Incidence and mortality of sepsis in Hong Kong between 2009 and 2018 based on electronic health records: abridged secondary publication

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KEY MESSAGES

1. Sepsis causes one in four deaths among adults in Hong Kong and affects eight in 1000 adults annually.
2. The incidence and mortality rate of sepsis in Hong Kong increased from 2009 to 2018. The mortality rate reached 47% among patients with sepsis complicated by multiorgan failure.
3. Objective clinical data from electronic health records provide more accurate sepsis surveillance compared with administrative coding.

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Introduction

In Hong Kong, septicaemia is among the top 10 causes of death, with an estimated annual incidence of 296.1 per 100 000.[1] Administrative codes from hospital discharge databases or death certificates are commonly used to estimate the sepsis burden. However, these methods lack sensitivity and have low specificity.[2] A more accurate and objective approach involves analysing electronic health records (EHRs) for clinical markers of infection and concurrent organ dysfunction. We used our previously validated EHR-based surveillance to determine age- and sex-adjusted standardised estimates of sepsis incidence and mortality among adults in Hong Kong between 2009 and 2018; we also compared the performance of this method with that of administrative methods.[3]

Methods

Using the Clinical Data Analysis and Reporting System, we applied our sepsis definition to all adults (age ≥18 years) admitted to the 41 public hospitals in Hong Kong between 1 April 2009 and 31 March 2019. Adult sepsis events were defined using the estimated Sequential Organ Failure Assessment (SOFA) score.[3,4] Sepsis was defined as clinical evidence of (1) presumed infection: any microbiological culture and antibiotic treatment within ±2 calendar days of the index culture date continued for at least 4 days (unless death or hospital discharge occurred before the fourth day); and (2) concurrent acute organ dysfunction: an increase of ≥2 points in SOFA score within ±2 calendar days of the index culture date, with the prehospital SOFA score as baseline. SOFA

scores were calculated based on prehospital and hospital laboratory data, vasopressor drug records, and (rarely) diagnostic/procedural codes. Hospital episodes involving presumed infection but an increase of <2 points in SOFA score were classified as 'uncomplicated infection'. The 'all infection' group included all 'uncomplicated infection' cases and all 'sepsis' cases. Microbiological samples collected for infection control purposes were not used to determine infection status.

To compare differences in estimated sepsis burden, we applied four additional administrative methods (implicit, explicit, Martin, and local sepsis codes) and two variations of the EHR-based definition to the same dataset. The two variations of the EHR-based definition included 'no prehospital SOFA score' (only using an in-hospital SOFA score of ≥2 to identify sepsis) and 'only objective data' (using clinical data [eg, bilirubin level, platelet count, creatinine level, Glasgow Coma Scale score, the ratio of partial pressure of oxygen in arterial blood to the fraction of inspiratory oxygen concentration, and vasopressor drug records] but not diagnostic/procedural codes to calculate SOFA scores).

Two physicians, both blinded to the EHR method, independently reviewed medical records for 500 hospital episodes to determine presence of sepsis. The performances of the different surveillance methods were assessed in terms of sensitivity, specificity, positive and negative predictive values, and area under the curve (AUC); physician consensus served as the gold standard.

Mortality was defined as all-cause mortality at hospital discharge. Standardised estimates of sepsis incidence and mortality were adjusted for age and sex, with the 2008 population structure as reference. Relative annual changes in estimated incidence and mortality were modelled by exponential regression. Case fatality risk (CFR) was calculated by dividing the number of all-cause deaths at hospital discharge by the total number of cases. The proportions of sepsis-related deaths were calculated by dividing the numbers of all-cause sepsis-related deaths by all deaths among Hong Kong population, all hospital episodes, and all infections. Differences in AUCs were assessed using the DeLong test. A P value of <0.05 was considered statistically significant.

Results

We analysed 13 540 945 adult hospital episodes involving 2 928 757 patients to identify sepsis cases during the study period. Among these episodes, there were 2 373 393 (17.5%) all infection cases, including 1 888 852 (14.0%) uncomplicated infection cases and 484 541 (3.6%) sepsis cases. Overall, 54.9% of sepsis cases requiring either mechanical ventilation or vasopressors were managed in general wards, rather than in intensive care units (ICUs). Among the sepsis cases, those managed in general wards had a higher mortality rate, compared with those admitted to ICUs (54.3% vs 30.0%, P<0.001). Sepsis cases with ≥4 organ dysfunctions (8.9%) had the highest CFR (47.3%); 43.2% of sepsis cases had two organ dysfunctions and a CFR of 18.4%.

Our EHR-based sepsis surveillance method showed that sepsis incidence from 2009 to 2018 increased from 623 to 756 per 100 000 (relative increase of 2.8%/year, P<0.001), whereas sepsis mortality increased from 142 to 156 per 100 000 (relative increase of 1.9%/year, P=0.002) [Fig 1]. The implicit method (relative decrease of 2.9%/year, P<0.001) and the explicit method (relative decrease of 4.0%/year, P=0.001) indicated decreases in sepsis incidence, as did sepsis mortality when the implicit method (relative decrease of 2.8%/year, P=0.001) and the explicit method (relative decrease of 4.8%/year, P<0.001) were used. Between 2009 and 2018, sepsis CFR slightly declined from 23.0% to 21.6% (relative decrease of 0.5%/year, P=0.03) [Fig 2]. A greater reduction in CFR from 3.0% to 2.4% (relative decrease of 2.2%/year, P<0.001) was observed among all hospital episodes. The proportion of sepsis-related deaths increased among all deaths (relative increase of 3.9%/year, P<0.001) [Fig 2].

The sensitivities of administrative methods ranged from 5% to 15%, compared with 84% for the EHR-based definition. In contrast, the specificities of the EHR-based and administrative methods were consistently ≥96%. The EHR method had the highest AUC (0.91) for distinguishing sepsis among all infection cases, compared with other methods (P<0.001). The implicit and explicit methods had AUCs of 0.55 and 0.52, respectively.

Discussion

In 2018, the standardised sepsis incidence in Hong Kong was 756 per 100 000, which is similar to rates in Sweden (780) and Taiwan (772); higher than rates in France (403), China (422), Spain (445), England (102), New Zealand (107), Norway (140), Brazil (290), and South Korea (453); and much lower than rates in Australia (1163) and Malawi (1772). Administrative methods demonstrated low sensitivity (15%) and thus greatly underestimated sepsis incidence in Hong Kong. In contrast, the EHR method displayed 84% sensitivity and 99% specificity. Our EHR-based estimates of sepsis incidence were generally higher than those reported in studies that used administrative methods alone such as studies from France, Spain, South Korea, Brazil, Norway, and New Zealand. In contrast, our estimates of sepsis incidence were similar to those reported in studies from Sweden and Beijing, which used objective clinical data.

The low sensitivity of administrative methods may be attributable to Hong Kong–specific factors

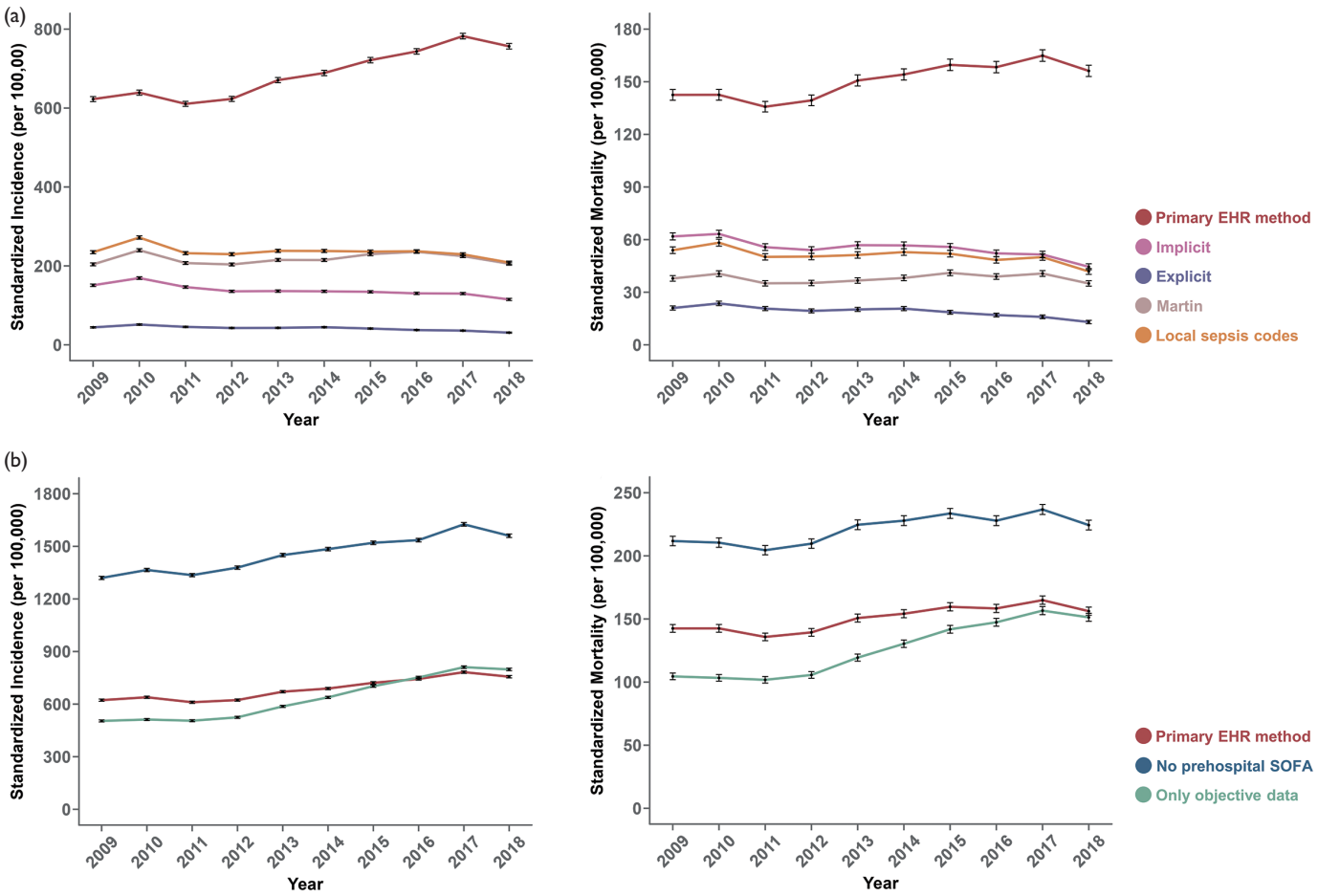

FIG 1. Age- and sex-adjusted standardised estimates of sepsis incidence and mortality in Hong Kong from 2009 to 2018, based on our electronic health record (EHR) method, compared with (a) four other administrative methods (implicit, explicit, Martin, and local sepsis codes) and (b) two variations of our EHR method ('no prehospital Sequential Organ Failure Assessment [SOFA] score' and 'only objective data').

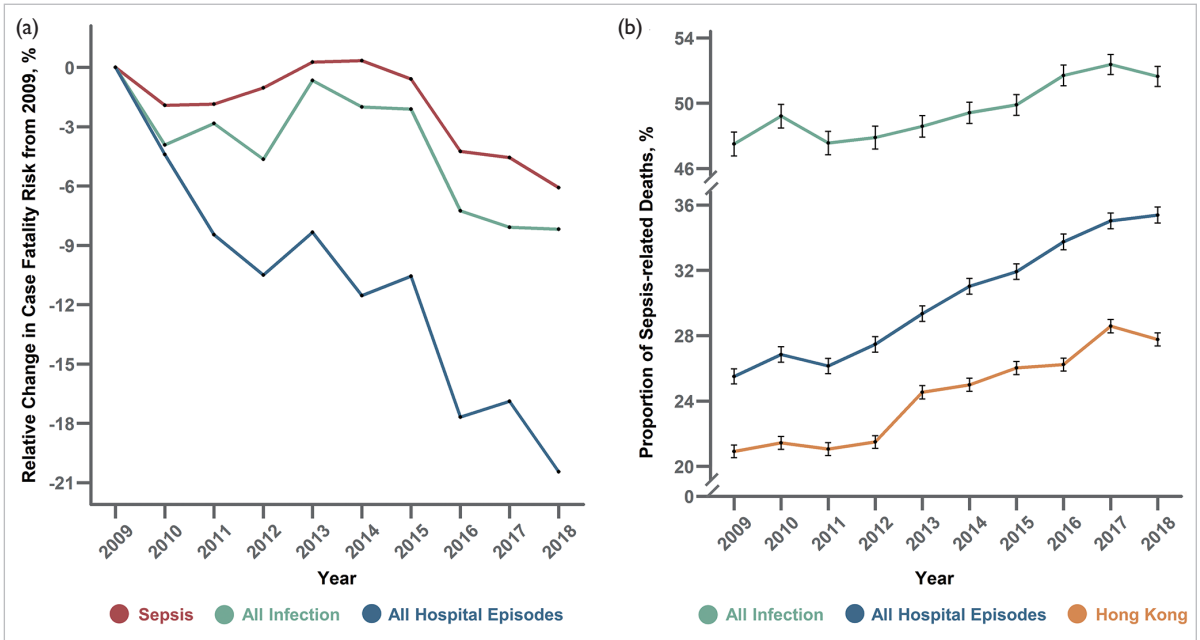

FIG 2. (a) Relative changes in case fatality risk for sepsis, all infections, and all hospital episodes at discharge from 2009 to 2018. (b) Annual proportions of sepsis-related deaths among all infection deaths, all hospital episode deaths, and all Hong Kong deaths.

such as the lack of dedicated coding teams, inadequate training in diagnostic coding, and independence from public healthcare funding. Notably, objective data regarding prescriptions for antihypertensive drugs and diagnostic codes for hypertension exhibited discrepancies in Hong Kong's population health database. In the United States, changes in coding practices and sepsis awareness over time have contributed to increases in reported sepsis incidence and declines in CFR estimated by administrative methods, compared with estimated by objective clinical data.[5] Our results highlight the potential for confounding when different sepsis surveillance methods are used without robust validation.

In 2018, 27.8% of all deaths in Hong Kong were at least partly attributable to sepsis. This percentage is at least 20% higher than official statistics based on death certificates, which combine pneumonia and septicaemia. Sepsis is increasingly becoming the primary cause of death because the slight improvement in sepsis CFR (relative decrease of 0.5%/year) has lagged behind the pace of overall improvement in survival from other diseases.

Hong Kong faces a substantial healthcare resource deficit in treating sepsis, considering that 54.9% of sepsis cases requiring vasopressors or mechanical ventilation were managed in general wards, rather than in ICUs. Only 12.9% of sepsis cases were managed in ICUs, likely because few ICU beds were available; this rate is much lower than the 54.7% reported in the United States but similar to the 17.1% reported in Japan and 13.8% reported in Beijing. Our results highlight the need to increase critical care provision in Hong Kong to match the sepsis burden, as timely ICU admission may improve sepsis survival rates.

Conclusions

Sepsis constitutes a major health challenge in Hong Kong, with one in four deaths attributable to sepsis. An expansion of critical care services is necessary to address the rising incidence and mortality rates of sepsis. Our findings demonstrate the feasibility and advantages of an EHR-based approach for sepsis surveillance.

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Disclosure

The results of this research have been previously published in:

1. Ling L, Zhang JZ, Chang LC, et al. Population sepsis incidence, mortality, and trends in Hong Kong between 2009-2018 using clinical and administrative data. Clin Infect Dis 2023:ciad491.

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