Accuracy of International classification of diseases, 10th revision codes for identifying severe sepsis in patients admitted from the emergency department

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ABSTRACT

Objective: To determine the accuracy of International classification of diseases, 10th revision, Australian modification (ICD-10-AM) codes in identifying severe sepsis in patients admitted from the emergency department (ED).

Design, setting and participants: A retrospective cohort study of ED patients transferred to the intensive care unit of a tertiary hospital within 24 hours of leaving ED, 2000–2006.

Main outcome measures: Clinical diagnosis of severe sepsis compared with diagnosis-based code (DB-C) categories based on ICD-10-AM codes in the Emergency Department Information Systems (EDIS) and Hospital Morbidity Data System (HMDS); sensitivity, specificity, positive predictive value (PPV) and negative predictive value of these databases.

Results: In the study period, 1645 patients were transferred to the ICU from the ED, of whom 254 had severe sepsis. Single discharge ICD-10-AM codes recorded in the EDIS and the principal ICD-10-AM codes recorded in the HMDS that fell into D-BC categories for sepsis, pneumonia, viscous perforation, peritonitis, cholecystitis or cholangitis had a PPV of 85.0% (95% CI, 78.4%–91.6%; 96/113) and 88.2% (95%CI, 72.6%–82.6%; 112/127), respectively. The respective sensitivity was 37.8% (95% CI, 31.8%–43.8%) (96/254) and 44.1% (95% CI, 38.0–50.2) (112/254). In contrast, ICD-10-AM codes in the HMDS that code for infection and organ dysfunction had a PPV of 33.5% (95% CI, 30.0%–37.0%; 227/677) and sensitivity of 89.4% (95% CI, 85.6%–93.2%; 227/254).

Conclusion: ICD-10-AM codes recorded in the EDIS or HMD had limited utility for identifying severe sepsis in patients admitted to ICU from the ED.

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Severe sepsis is a common, highly lethal and expensive disease. The incidence of severe sepsis has been estimated to be one to three cases per 1000 population.[1-4] The inhospital mortality has ranged from 20% to 50% in different studies across the world.[2,5,6] Patients with severe sepsis are usually treated in highly specialised areas of the hospital, such as the intensive care unit, to allow close monitoring and intensive treatment to be provided. Severe sepsis has been reported to account for 6%–15% of the ICU patient population and for half of ICU resources.[7-9] Direct costs accounts for a mere 20%–30% of the total cost; the remaining indirect costs are attributable to loss of productivity due to mortality.[7]

The differential diagnosis and management of severe sepsis is particularly challenging in the emergency department (ED) due the diversity of conditions that overlap with sepsis.[10] Recent recommendations for the management of severe sepsis have acknowledged the essential role of ED physicians in providing crucial, timely care.[11] The emergence of ED-initiated treatment protocols has led to interest in better understanding the disease from the ED perspective.[12,13]

Research into patient outcomes after ED presentation for severe sepsis requires accurate case identification, and would ideally involve prospective data collection and clinical validation of cases. However, this is both time-consuming and expensive, and may not be feasible in some settings. In contrast, administrative data, such as hospital morbidity data, are more readily available and have been used frequently as surrogate measures in other conditions that lack precise clinical criteria, such as pneumonia.[14] International classification of diseases codes from hospital or ED discharge data that describe infection or sepsis in conjunction with organ dysfunction have been used to identify patients with severe sepsis who have been admitted to the hospital; however, the validity of these codes has not been well established.[1,2,15]

We aimed to determine the performance of International classification of diseases, 10th revision, Australian modification (ICD-10-AM) coding in the ED discharge or hospital morbidity data to correctly identify ED patients with severe sepsis who were admitted to ICU within 24 hours of leaving the ED.

Methods

We conducted a retrospective cohort study of all patients who presented to the Royal Perth Hospital (RPH) ED and were transferred to the RPH ICU within 24 hours of leaving the ED, between 1 July 2000 and 31 December

Table 1. Intensive care unit diagnoses for inclusion in the severe sepsis group from the Royal Perth Hospital ICU Clinical Database.

1. All patients with Acute Physiology and Chronic Health Evaluation (APACHE) II diagnosis of sepsis of any aetiology.

2. All patients with APACHE II diagnosis of respiratory failure from respiratory infection AND any of the International classifications of diseases, 9th clinical modification (ICD-9-CM) codes indicate pneumonia, sepsis or shock (ICD-9-CM 480-486, 785).

3. All patients with APACHE II diagnosis of gastrointestinal perforation/obstruction AND any of the ICD-9-CM codes indicate perforation or peritonitis or intestinal ischaemia or operation (such as resection) consistent with septic aetiology.

4. Any of the following ICD-9-CM codes:

ICD-9-CM code	Description
36.2	Meningococcaemia
38	Septicaemia
041.1/7	Staphylococcal/*Pseudomonas* bacterial infection
84	Malaria
790.7	Bacteraemia
481	Pneumococcal pneumonia
482.2/4/9	Streptococcal/staphylococcal/bacterial pneumonia
486	Pneumonia, unspecified
510.9	Empyema
513	Lung abscess
530.4	Oesophagus perforation
531.5	Gastric ulcer perforation
532.5	Duodenal ulcer perforation
566	Anal/rectal abscess
567	Peritonitis
575.1	Cholecystitis
576.1	Cholangitis
590.8	Pyelonephritis
682.1/6	Cellulitis/abscess
728.8	Necrotising fasciitis
730.2	Osteomyelitis

2006. The RPH is an 800-bed metropolitan university teaching hospital that serves both the metropolitan area and rural transfers. The ED has an estimated 44 000 attendances per year, and about 50% of ED attendances result in a hospital admission. The 22-bed ICU admits critically ill adult patients from all specialties and is the largest in Western Australia.

The rationale for using the 24-hour ED-ICU lag-time cut-off was twofold. First, we assumed that sepsis was present or developing within this period, as the median time from sepsis to severe sepsis is 24 hours.[16] Second, we intended to capture patients who had spent some time in the operating theatre for sepsis control before admission to the ICU. The cohort of interest was sepsis due to infection that had been acquired outside of hospital. Therefore, patients who were transferred from another hospital were excluded, as they had been assessed, stabilised or even treated before attending the RPH ED. Patients with missing ICD-10-AM diagnosis codes in their Emergency Department Information System (EDIS) records were also excluded.

Data sources

Emergency Department Information System

EDIS is a database used by all public metropolitan EDs in Perth for the purpose of collecting data on ED activity and patient acuity. It is a real-time patient-tracking tool that allows ED staff to electronically record a patient's demographic details, triage score and some clinical details and track the patients as they move through the ED. The ED discharge diagnosis is selected by the doctor using a pull-down menu, and the diagnosis is automatically mapped to a single ICD-10-AM code.[17] The completeness of EDIS has been found to be above 95%.[18]

Royal Perth Hospital Intensive Care Unit Clinical Database

This database contains clinical data of all patients admitted to the RPH ICU since 1987 and has been described in previous studies.[19,20] Information in this database is collected by the duty ICU consultant within 24 hours of ICU admission and entered by designated trained clerical staff. During the study period, a single data custodian was responsible for ensuring data quality. The data were reviewed for internal consistency annually, and no patients were lost to follow-up or had missing data. Each patient's ICU diagnosis is described by up to four International classifications of diseases, 9th revision, clinical modification (ICD-9-CM) codes and an Acute Physiology and Chronic Health Evaluation (APACHE) score.[21,22]

On the basis of the ICU diagnoses, patients were classified as having "severe sepsis" or a diagnosis other than severe sepsis ("not severe sepsis"). An ICU diagnosis of severe sepsis was defined by the criteria listed in Table 1, and was regarded as the reference-standard indicator of severe sepsis for the purpose of this study.

Hospital Morbidity Data System

The Hospital Morbidity Data System (HMDS) comprises information about all hospital separations (discharges, transfers and deaths) in WA public and private acute hospitals since 1970 and is maintained by WA Health. The quality of the data is regularly validated by 21 quality checks and periodic audits.[23] Information used in this study includes patient demographics, date and time of

hospital admission and discharge diagnosis codes. There are up to 21 hospital discharge diagnoses (one principal diagnosis and other co-diagnoses) for each hospital separation and for the study period these were coded using the ICD-10-AM.

Data linkage

The RPH ICU clinical dataset was first linked ("in-house") to the RPH EDIS data to identify patients who presented to the RPH ED and were transferred to the RPH ICU within 24 hours of leaving the ED. The deterministic linkage was performed using the medical record number, which is a unique patient identifier used across public hospitals in WA.

Linkage of EDIS and HMDS datasets was conducted by the WA Data Linkage System, using probabilistic matching. Record linkage is the process used to link entries in one dataset to entries in another dataset by using patient identifiers and/or admission dates common to both datasets, bringing together all records belonging to an individual. This method has been described previously.[23,24] In our study cohort, both the deterministic and the probabilistic linkage were 100% successful.

Diagnosis-based code categories

Upon examining the ICD-10-AM codes in the EDIS and HMDS of the ICU patients with severe sepsis we discovered that a wide variety of codes was used. Hence, to facilitate analysis, these codes were grouped together into meaningful categories based on the diagnostic conditions (Table 2). For example, all ICD-10-AM codes that describe pneumonia (J13, J15.9, J18.0, J18.8, J18.9, and J85.2) were grouped under the diagnosis-based code (D-BC) category of "Pneumonia". Each D-BC category was compared with the ICU classification of "severe sepsis" or "not severe sepsis" to obtain the positive predictive value (PPV), negative predictive value (NPV), sensitivity and specificity. We selected only the D-BC categories with a PPV of 75% and above. The list of codes contained in the selected D-BC categories was subsequently combined as a single category referred to as "Combined D-BC" category. The Combined D-BC category was then compared with the ICU classification to determine the sensitivity, specificity, PPV and NPV.

For the HMDS discharge codes, the same D-BC categories were utilised, using the ICD-10-AM codes from the principal diagnosis codes. Similarly, the D-BC categories with a PPV value above 75% were selected, combined and compared with the ICU classification.

Separately, we grouped the principal diagnosis ICD-10-AM codes into infection categories and the co-diagnoses into organ dysfunction categories and, again, compared against the ICU classification. This code grouping was described in Angus and colleagues' landmark study to determine the incidence of sepsis;[1] however, the study used the previous version of ICD (the ICD-9-CM). To be comparable, we translated the ICD-9-CM codes to ICD-10-AM codes adapted from published Australian studies that had dealt with diagnosis codes of sepsis.[15,25]

Table 2. ICD-10-AM codes used to derive D-BC categories in the study cohort

D-BC category	ICD-10-AM codes
Pneumonia	J13, J15.9, J18.0, J18.8, J18.9, J85.2
Perforation	K22.3, K27.5, K63.1
Sepsis	A40.0, A40.1, A40.2, A40.3, A40.8, A40.9, A41.0, A41.1, A41.2, A41.3, A41.4, A41.5, A41.51, A41.52, A41.58, A41.8 and A41.9
Cholecystitis/cholangitis	K81.0, K83.0
Peritonitis	K65.9

D-BC = diagnosis-based code. ICD-10-AM = International classification of diseases, 10th revision, Australian modification.

Statistical analysis and ethics approval

Data were analysed using SPSS, version 15.0 (IBM, Armonk, NY, USA). For nominal variables, we compared groups using the χ^2 test. For continuous variables, we compared parametric data using the *t* test, and non-parametric data using the Mann–Whitney U test. We considered a *P* of less than 0.05 as significant. Sensitivity, specificity, PPV and NPV estimates are presented as percentages with 95% confidence intervals. Ethics approval was obtained from the RPH Humans Ethics and Research Committee (RPH approval number 2003/108).

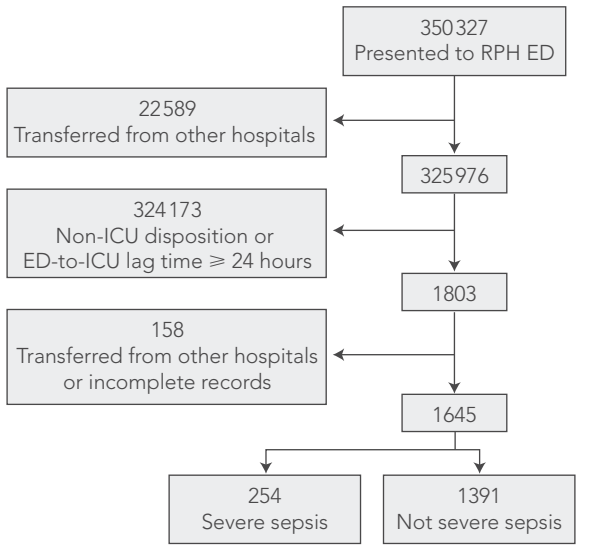
Results

Between 1 July 2000 and 31 December 2006, 1645 RPH ED patients were transferred to the RPH ICU within 24 hours of leaving the ED. A total of 254 (15.4%) were classified as "severe sepsis" and 1391 (84.6%) were classified as "not severe sepsis". The cohort derivation process is summarised in Figure 1. In the "not severe sepsis" group, isolated head injury and multiple trauma accounted for 23.4% of the patients. Other common diagnoses included non-traumatic intracranial haemorrhage (15.6%), drug overdose (13.6%), peripheral vascular disease including abdominal aortic aneurysm (4.5%) and seizure disorder (4.2%). The demographic profile of the two groups is shown in Table 3. There were significantly more comorbidities in the "severe sepsis" group than in the "not severe sepsis" group. More patients

in the "severe sepsis" group displayed the criteria of systemic inflammatory response syndrome (SIRS).[10] The mean arterial pressure was significantly lower and more patients were diagnosed with acute renal failure in the "severe sepsis" group.

In the "severe sepsis" group, only 7.9% of patients (18/254) had ICD-10-AM codes that fell within the D-BC categories for sepsis in their ED discharge diagnosis. In contrast, 48.8% of patients (124/254) in the group had ICD-10-AM HMDS diagnosis in the principal diagnosis that fell within the DB-C categories for sepsis.

Figure 1. Cohort derivation process for patients admitted to the ICU from the ED within 24 hours



ED = emergency department. ICU = intensive care unit.
RPH = Royal Perth Hospital.

The D-BC categories with a PPV of 75% and above from the single discharge diagnosis in the EDIS were sepsis, cholecystitis or cholangitis, peritonitis, pneumonia, viscous perforation and peritonitis. Each of these D-BC categories had an NPV of above 84% and a specificity close to 100%; however, the sensitivity was less than 15% (Table 4). ICD-10-AM codes that fell into any of the five D-BC categories, as represented by the Combined D-BC category, had an NPV and a specificity of 89.7% and 98.8%, respectively, but with a higher PPV and specificity of 85% and 37.8%, respectively, compared with the individual D-BC categories.

Similar results were obtained on analysis of the HMDS principal diagnosis. The same five D-BC categories (sepsis, cholecystitis or cholangitis, peritonitis, pneumonia, viscous perforation and peritonitis) in the HMDS had a PPV of 75% and above. Each of these D-BC categories had an NPV above 84% and a specificity approaching 100%, respectively, but very low sensitivity. As with the ED discharge diagnosis, the NPV and specificity changed minimally in the Combined D-BC category in the HMDS; however, the PPV (88.2%) and the sensitivity (44.1%) were greater. Using the principal and co-diagnoses codes in the HMDS, the codes for infection in conjunction with organ dysfunction yielded a higher proportion of false negatives (PPV, 33.5%) and higher sensitivity (89.4%).

Table 3. Demographics of the "severe sepsis" and "not severe sepsis" groups

Variable	Severe sepsis ($n = 254$)	Not severe sepsis ($n = 1391$)	P
Mean age in years (SD)	60.79 (18.15)	48.11 (20.34)	< 0.001
Men, no. (%)	142 (55.9%)	878 (63.1%)	0.03
Comorbidities, no. (%)			
Liver disease	7 (2.8%)	11 (0.8%)	0.06
Cardiovascular disease	7 (2.8%)	25 (1.8%)	0.31
Respiratory disease	18 (7.1%)	31 (2.2%)	< 0.001
Renal disease	14 (5.5%)	18 (1.3%)	< 0.001
Immunocompromised	31 (12.2%)	22 (1.6%)	< 0.001
Admission, mean (SD)			
Temperature, °C*	36.72 (1.31)	36.08 (1.22)	< 0.001
Heart rate, beats/min*	102.6 (23.0)	88.4 (21.6)	< 0.001
Respiratory rate, breaths/min*	18.6 (9.1)	14.6 (5.7)	< 0.001
Mean arterial pressure, mmHg	80.5 (16.7)	89.6 (19.0)	< 0.001
White cell count, 10^9 cells/mm^3*	14.0 (11.6)	13.0 (6.4)	0.57
Acute renal failure, no. (%)	33 (13.0%)	32 (2.3%)	< 0.001

* These four variables constitute the systemic inflammatory response syndrome criteria.

Discussion

Our study explored the utility of ICD-10-AM codes in administrative data to identify severe sepsis in ED patients. We found that the ICD-10-AM codes in the EDIS and the HMDS had limited utility for identifying severe sepsis patients in the ED. In severe sepsis, codes with low false negatives, and hence high sensitivity, are regarded as useful for determining the incidence of severe sepsis in the ED. We found that any of the five D-BC categories of sepsis, cholecystitis or cholangitis, peritonitis, pneumonia, viscous perforation and peritonitis, derived from a single discharge ICD-10-AM codes in the EDIS or the principal diagnoses codes in the HMDS provided good PPV, NPV and specificity, but poor sensitivity. In contrast, HMDS ICD-10-AM codes for organ dysfunction in the principal diagnosis and infection in the co-diagnosis had better sensitivity but poor PPV. Therefore, not one D-BC category, by itself or combined, was satisfactorily accurate to be used to identify severe sepsis patients in the ED. The reference standard used in this study, based on the ICU diagnosis, is likely to have high validity based on the demographic profile of the "severe sepsis" group, which shows a higher proportion of patients with SIRS criteria, renal failure and at risk of sepsis. Furthermore, the final ICU diagnosis assigned represented the expert opinion of the treating ICU consultant after thorough evaluation.

We observed that less than 10% of the severe sepsis patients were assigned the ED ICD-10-AM codes that fell into the D-BC category for "sepsis". Instead, organ-specific infection codes (eg, "pneumonia" or "perforation") were used. Using only the ICD-10-AM codes in the D-BC category for "sepsis" would have grossly underestimated the incidence of severe sepsis, hence the need to include other D-BC categories to identify these patients. The five D-BC categories that had the best PPV reflect the most common origin of severe sepsis in Australia and internationally, the lungs and the abdomen.[1,3,26] Even with the expansion of the codes used, the accuracy of the codes was still suboptimal. We also observed that using both the principal and co-diagnosis ICD-10-AM codes in the HMDS improved the true incidence of severe sepsis (48.8%), but half the severe sepsis cases were still missed. Our findings support previous concerns regarding the limitations of ICD-10-AM codes when estimating of the burden of sepsis.[27] Large epidemio-

Table 4. Performance of combined and D-BC categories with PPV of 75% and above

ICD-10-AM codes	No. of D-BC category diagnosis in each database (n/n)	PPV (95% CI)	NPV (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
D-BC categories in EDIS	EDIS/RPH ICU				
Sepsis ($n = 23$)	18/5	78.3 (61.5–95.1)	85.5 (83.8–87.2)	7.1 (3.9–10.3)	99.6 (99.3–99.1)
Cholecystitis or cholangitis ($n = 11$)	11/0	100 (100–100)	85.1 (83.4–86.8)	4.3 (1.8–6.8)	100 (100–100)
Perforation ($n = 29$)	27/2	93.1 (83.1–100)	86.0 (84.3–87.7)	10.6 (6.8–14.4)	99.9 (99.7–100)
Peritonitis ($n = 6$)	5/1	83.3 (53.4–100)	84.8 (83.1–86.5)	2.0 (0.3–3.7)	99.9 (99.7–100)
Pneumonia ($n = 44$)	35/9	79.5 (67.6–91.4)	86.3 (84.6–88.0)	13.8 (9.6–18.0)	99.4 (99.0–99.8)
Combined D-BC* categories in EDIS ($n = 113$)	96/17	85.0 (78.4–91.6)	89.7 (88.2–91.2)	37.8 (31.8–43.8)	98.8 (98.2–99.4)
D-BC categories in HMDS	HMDS/RPH ICU				
Sepsis ($n = 45$)	42/3	93.9 (86.0–100)	86.8 (85.1–88.5)	16.5 (11.9–21.1)	99.8 (99.6–100)
Cholecystitis or cholangitis ($n = 8$)	6/2	75.0 (45.0–100)	84.9 (83.2–86.6)	2.4 (0.5–4.3)	99.9 (99.7–100)
Perforation ($n = 36$)	33/3	91.7 (82.7–100)	86.3 (84.6–86.0)	13.0 (8.9–17.1)	99.7 (99.4–100)
Peritonitis ($n = 1$)	1/0	100 (100–100)	84.6 (82.9–86.3)	0.4 (0–1.2)	100 (100–100)
Pneumonia ($n = 37$)	30/7	81.1 (68.5–93.7)	86.1 (84.4–87.8)	11.8 (7.8–15.8)	99.5 (99.1–99.9)
Combined D-BC† categories in the HMDS ($n = 127$)	112/15	88.2 (72.6–82.6)	90.6 (89.1–92.1)	44.1 (38.0–50.2)	98.9 (98.4–99.4)
Infection AND organ dysfunction in HMDS ($n = 677$)	HMDS/RPH ICU				
	227/450	33.5 (30.0–37.0)	97.2 (96.2–98.2)	89.4 (85.6–93.2)	67.6 (65.1–70.1)

D-BC = diagnosis-based code. EDIS = Emergency Department Information System. HMDS = Hospital Morbidity Data System. ICD-10-AM = International classification of diseases, 10th revision, Australian modification. NPV = negative predictive value. PPV = positive predictive value. RPH ICU = Royal Perth Hospital Intensive Care Unit. * This single category contains all the ICD-10-AM codes listed in Table 2 that appeared in EDIS. † This single category contains all the ICD-10-AM codes listed in Table 2 that appeared in the HMDS.

logical studies have used multiple ICD codes in the hospital and ED discharge data to estimate frequency of severe sepsis in the ED.[1,2,28,29] These studies used principal and co-diagnosis ICD-9-CM codes that describe infection and organ dysfunction to identify severe sepsis patients admitted to the hospital. However, this method is not applicable in WA metropolitan EDs where, for each ED attendance, the EDIS software allows only a single diagnosis code to be entered upon discharge from the ED.

Discrepancy in the estimation of severe sepsis using ICD codes upon hospital discharge showed that while Angus and co-workers estimated the incidence of severe sepsis to be three per 1000 population,[1] Martin and colleagues used more restricted codes to identify severe sepsis patients in the same population.[2] In this latter study, the codes for sepsis (ICD-9-CM code 038) and organ dysfunction were shown to have a PPV of 97.7%, an NPV of 80.0%, a sensitivity of 18.8% and a specificity of 98.9%, which is comparable to the performance of the combined D-BC category in our study. The estimated incidence was four per 1000 population for the same year. It has been projected that if the broader codes of Angus et al's study were applied to Martin et al's study cohort, the incidence would have been expanded fourfold. Therefore, the wide discrepancy in the estimates of severe sepsis in the same population raised concern about the validity of using these codes.[27]

The accurate estimation of the disease burden of severe sepsis is important for allocation of resources. It has been suggested that severe sepsis has the characteristics of a public health problem.[30] Administrative data, while it can be conveniently available, show the lack of validity. Hence, over-reliance may provide erroneous estimation of the true incidence and inaccurate evaluation of strategies to reduce morbidity and mortality in severe sepsis. Therefore, to understand its impact on public health, future epidemiological studies should use prospectively collected data whereby each case labelled as severe sepsis has been verified by a clinician.

Although none of the D-BC categories satisfied the criteria for accuracy, they may have some utility in different research settings. If the aim was to determine frequency of true sepsis from the administrative data, D-BC categories with low false positives (ie, combined D-BC categories) in EDIS or HMDS will be desirable, taking into account that the PPV may be affected by the prevalence of the disease. However, if the aim was to screen potential study participants, D-BC categories with maximal sensitivity are preferred, which in this respect would be the combined D-BC in the HMDS for organ dysfunction plus infection.

The findings in our study might support a slightly different conclusion if indeed the diagnosis "labelled" in ED were a true reflection of the diagnosis considered by the clinicians caring for the patient at discharge from the ED and before transfer to ICU: that clinicians have an ability to identify a sick patient and correctly send them to ICU even before a diagnosis of sepsis is made.

Our study has several limitations. We did not evaluate the accuracy of data within each database; however, previous studies, albeit in other clinical groups, have demonstrated a high level of accuracy of the HMDS data.[31]

In our reference standard, we assumed that diagnosis of sepsis made in the ICU to be directly related to the diagnosis made in the ED. It was possible that some of the patients did not have sepsis in the ED but developed sepsis later in the ICU stay. Ideally, these patients should have been excluded. However, we reasoned that the number is small because the profile of the two groups on admission showed that likely sepsis diagnosis was already present in ED.

Part of our analysis had tested the link between specific diagnosis and a broader diagnostic group; for example, "cholangitis on discharge from ED" has been linked to "severe sepsis in ICU" not to "cholangitis in ICU", which is a subset of severe sepsis. We recognised that this will intrinsically affect the findings of specificity and sensitivity.

We used both the ICD-10-AM and ICD-9-CM codes in our study. The RPH ICU database lagged in the transition from ICD-9-CM coding to ICD-10-AM coding during the period of the study and are only used to establish our cases. In contrast, the ICD-10-AM is used consistently in the EDIS and the HMDS data for analysis. The translation of ICD-9-CM to ICD-10-AM may have introduced unavoidable errors, a consequence of the coding transition. With our findings, we had attempted to extrapolate the incidence of sepsis in the general population to allow comparison with other epidemiological studies. However, we have only tested these diagnostic systems among patients who were subsequently admitted to ICU. Hence, the conclusion is limited without testing the validity of these diagnostic systems in the whole ED cohort.

The results were derived from a single tertiary centre that receives transferred patients from other hospitals. These patients may have a sepsis diagnosis established in the primary hospital and may have different characteristics and outcomes compared with the community acquired sepsis. We therefore excluded transfer patients in our cohort to enable the findings to be generalised to other health care settings.

In conclusion, ICD-10-AM codes are limited in identifying severe sepsis patients admitted to ICU from the ED. Hence, the use of administrative data may not be useful to estimate disease burden.

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Competing interests

None declared.

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