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Comparison of In-Hospital Maternal Mortality Between Hospital Systems in Queensland, Australia and Louisiana, United States

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Background: It is well documented that the American maternal mortality ratio has increased during the years 2000-2015. The Australian maternal mortality ratio, in contrast, has decreased during the same time period, a trend common among most Western countries.

Methods: This study was a retrospective cohort study of cases of in-hospital maternal deaths in the Ochsner Health System (Louisiana, United States) and the Queensland Health System (Australia) from 1995 to 2013. The aim was to determine if American and Australian women have a similar rate of preventable maternal death and if the deaths were attributable to the same factors. A multidisciplinary team assessed medical records to determine preventability.

Results: Sixteen eligible medical records were identified in the Ochsner Health System and 15 in the Queensland Health System. In the American cohort, deaths in the private insurance group (n=5) were least likely to be preventable (P=0.003). Australian maternal deaths were less likely to occur among women with late or no prenatal care than American maternal deaths; the risk difference was 44.5% for all deaths (95% confidence interval [CI]=9.7%, 79.4%; P=0.03) and 50.0% for potentially preventable deaths (95% CI=9.3%, 90.6%; P=0.04).

Conclusion: Women from Louisiana, United States and Queensland, Australia have similar rates of preventable maternal death. No statistically significant factors explained trends in Australian maternal death; American maternal mortality was significantly associated with point of entry into prenatal care, likely influenced by insurance status. Furthermore, the majority of deaths in this group were complicated by hospital systems–based factors.

Keywords: *Australia, delivery of health care, epidemiology, maternal death, maternal mortality, United States*

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INTRODUCTION

In 2000, when United Nations Millennium Development Goal 5 was identified as demonstrating the slowest worldwide progress, a global commitment was made to achieve its 2 parts: a 75% reduction in maternal mortality ratio (MMR) from 1990–2015 and provision of universal access to reproductive health.[1] In the report *Trends in Maternal Mortality: 1990-2015*, MMR is defined as maternal deaths per 100,000 live births, and maternal death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration or site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental causes.[1] The United States is the only developed country to show an increase in MMR between 1990 and 2015, rising from 12 to 14, a 16.7% increase.[1]

Morong et al previously conducted a multicenter study of the preventability of maternal mortality in Louisiana within the Ochsner Health System (OHS).[2] OHS is a multihospital tertiary care center and referral center serving pregnant women in Southeast Louisiana and the Gulf Coast and is 1 of 3 major birthing centers in Orleans Parish. Louisiana has the sixth highest MMR in the United States with a rate of 17.9 in 2010.[3] Morong et al reported a statistically significant

association between preventable maternal death and Medicaid or self-pay insurance accommodation, late entry into prenatal care, and patient status requiring transfer to OHS. These findings were the motivation to conduct a comparative study to determine if the same factors contribute to maternal death in a western country with a low MMR.

Australia proved to be the ideal country for comparison; the country has a low MMR that has been decreasing during the same period that the MMR in the United States has been increasing. In Australia, MMR decreased 25% from 1990 to 2015.[1] Australia and the United States have similar levels of wealth, as measured by gross domestic product per capita on purchasing power parity.[4] The two countries have similar rates of medical comorbidities known to affect pregnancy, such as hypertension, diabetes, and obesity.[5,6] However, all Australian citizens and permanent residents are eligible for public health insurance under a socialized system, providing an interesting point of comparison to the health system in the United States during the study period. The aim of this study was to determine whether Americans and Australians have a similar rate of preventable maternal death and if the deaths were attributable to the same factors.

METHODS

A retrospective cohort study of all known cases of in-hospital maternal deaths within the OHS and Queensland Health System (QHS) was conducted (Figure 1). The QHS encompasses all public hospitals within the state of Queensland, an Australian state with a population of approximately 4.7 million residents. Sixteen Health and Hospital Services (HHS) span the state, each of which is a statutory body governing many hospitals and clinics. We approached 3 HHS for a total of 7 hospitals; one, the Mater Mothers' hospital, is not part of the QHS. Not all hospitals within the QHS are maternity hospitals. Initial institutional review board (IRB) approval was granted by the Royal Brisbane and Women's Hospital IRB and this approval was expanded to include all Queensland hospitals via a Queensland Health Statistics Branch (HSB) IRB approval. Approval through the OHS IRB was based on Royal Brisbane and Women's Hospital IRB approval, the first time the Ochsner IRB has approved a project based on a foreign permission. A waiver of consent was issued for all hospital sites through a Public Health Act application. Individual hospitals' site-specific applications were completed when requested.

Medical records were identified within the OHS by obstetric diagnosis-related group and a discharge code of deceased for the period January 1, 1995 through December 31, 2013. All 11 hospitals in the OHS were examined for inclusion. As with the QHS, not all OHS hospitals offer maternity services. Of the 104 OHS medical records identified and reviewed, 16 fit the inclusion criteria of (1) meeting the World Health Organization (WHO) definition of maternal mortality and (2) death within a hospital. In the QHS, the HSB provided linkage data between the Queensland Perinatal Data Collection (PDC) and death records and the Queensland Hospital Admitted Patient Data Collection (QHAPDC) and death records.[7,8] The PDC and QHAPDC are government-maintained electronic records of all births and all admitted hospital patients in Queensland, respectively. Initial identification was based on International Classification of Diseases, 9th Edition and 10th Edition codes, as well as text search for the words maternal, obstetric, pregnant, labor, puerperium, and/or placenta in the cause-of-death field.

The Queensland HSB was responsible for extracting patient medical records that fit the inclusion criteria and ensuring patients were not counted twice (Figure 2). A total of 57 medical records were initially identified by the HSB for inclusion. Records could only be accessed at facilities where ethical approval was granted during the years that the study was ongoing and where a research investigator was present, limiting the geographic scope of the study to southeastern Queensland. The investigators reviewed 18 charts, and 15 were ultimately included. Three were excluded because cause of death was missing. In all 3 cases, a paucity of data prevented evaluation by the multidisciplinary team (MDT) described below.

An MDT of 10 obstetrician/gynecologists, maternal-fetal medicine specialists, anesthesiologists, and nurses convened on 2 separate occasions to review the 31 cases. These 31 cases represented all cases identified in the OHS and all cases at institutions where an investigator was present in the QHS. The team was asked to reach a consensus decision if the deaths were preventable, potentially preventable, or not preventable based on a literature search that yielded unanimous support of the preventability classifications put forth by Geller et al at the University of Illinois, Chicago.[9] This methodology required members of the MDT to classify preventable deaths as those that could have been avoided by any "action or inaction on the part of the health care provider, the system, or the patient that may have caused or contributed to progression to more severe morbidity or death."[9] This method has high interrater reliability (overall agreement 77%, Cohen kappa 0.49).[10] Because of the rarity of maternal mortality and the consequent small number of identified cases, deaths classified as preventable or potentially preventable were analyzed together (categorized as potentially preventable) and contrasted with not-preventable deaths.

The MDT was also asked to reach a majority decision if preventable and potentially preventable deaths were also complicated by provider-, systems-, or patient-based failures of care or some combination thereof. A full list of the failures identified by the MDT is available as supplemental information to the article "Establishment of a National Severe Maternal Morbidity Preventability Review in New Zealand" by MacDonald et al.[11] The same definitions were used in the American and Australian cohorts. Finally, the MDT was asked to reach a majority decision if the patient entered her pregnancy in a healthy state or with minor or major morbidity.

Summary statistics are presented as frequency (percentage) for categorical outcomes and mean (range) for continuous outcomes. The association between patient characteristics and cohort (Louisiana/Queensland) and type of death (potentially preventable/not preventable) was examined using Fisher exact test for categorical outcomes and the Mann-Whitney *U* test for continuous outcomes. The association between clinical characteristics and cohort is reported using risk difference (RD) and 95% confidence interval (CI). RD was calculated by subtracting the Austra-

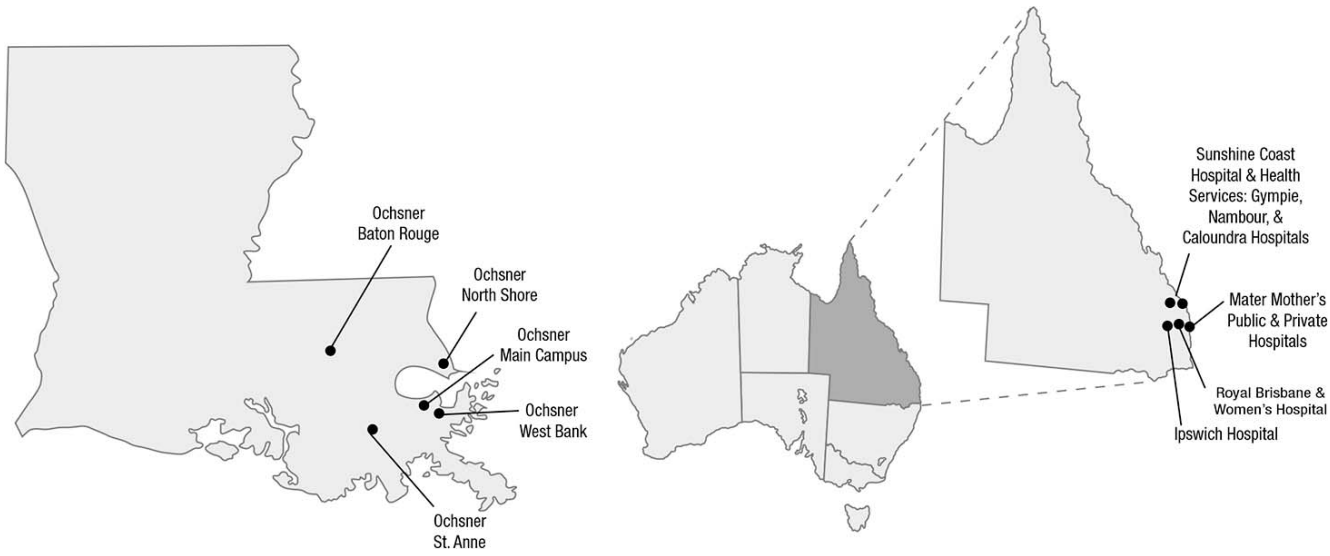

Figure 1. Geographic reach of study.

lian risk from the American risk; a positive RD favors the Australian cohort, a negative RD favors the American. All available data points were analyzed for each outcome, with missing data excluded on an item-by-item basis. A *P* value <0.05 was considered statistically significant. Statistical analysis was undertaken using Stata statistical software v.13.1 (StataCorp).

RESULTS

Demographic, social, and clinical characteristics are displayed in Table 1. We found no statistically significant differences in characteristics between the cohorts, although the Australian women tended to be older (mean age of 32.5 years vs 28.8 years, $P=0.14$) and less likely to have private insurance (6.7% vs 31.3%, $P=0.17$) than the American

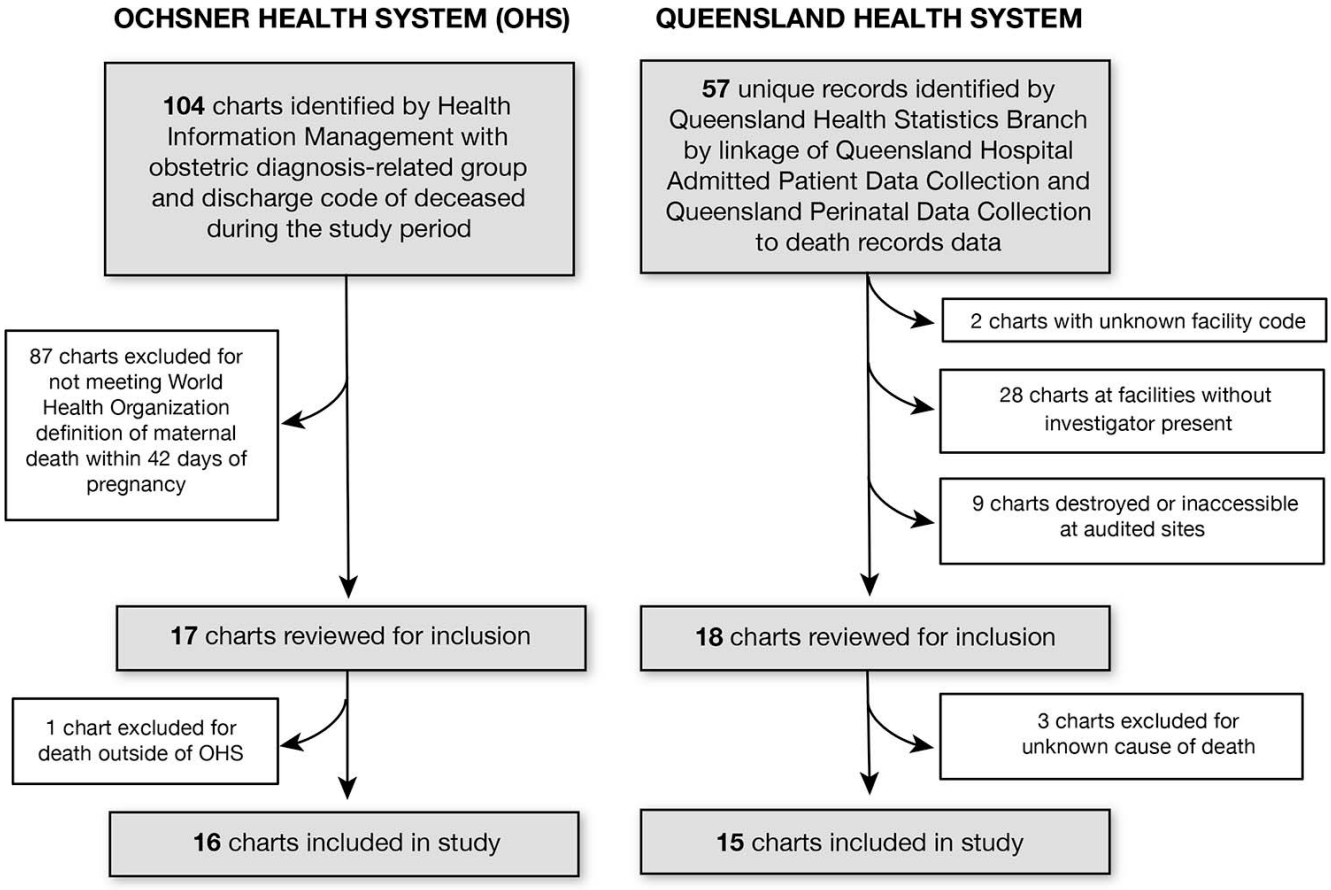

Figure 2. Data collection process.

Table 1. Baseline Characteristics

Variable	American Cohort (n=16)	Australian Cohort (n=15)	*P* Value
Mean age, years	28.8 (19-37)	32.5 (23-41)	0.14
Caucasian	9 (56.3)[a]	7 (46.7)[a]	0.43
Mean body mass index,[b] kg/m^2	30.6 (16.1-54.9)	26.4 (18.7-35.0)	0.57
Lifestyle factors complicating pregnancy[c]	6 (42.8)	3 (23.1)	0.25
Entering with healthy pregnancy	2 (12.5)	1 (6.7)	1.00
Entering with minor morbidity	4 (25.0)	6 (40.0)	0.46
Entering with major morbidity	10 (62.5)	7 (50.0)[a]	0.48
Primigravida	3 (18.8)	1 (7.1)[a]	0.60
Multiparous	13 (81.3)	13 (92.9)[a]	0.35
Private insurance	5 (31.3)	1 (6.7)	0.17
Public insurance/Medicaid	9 (56.3)	12 (85.7)[a]	0.08
Received general anesthesia	5 (31.3)	8 (53.3)	0.29
Transferred during care[d]	5 (31.3)	3 (20.0)	0.69
Late or no prenatal care	6 (54.5)[e]	1 (10.0)[e]	0.03

Note: Continuous characteristics are presented as mean (range) and categorical characteristics are presented as frequency (%).
[a]Not available for 1 patient.
[b]Body mass index at death. Not available for 2 American and 6 Australian patients.
[c]Any alcohol, tobacco, or illicit drug consumption during pregnancy; does not include previous use. Not available for 2 American and 2 Australian patients.
[d]Between facilities; does not include intensive care unit admission.
[e]Not available for 5 patients.

women. The American cohort was 40% African American (6 of 15, with 1 case of unrecorded ethnicity) and 60% Caucasian (9 of 15), whereas the Australian cohort was 50% Caucasian (7 of 14, with 1 case of unrecorded ethnicity) and the other 7 patients (50%) were a mix of Middle Eastern, Aboriginal Australian, Asian, and African.

Seventy-five percent of American deaths (n=12) and 73.3% of Australian deaths (n=11) were deemed potentially preventable. Of the American deaths, 3 (75.0%) of the patients with not-preventable deaths and 7 (58.3%) of the patients with potentially preventable deaths entered their pregnancies with a major morbidity (RD=16.7%, 95% CI=–34.1%, 67.4%; *P*=1.00) (Table 2). Of the Australian deaths, 2 (66.7%) of the patients with not-preventable deaths and 5 (45.5%) of the patients with potentially preventable deaths entered their pregnancies with a major morbidity (RD=21.2%, 95% CI=–39.7%, 82.1%; *P*=0.71) (Table 3). No statistically significant risk difference for preventable death between Australian or American woman entering their pregnancies with a major morbidity was found (RD=12.9%, 95% CI=–27.7%, 53.4%; *P*=0.54) (Table 4).

The MDT classified potentially preventable deaths as provider-based, systems-based, and/or patient-based failures. Nine (75.0%) of the potentially preventable American deaths were thought to be complicated by provider-based failures of care, 9 (75.0%) by systems-based failures, and 6 (50.0%) by patient-based failures. Of the potentially preventable Australian deaths, 8 (72.7%) were thought to be complicated by provider-based failures of care, 6 (54.5%) by systems-based failures, and 7 (63.6%) by patient-based failures.

Table 2. Association Between Patient Characteristics and Preventability of Maternal Death: American Cohort

Variable	Not-Preventable Death (n=4)	Potentially Preventable Death (n=12)	*P* Value
Major morbidity	3 (75.0)	7 (58.3)	1.00
Non-Caucasian ethnicity	0 (0)[a]	6 (50.0)	0.23
Age ≥35 years	0 (0)	2 (16.7)	0.73
Private insurance	4 (100.0)	1 (8.3)	0.003
Public insurance/Medicaid[a]	0 (0)	9 (75)	0.26
Transferred during care	1 (25.0)	4 (33.0)	0.82
Late or no prenatal care	1 (33.0)[b]	5 (62.5)[c]	0.55
Multiparous	3 (75.0)	10 (83.3)	1.00

Note: Data are presented as frequency (%).
[a]Does not include uninsured patients (n=2).
[b]Not available for 1 patient.
[c]Not available for 4 patients.

Table 3. Association Between Patient Characteristics and Preventability of Maternal Death: Australian Cohort

Variable	Not-Preventable Death (n=4)	Potentially Preventable Death (n=11)	*P* Value
Major morbidity	2 (66.7)[a]	5 (45.5)	0.71
Non-Caucasian ethnicity	1 (25.0)	6 (60.0)[a]	0.56
Age ≥35 years	3 (75.0)	3 (27.3)	0.30
Private insurance	0 (0)	1 (9.1)	1.0
Public insurance[b]	3 (75.0)	9 (81.8)	1.0
Transferred during care	0 (0)	3 (27.3)	1.00
Late or no prenatal care	0 (0)[c]	1 (12.5)[d]	1.0
Multiparous	3 (100.0)[a]	10 (90.9)	1.00

Note: Data are presented as frequency (%).
[a]Not available for 1 patient.
[b]Does not include uninsured (n=1) or unknown (n=1) insurance accommodation.
[c]Not available for 2 patients.
[d]Not available for 3 patients.

Looking at the 2 cohorts separately, preventability of Australian maternal mortality could not be significantly linked to any demographic qualifier (Table 3). In the American cohort, however, private insurance accommodation was less correlated with preventable maternal mortality (*P*=0.003) (Table 2).

Comparing the 2 cohorts, late point of entry into prenatal care—defined as after 14 weeks' gestational age or no prenatal care—was correlated with a higher risk of potentially preventable death (RD=50.0%, 95% CI=9.3%, 90.6%; *P*=0.04) and of overall death (RD=44.5%, 95% CI=9.7%, 79.4%; *P*=0.03) in the American cohort compared to the Australian cohort (Tables 4 and 5). No other factors reached statistical significance.

DISCUSSION

Because of the large catchment area of each hospital system, our impression is that the cohorts in this study reflect larger trends in national maternal mortality. The American data in this study mirror national mortality trends, with a majority of cases clustered in the later years of the study period. The Australian data in this study reach peak incidence in 2004 and then taper off, whereas Australian national data show a peak in 2000 and then a downward trend.[1]

Compared to Australian deaths, a statistically significant number of American deaths, both preventable and overall, were linked to a late point of entry into prenatal care. Numerous factors affect a woman's decision to seek prenatal care, including insurance status, patient education, socioeconomic status, and time when the pregnancy is first confirmed. Our study found that among the American cohort, deaths in the group with private insurance were likely to be not preventable. In fact, 100% of the American patients who had not-preventable deaths had private insurance, and only 1 of the 12 American patients with a potentially preventable death had private insurance. Conversely, all deaths among American patients who were covered by Medicaid or were uninsured were considered potentially preventable. As a point of reference, from 2010 (when insurance data became available at a statewide level) to 2013 (when this study began), 33.0% of maternity patients in the OHS had private insurance, 65.4% had Medicaid, and 1.6% had no insurance according to data made available to us by the State of Louisiana Office of Public Health.

The same trends did not hold true in the Australian cohort. Australian maternal mortality could not be appreciably linked to any of the demographic factors assessed, indicating that deaths in this cohort are more likely to be

Table 4. Association Between Clinical Characteristics in the American and Australian Cohorts: Preventable Deaths

Variable	American Cohort (n=12)	Australian Cohort (n=11)	Risk Difference (95% CI); *P* Value
Major morbidity	7 (58.3)	5 (45.5)	12.9% (–27.7%, 53.4%); 0.54
Non-Caucasian ethnicity	6 (50.0)	6 (60.0)[a]	–10.0% (–51.5%, 31.5%); 0.64
Age ≥35 years	2 (16.7)	3 (27.3)	–10.6% (–44.3%, 23.1%); 0.54
Private insurance	1 (8.3)	1 (9.1)	–0.8% (–23.8%, 22.3%); 0.95
Public insurance/Medicaid	9 (75.0)	9 (81.8)	–6.8% (–40.3%, 26.6%); 0.69
Transferred during care	4 (33.3)	3 (27.3)	6.1% (–31.4%, 43.5%); 0.75
Late or no prenatal care	5 (62.5)[b]	1 (12.5)[c]	50.0% (9.3%, 90.6%); 0.04
Multiparous	10 (83.3)	10 (90.9)	–7.6% (–34.7%, 19.5%); 0.59

Note: Data are presented as frequency (%). CI, confidence interval.
[a]Not available for 1 patient.
[b]Not available for 4 patients.
[c]Not available for 3 patients.

Table 5. Association Between Clinical Characteristics in the American and Australian Cohorts: All Deaths

Variable	American Cohort (n=16)	Australian Cohort (n=15)	Risk Difference (95% CI); *P* Value
Major morbidity	10 (62.5)	7 (50.0)[a]	12.5% (–22.8%, 47.8%); 0.49
Non-Caucasian ethnicity	6 (40.0)[a]	7 (50.0)[a]	–10.0% (–46.1%, 26.1%); 0.59
Age ≥35 years	2 (12.5)	6 (40.0)	–27.5% (–57.1%, 2.1%); 0.08
Private insurance	5 (31.3)	1 (6.7)	24.6% (–1.4%, 50.6%); 0.08
Public insurance/Medicaid	9 (56.3)	12 (85.7)[a]	–29.5% (–59.9%, 1.0%); 0.08
Transferred during care	5 (31.3)	3 (20.0)	11.3% (–19.2%, 41.7%); 0.47
Late or no prenatal care	6 (54.5)[b]	1 (10.0)[b]	44.5% (9.7%, 79.4%); 0.03
Multiparous	13 (81.3)	13 (92.9)[a]	–11.6% (–35.0%, 11.8%); 0.35

Note: Data are presented as frequency (%). CI, confidence interval.
[a]Not available for 1 patient.
[b]Not available for 5 patients.

random occurrences. The authors concluded that although pregnant women and new mothers face similar comorbidities in their home countries, women in Australia and America encounter different barriers in access to healthcare. Anecdotal evidence suggests that Australian hospitals serve a more remote population. However, with respect to the population to hospital ratio (measured as hospital beds per 1,000 persons) Australia led the United States 3.9 to 2.9 in 2010.[12] In addition, Australian Medicare is a publicly funded universal healthcare system. It allows the holder—an Australian citizen or permanent resident—a subsidized rate from practitioners who hold a provider number and free care in public hospitals. Private insurance also exists and allows the holder access to a wider range of services or care. Of the Australian hospitals surveyed, public insurance accommodation was vastly more common among maternity patients; the majority of hospitals had ≤5% of patients with private insurance during the study period (data furnished by the Queensland PDC). The American healthcare system during the years of our study (ie, before the implementation of the Affordable Care Act) did not require Americans to have an employer-sponsored health plan, Medicaid, Medicare, or other public insurance program. The Affordable Care Act mandated this requirement; otherwise, the uninsured person risked a penalty.[13]

Rates of access to prenatal care, in both the not-preventable and potentially preventable death categories, were much lower in the American cohort than in the Australian cohort. The authors believe difficulties in access to prenatal care may represent financial barriers to care existing in the American system that are not inherent in the Australian system. None of the crucial factors identified in the first study—point of entry into prenatal care, insurance accommodation, or transfer to a higher level of care—was statistically significant in the Australian arm of the data. The MMR in Australia is and has been much lower than the MMR in the United States since the earliest documented WHO data in 1990. We conclude that this lower MMR is more likely due to chance than to the demographic factors we surveyed.

A limitation of our study is the cohort size. Because of the relatively small sample sizes of our cohorts, the analyses may be underpowered, particularly the demographic and clinical factors with missing data, the most important of which is the late or no prenatal care category that was missing 5 data points in both the American and Australian arms of the study. The strengths of this study, however, are the rigorous method of case identification used in each country and the thorough account of a woman's path that was presented to a highly trained MDT.

CONCLUSION

The events leading to a maternal death can be conceptualized as predisposing and precipitating factors. Predisposing factors are those that place a woman at a more high-risk point on the maternal mortality continuum, while precipitating factors are those that accelerate her trajectory to ultimate mortality. The largest disparity between the United States and Australia with regard to maternal health seems to be in predisposing factors such as insurance accommodation and access to prenatal care that affect the course of pregnancy before delivery. Census data indicate that the United States is still failing to achieve United Nations Millennium Development Goal 5A—a 75% reduction in its MMR. But, equally importantly, this study suggests the United States is not meeting goal 5B—universal access to reproductive healthcare—either.

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