were 725,294 non-day-stay discharges from New Zealand public hospitals (see Appendix). 174,619 discharges (24%) were associated with a NZMI code. 47% of patients were male, 40% were over 70 years of age and 16% were under 20. NZMI admissions absorbed 949,026 hospital bed days, for which $1,191,279,897 was reimbursed. The average length of stay (ALOS) for these admissions was 5.5 days (range 1–225 days, median 3.0 days, inter-quartile ration (IQR) 1–6 days) and the average reimbursement per discharge was $6,822 (range $147–$410,599, median $3,995, IQR $2,231–$6,865). 46,627 NZMI discharges (26.7%) were associated with readmission within 30 days, accounting for 341,606 additional bed days and reimbursement of $373,700,000 (mean $8,014, median $5,167, IQR $2,807–$8,446). We found 3,904 (2.2%) NZMI cases that were not reimbursed using the Casemix System. Assigning the casemix average to these admissions added $26,300,000 to the total.

1,868 hospital discharges were identified using NZS codes. Of these patients, 54% were male and 60% were aged 70 or over. NZS admissions absorbed 15,137 hospital bed days, for which $21,500,000 was reimbursed. The ALOS was 8.1 (range 1–86, median 6, IQR 3–10) and the average reimbursement per discharge was $11,552 (range $717–$181,988, median $10,381, IQR $6,177–$10,964). There were 203 NZS discharges (11%) that were associated with readmission within 30 days. This accounted for an additional 2,418 bed days and a further reimbursement of $2,800,000 (average $13,682, range $717–$179,231, median $10,381, IQR $6,093–$10,964). We found 26 (1.4%) NZS cases that were not reimbursed using the Casemix System. Assigning the casemix average to these admissions added $355,732 to the total reimbursement.

For the 192 patients in the clinical validation cohort at Waikato District Health Board, 79% of the actual costs of care were identified using national casemix methodology (costs of $2,150,209 against reimbursement of $1,699,155).

Discussion

To our knowledge, this is the first study that attempts to report hospital resource utilisation associated with episodes of infection and sepsis in New Zealand. Codes for 'major infection' were associated with 24% of all hospital discharges, almost 1,000,000 hospital bed days and over $1,000,000,000 in reimbursement. A high proportion of patients were readmitted to hospital within 30 days (27% and 11% of the NZMI and NZS cohorts, respectively). Sepsis episodes were high-cost events, and the actual costs of care for a sepsis cohort identified at a large district health board were 26% higher than reimbursement derived using the case-weight system.

As an exploratory analysis, our aim was to estimate the population-at-risk of sepsis and the likely cost of a sepsis episode while recognising the limitations placed on studies using routine data. We did this by applying two entirely different algorithms to a single database: one which identified patients with the infections that cause sepsis (NZMI), the other which identifies patients with a high likelihood of true clinical sepsis (NZS). Comparison of these cohorts provides two important observations. Firstly, NZMI codes more completely represent the bimodal distribution of infection-related hospital admissions, a pattern observed in the Global Burden of Disease study but not by the NZS algorithm.[2,8] Secondly, both methods demonstrate a steep increase in the proportion of cases with age. This is a universal observation in studies of infection and sepsis incidence, including those reported from New Zealand.[7,8]

The NZS algorithm was designed to report sepsis incidence from hospital coding data. Due to concerns about the reliability of coding strategies to identify true clinical sepsis, it aims to maintain specificity for the sepsis syndrome at the expense of sensitivity. This is achieved by requiring an explicit organ failure code while also excluding infection codes other than in the primary position (see Appendix). Merely by including cases with infection codes in primary *or secondary* positions in our database, we would have increased the number of NZS cases by 64% to 3,073, and

a further 2,615 cases would have been identified by combining infection and organ failure codes in any position. With 86% of cases satisfying contemporary sepsis definitions in our validation work, we conclude that NZS codes can be used to estimate the cost of sepsis episodes, although they will underestimate sepsis incidence and prevalence.

This brings earlier findings into question. In the Waikato region, the NZS algorithm led to an estimate of 107 cases of sepsis per 100,000 in the year to June 2012.[4] This is at the lower limit of sepsis incidence estimated in high-income economies by the Global Burden of Disease study, which employed code-based methods to estimate 120 to 200 cases per 100,000 population in high-income countries including New Zealand and Sweden.[2] Swedish studies identifying the presence of sepsis in patients receiving intravenous antibiotics report annual sepsis rates of 800 per 100,000 population.[20,21] By implication, rates of sepsis are much higher in New Zealand than previously reported. Better estimates of sepsis incidence are needed, particularly given the severity of the associated outcomes and the high cost presented to public hospitals.

We also note that critical illnesses requiring complex multidisciplinary care have been associated with deficits in hospital reimbursement. For example, the average case-weighted inpatient reimbursement for major trauma at Whangārei Hospital from 2015 to 2017 was $17,042, but the actual costs of care were 36% higher.[17] For both trauma and sepsis, additional costs will extend well beyond hospital care, with non-inpatient ('indirect') costs adding substantially to total spending following critical illness.[18] Sepsis has recently been shown to cause a durable increase in health spending over at least five years of follow-up.[19] Further work is required to establish a better estimate of short- and long-term costs, but a clue to the true extent of resource utilisation associated with infectious disease and sepsis diagnosis is provided by the high readmission rate found in this study.

The 30-day readmissions in the NZMI and NZS cohorts respectively added 31% ($373,700,000 added to $1,200,000,000) and 13% ($2,800,000 added to $21,500,000) to the reimbursement associated with index hospitalisation. Large studies in the US have shown that readmission rates after sepsis are similar for heart failure and myocardial infarction.[5] Reasons for hospital readmission are likely to be heterogenous. Possibly for this reason, interventions focused solely on supporting sepsis survivors at discharge have shown little impact on rates of readmission.[22–24] Intriguingly, though, total healthcare utilisation does appear to be reduced by efforts to identify and treat patients at risk of sepsis in hospital. A machine-learning algorithm designed to identify sepsis using electronic medical records reduced 30-day readmission rates from a baseline of 46% to 23% in one single-centre study.[25] Evaluation of a state-wide sepsis quality improvement programme in New South Wales, Australia, pointed to a reduction in intensive care utilisation and the total length of stay.[26] The hypothesis proposed by these authors and others is that early sepsis identification and treatment improves clinical recovery by preventing the accumulation of sepsis-associated tissue injury. We can't support this conclusion from the data provided here, but we have shown that quality improvement programmes aimed at preventing, mitigating and treating infection and sepsis would be relevant to a high proportion of our inpatient population.

A major weakness of our study is the omission of data relating to mortality and ethnicity. The dynamic impacts of infection are most marked among populations suffering high rates of chronic morbidity and socioeconomic disadvantage, which unfortunately includes a significant proportion of Māori and Pacific people. For example, compared with non-Māori living in the Waikato, Māori are 3.2 times more likely to suffer sepsis and at a much younger age.[4] Under-reporting rates of infection and sepsis at a national level risks obscuring the important contribution of these conditions to health inequity.

In summary, infection and sepsis are costly and previously under-appreciated sources of direct healthcare spending in New Zealand. Total healthcare spending on sepsis will be significantly higher than reported here, due to under-reporting, the ongoing costs of care in the community

and, potentially, the significant gap between reimbursement and actual spending. The NZMI and NZS approaches have their strengths and weaknesses. The first can estimate the size of the inpatient population at risk of sepsis, and the second can provide a representative sample of patients with a high probability of sepsis, which can be used to study clinical outcomes and costs. Both groups would benefit from investments in infection control, antimicrobial stewardship and sepsis care aimed at preventing or reducing long lengths of stay and readmission.

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Appendix

Figure A1: New Zealand Major Infection and New Zealand Sepsis indicator methodologies

Hospital discharge episodes in 2016 (eg, from 1 January 2016 to 31 December 2016) were identified using two separate algorithms applied to the National Minimum Data Set (NMDS). The resulting cohorts were analysed separately. For each episode, readmission within 30 days was identified. In both cohorts, admission more than 30 days after the index discharge was counted as a separate episode.

To estimate total in-patient discharges in calendar year 2016, we first subtracted day-case admissions from total reported hospital episodes provided by the New Zealand Ministry of Health (tables available at https://www.health.govt.nz/nz-health-statistics/health-statistics-and-data-sets/publicly-funded-hospital-discharges-series/publicly-funded-hospital-discharges-series/publicly-funded-hospital-discharges-series. [Accessed October 2020]). We then calculated an average based on numbers derived for the period July–June 2016/2017 and 2015/2016002E.

New Zealand Major Infection indicator

The 'New Zealand Major Infection' (NZMI) indicator is comprised of the ICD-10-AM codes identified by Inada-Kim et al,[14] with the addition of 14 ICD-10-AM codes used in a Waikato-based study conducted by Huggan et al[4] These ICD-10 codes are applied to the first 30 diagnosis codes entered into the NMDS. Codes are listed under ICD-10-AM chapter headings.

I. Certain infectious and parasitic diseases

1. A01 Typhoid and paratyphoid fevers (incl. A01.0, A01.1, A01.2, A01.3, A01.4)
2. A02 Other salmonella infections (incl. A02.0, A02.1, A02.2, A02.8, A02.9)
3. A03 Shigellosis (incl. A03.0, A03.1, A03.2, A03.3, A03.8, A03.9)
4. A04 Other bacterial intestinal infections (incl. A04.0, A04.1, A04.2, A04.3, A04.4, A04.5, A04.6, A04.7, A04.8, A04.9)
5. A06 Amoebiasis (incl. A06.0, A06.1, A06.2, A06.3, A06.4, A06.5, A06.6, A06.7, A06.8, A06.9)
6. A15 Respiratory tuberculosis (incl. A15.0, A15.2, A15.3, A15.4, A15.5, A15.6, A15.7, A15.8, A15.9)
7. A16 Respiratory tuberculosis, not confirmed bacteriologically or histologically (incl. A16.0, A16.1, A16.2, A16.3, A16.4, A16.5, A16.7, A16.8, A16.9)
8. A17 Tuberculosis of nervous system (incl. A17.0, A17.1, A17.8, A17.9)
9. A18 Tuberculosis of other organs (incl. A18.0, A18.1, A18.2, A18.3, A18.4, A18.5, A18.6, A18.7, A18.8)
10. A19 Miliary tuberculosis (incl. A19.0, A19.1, A19.2, A19.8, A19.9)
11. A27 Leptospirosis (incl. A27.0, A27.8, A27.9)
12. A32 Listerosis (incl. A32.0, A32.1, A32.7, A32.8, A32.9)
13. A37 Whopping cough (all subcategories)
14. A38 Scarlet fever
15. A39 Meningococcal infection (incl. A39.0, A39.1, A39.2, A39.4, A39.5, A39.8, A39.9)
16. A40 Streptococcal sepsis (incl. A40.0, A40.1, A40.2, A40.3, A40.8, A40.9)
17. A41 Other Sepsis (incl. A41.0, A41.1, A41.2, A41.3, A41.4, A41.5, A41.8, A41.9)
18. A42 Actinomycosis (all subcategories)
19. A43 Nocardiosis (all subcategories)

20. A44 Bartenollosis (all subcategories)
21. A46 Erysipelas
22. A48 Other Bacterial diseases, not elsewhere classified (incl. A48.0, A48.1, A48.2, A48.3, A48.4, A48.8)
23. A49 Bacterial infection of unspecified site (incl. A49.0, A49.1, A49.2, A49.3, A49.8, A49.9)
24. A51 Early syphilis (all subcategories)
25. A54 Gonococcal infection (incl. A54.1, A54.2, A54.3, A54.4, A54.5, A54.6, A54.8, A54.9)
26. A55 Chlamydial lymhogranuloma (venereum)
27. A56 Other sexually transmitted chlamydial diseases (incl. A56.0, A56.1, A56.2, A56.3, A56.4, A56.8)
28. A68 Relapsing fevers (all subcategories)
29. A69.2 Lyme disease
30. A70 Chlamydia psittaci infection
31. A75 Typhus fever (all subcategories)
32. A77 Spotted fever (all subcategories)
33. A78 Q fever
34. A79 Other rickettsioses (all subcategories)
35. B59 Pneumocystosis

VI. Diseases of the nervous system

36. G00 Bacterial meningitis, not elsewhere classified (incl. G00.0, G00.1, G00.2, G00.3, G00.8, G00.9)
37. G01 Meningitis in bacterial diseases classified elsewhere
38. G04.2 Bacterial meningoencephalitis and meningomyelitis, not elsewhere classified
39. G06 Intracranial and intraspinal abscess and granuloma (incl. G06.0, G06.1, G06.2)

VIII. Diseases of the ear and mastoid process

40. H60 Otitis externa (incl. H60.0, H60.1, H60.2, H60.3)
41. H66 Suppurative and unspecified otitis media (incl. H66.0, H66.4, H66.9)
42. H67.0 Otitis media in bacterial diseases classified elsewhere
43. H68.0 Eustachian salpingitis
44. H70 Mastoiditis and related conditions (incl. H70.0, H70.9)
45. H73.0 Acute myringitis

IX. Diseases of the circulatory system

46. I00 Rheumatic fever without mention of heart involvement
47. I01 Rheumatic fever with heart involvement (incl. I01.0, I01.1, I01.2, I01.8, I01.9)
48. I02 Rheumatic chorea (incl. I02.0, I02.9)
49. I33 Acute and subacute endocarditis (incl. I33.0, I33.9)
50. I38 Endocarditis, valve unspecified

X. Diseases of the respiratory system

51. J01 Acute sinusitis (incl. J01.0, J01.1, J01.2, J01.3, J01.4, J01.8, J01.9)
52. J02 Acute pharyngitis (incl. J02.0, J02.9)
53. J03 Acute tonsillitis (incl. J03.0, J03.9)

54. J05.1 Acute epiglottitis
55. J06.9 Acute upper respiratory infection, unspecified
56. J13 Pneumonia due to Streptococcus pneumoniae,
57. J14 Pneumonia due to Haemophilus influenza,
58. J15 Bacterial pneumonia, not elsewhere classified (J15.0, J15.1, J15.2, J15.3, J15.4, J15.5, J15.6, J15.7, J15.8, J15.9)
59. J16 Pneumonia due to other infectious organisms, not elsewhere classified (incl. J16.0, J16.8)]
60. J17.0 Pneumonia in bacterial diseases classified elsewhere (incl. J17.0, J17.8)
61. J18 Pneumonia, organism unspecified (including J18.0, J18.1, J18.2, J18.8 and J18.9)
62. J20 Acute bronchitis (incl. J20.0, J20.1, J20.2, J20.8, J20.9)
63. J22 Unspecified acute lower respiratory infection
64. J36 Peritonsillar abscess
65. J39 Other diseases of upper respiratory tract (incl. J39.0, J39.1)
66. J44.0 Chronic obstructive pulmonary disease with acute lower respiratory infection
67. J69 Pneumonitis due to solids and liquids (incl. J69.0, J69.8)
68. J84.9 Interstitial pulmonary disease unspecified (interstitial pneumonia NOS)
69. J85 Abscess of lung and mediastinum (incl. J85.1, J85.2, J85.3)
70. J86 Pyothorax (incl. J86.0, J86.9)
71. J95.0 Sepsis of tracheostomy stoma
72. J98.5 Diseases of mediastinum, not elsewhere classified- Mediastinitis

XI. Diseases of the digestives system (dental disorders omitted)

73. K22.3 Perforation of oesophagus
74. K35 Acute appendicitis (incl. K35.2, K35.3, K35.8)
75. K37 Unspecified appendicitis
76. K57 Diverticular disease of intestine (incl. K57.0, K57.2, K57.4, K57.8,)
77. K61 Abscess of anal and rectal regions (incl. K61.0, K61.1, K61.2, K61.3, 61.4)
78. K63.0 Abscess of intestine
79. K63.1 Perforation of intestine (nontraumatic)
80. K65.0 Acute peritonitis (incl. K65.0, K65.8, K65.9)
81. K67 Disorders of peritoneum in infectious diseases classified elsewhere (all subcategories)
82. K75.0 Abscess of liver
83. K80.0 Calculus of gallbladder with acute cholecystitis/cholangitis (incl. K80.0, K80.1, K80.3, K80.4)
84. K81 Cholecystitis (incl. K81.0, K81.1, K81.8, K81.9)
85. K82.2 Perforation of gallbladder
86. K83.0 Cholangitis
87. K83.2 Perforation of bile duct

XII. Diseases of skin and subcutaneous tissue

88. L00 Staphylococcal scalded skin syndrome
89. L01 Impetigo (L01.0, L01.1)

90. L02 Cutaneous abscess, furuncle and carbuncle (incl. L02.0, L02.1, L02.2, L02.3, L02.4, L02.8, L02.9)
91. L03 Cellulitis (including L03.0, L03.1, L03.2, L03.3, L03.8 and L03.9)
92. L05.0 Pilonidal cyst with abscess
93. L08 Other local infections of skin and subcutaneous tissue (incl. L08.0, L08.8, L08.9)
94. L30.3 Infective dermatitis
95. L53.3 Erythema marginatum
96. L98.0 Pyogenic granuloma

XIII. Diseases of the musculoskeletal system and connective tissue

97. M00 Pyogenic arthritis (incl. M00.0, M00.1, M00.2, M00.8, M00.9)
98. M01 Direct infections of joint in infectious and parasitic diseases classified elsewhere (incl. M01.0, M01.1, M01.2, M01.3)
99. M46.2 Osteomyelitis of vertebra
100. M46.4 Discitis, unspecified
101. M65 Synovitis and tenosynovitis (incl. M65.0, M65.1)
102. M71.0 Abscess of bursa
103. M72.6 Necrotizing fasciitis
104. M86 Osteomyelitis

XIV. Diseases of genitourinary system

105. N10 Acute tubulo-interstitial nephritis
106. N11 Chronic tubulo-interstitial nephritis (incl. N11.0, N11.1, N11.8, N11.9)
107. N12 Tubulo-intestitial nephritis, not specified as acute or chronic
108. N13.6 Pyonephrosis
109. N15.1 Renal and perinephric abscess
110. N15.9 Renal tubulo-interstitial disease, unspecified
111. N30 Cystitis, unspecified (including N30.0, N30.8, N30.9)
112. N34.0 Urethral abscess
113. N39.0 Urinary tract infection, site not specified
114. N41.0 Acute prostatitis
115. N43.1 Infected hydrocele
116. N45 Orchitis and epididymitis (incl. N45.0, N45.9)
117. N48.2 Other disorders of penis (incl. N48.1, N48.2)
118. N49.9 Inflammatory disorder of unspecified male genital organ
119. N61 Inflammatory disorders of breast
120. N70 Salpingitis and oophoritis (incl. N70.0, N70.9)
121. N71 Inflammatory disease of uterus, except cervix (incl. N71.0, N71.9)
122. N73 Other female pelvic inflammatory diseases (incl. N73.0, N73.1, N73.2, N73.4, N73.9)
123. N75.1 Abscess of Bartholin gland
124. N76 Other inflammation of vagina and vulva (incl. N76.0, N76.1, N76.3, N76.4, N76.8)

XV. Pregnancy, childbirth and the puerperium

125. O08.0 Genital tract and pelvic infection following abortion and ectopic and molar pregnancy

126. O23 Infections of genitourinary tract in pregnancy (incl. O23.0, O23.1, O23.2, O23.3, O23.4, O23.5, O23.9)

127. O41.1 Infection of amniotic sac and membranes

128. O85 Puerperal sepsis

129. O86 Other puerperal infections (incl. O86.0, O86.1, O86.2, O86.3, O86.4, O86.8)

130. O88.3 Obstetric pyaemic and septic embolism

131. O91 Infections of breast associated with childbirth (incl. O91.0, O91.1)

XVI. Certain conditions originating in the perinatal period

132. P36 Bacterial sepsis of newborn (incl. P36.0, P36.1, P36.2, P36.3, P36.4, P36.5, P36.8, P36.9)

133. P39 Other infections specific to the perinatal period (incl. P39.0, P39.2, P39.3, P39.4, P39.8, P39.9)

134. P78 Other perinatal digestives system disorders (P78.0, P78.1,)

135. T814 Infection following a procedure, not elsewhere classified

136. T845 Infection and inflammatory reaction due to internal joint prosthesis

XVIII. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified

137. R57.2 Septic shock

138. R65 Systemic Inflammatory Response syndrome (incl. R65.0, R65.1, R65.9)

The following 14 ICD-10-AM codes were added to the NZMI indicator as they are included in the NZS indicator and part of the study conducted by Huggan et al.

A241 Acute and fulminating melioidosis
B377 Candidal sepsis
B387 Disseminated coccidioidomycosis
B393 Disseminated histoplasmosis capsulati
B407 Disseminated blastomycosis
B417 Disseminated paracoccidioidomycosis
B427 Disseminated sporotrichosis
B447 Disseminated aspergillosis
B457 Disseminated cryptococcosis
B464 Disseminated mucormycosis
A4150 Sepsis due to unspecified Gram-negative organisms
A4151 Sepsis due to Escherichia coli [E Coli]
A4152 Sepsis due to Pseudomonas
A4158 Sepsis due to other Gram-negative organisms

New Zealand Sepsis indicator

The New Zealand Sepsis (NZS) indicator is present when a 'Primary Infection' code is found together with an 'Organ Failure' code.

Definition of 'Primary Infection': Where a pre-specified ICD10 code defining infectious

disease was present in the first (primary) diagnosis position the indicator 'Primary_ infection' was assigned. Where the primary position was occupied by an ICD10 Z-code and an indicator code (as defined below) was in the second position, the 'Primary_infection' indicator was also assigned. Note that in the original study by Huggan et al[4] identified only Infection Codes in the first (primary) position.

1	A010	Typhoid fever
2	A021	Salmonella sepsis
3	A190	Acute miliary tuberculosis of a single specified site
4	A191	Acute miliary tuberculosis of multiple sites
5	A192	Acute miliary tuberculosis, unspecified
6	A198	Other miliary tuberculosis
7	A199	Miliary tuberculosis, unspecified
8	A241	Acute and fulminating melioidosis
9	A327	Listerial sepsis
10	A394	Meningococcaemia, unspecified
11	A400	Sepsis due to streptococcus, group A
12	A401	Sepsis due to streptococcus, group B
13	A402	Sepsis due to streptococcus, group D
14	A403	Sepsis due to Streptococcus pneumoniae
15	A408	Other streptococcal sepsis
16	A409	Streptococcal sepsis, unspecified
17	A410	Sepsis due to Staphylococcus aureus
18	A411	Sepsis due to other specified staphylococcus
19	A412	Sepsis due to unspecified staphylococcus
20	A413	Sepsis due to Haemophilus influenzae
21	A414	Sepsis due to anaerobes
22	A4150	Sepsis due to unspecified Gram-negative organisms
23	A4151	Sepsis due to Escherichia coli [E Coli]
24	A4152	Sepsis due to Pseudomonas
25	A4158	Sepsis due to other Gram-negative organisms
26	A418	Other specified sepsis
27	A419	Sepsis, unspecified
28	A427	Actinomycotic sepsis
29	A430	Pulmonary nocardiosis
30	A481	Legionnaires' disease
31	A483	Toxic shock syndrome
32	A499	Bacterial infection, unspecified
33	A548	Other gonococcal infections
34	B377	Candidal sepsis
35	A78	Q fever (coded in logic as A780)
36	B387	Disseminated coccidioidomycosis
37	B393	Disseminated histoplasmosis capsulati
38	B407	Disseminated blastomycosis
39	B417	Disseminated paracoccidioidomycosis
40	B427	Disseminated sporotrichosis

41	B447	Disseminated aspergillosis
42	B457	Disseminated cryptococcosis
43	B464	Disseminated mucormycosis
44	P360	Sepsis of newborn due to streptococcus, group B
45	P361	Sepsis of newborn due to other and unspecified streptococci
46	P362	Sepsis of newborn due to Staphylococcus aureus
47	P363	Sepsis of newborn due to other and unspecified staphylococci
48	P364	Sepsis of newborn due to Escherichia coli
49	P365	Sepsis of newborn due to anaerobes
50	P368	Other bacterial sepsis of newborn
51	P369	Bacterial sepsis of newborn, unspecified

d. Organ failure: These ICD-10 codes, applied to the first 30 diagnosis codes, were used to identify organ failure. In addition, the 'Organ_failure' indicator was also applied when one of the three operation/procedure codes appeared within the first 30 operation/procedure codes.

1	I950	Idiopathic hypotension
2	I951	Orthostatic hypotension
3	I959	Hypotension, unspecified
4	R031	Nonspecific low blood-pressure reading
5	R572	Septic shock
6	R570	Cardiogenic shock (missing)
7	R571	Hypovolaemic shock
8	R578	Other shock
9	R579	Shock, unspecified
10	D65	Disseminated intravascular coagulation [defibrination syndrome]
11	D688	Other specified coagulation defects
12	D689	Coagulation defect, unspecified
13	D695	Secondary thrombocytopenia
14	D696	Thrombocytopenia, unspecified
15	K720	Acute and subacute hepatic failure
16	E872	Acidosis
17	F050	Delirium not superimposed on dementia, so described
18	F051	Delirium superimposed on dementia
19	F058	Other delirium
20	F059	Delirium, unspecified
21	G934	Encephalopathy, unspecified
22	R400	Somnolence
23	R401	Stupor
24	R402	Coma, unspecified
25	N000	Acute nephritic syndrome, minor glomerular abnormality
26	N001	Acute nephritic syndrome, focal and segmental glomerular lesions
27	N002	Acute nephritic syndrome, diffuse membranous glomerulonephritis
28	N003	Acute nephritic syndrome, diffuse mesangial proliferative glomerulonephritis
29	N004	Acute nephritic syndrome, diffuse endocapillary proliferative

glomerulonephritis

30 N005 Acute nephritic syndrome, diffuse mesangiocapillary glomerulonephritis

31 N006 Acute nephritic syndrome, dense deposit disease

32 N007 Acute nephritic syndrome, diffuse crescentic glomerulonephritis

33 N008 Acute nephritic syndrome, other

34 N009 Acute nephritic syndrome, unspecified

35 N010 Rapidly progressive nephritic syndrome, minor glomerular abnormality

36 N011 Rapidly progressive nephritic syndrome, focal and segmental glomerular lesions

37 N012 Rapidly progressive nephritic syndrome, diffuse membranous glomerulonephritis

38 N013 Rapidly progressive nephritic syndrome, diffuse mesangial proliferative glomerulonephritis

39 N014 Rapidly progressive nephritic syndrome, diffuse endocapillary proliferative glomerulonephritis

40 N015 Rapidly progressive nephritic syndrome, diffuse mesangiocapillary glomerulonephritis

41 N016 Rapidly progressive nephritic syndrome, dense deposit disease

42 N017 Rapidly progressive nephritic syndrome, diffuse crescentic glomerulonephritis

43 N018 Rapidly progressive nephritic syndrome, other

44 N019 Rapidly progressive nephritic syndrome, unspecified

45 N170 Acute kidney failure with tubular necrosis

46 N172 Acute kidney failure with medullary necrosis

47 N178 Other acute kidney failure

48 N179 Acute kidney failure, unspecified

49 N171 Acute kidney failure with acute cortical necrosis

50 J80 Adult respiratory distress syndrome

51 J951 Acute pulmonary insufficiency following thoracic surgery

52 J952 Acute pulmonary insufficiency following nonthoracic surgery

53 J9600 Acute respiratory failure, type I

54 J9601 Acute respiratory failure, type II

55 J9609 Acute respiratory failure, type unspecified (J6909)

56 J9690 Respiratory failure unspecified, type I

57 J9691 Respiratory failure unspecified, type II

58 J9699 Respiratory failure unspecified, type unspecified

59 J960 Acute respiratory failure

60 J969 Respiratory failure, unspecified

61 R092 Respiratory arrest

Procedure codes:

66 1388200 Management of continuous ventilatory support, <= 24 hours

67 1388201 Management of continuous ventilatory support, more than 24 hours and less than 96 hours

68 1388202 Management of continuous ventilatory support, 96 hours or more

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