**Annals of Internal Medicine** SUPPLEMENT

**Regional Variations in Maternal Mortality and Health Workforce Availability in the United States**

**John E. Snyder, MD, MS, MPH; Anne L. Stahl, PhD; Robin A. Streeter, PhD, MPH; and Michelle M. Washko, PhD, MS**

**Background:** Skilled, high-quality health providers and birth at- tendants are important for reducing maternal mortality.

**Objective:** To assess whether U.S. regional variations in mater- nal mortality rates relate to health workforce availability.

**Design:** Comparison of regional variations in maternal mortality rates and women's health provider rates per population and identiﬁcation of a relationship between these measures.

**Setting:** U.S. health system.

**Participants:** Women of child-bearing age and women's health providers, as captured in federal data sources from the Centers for Disease Control and Prevention, Census Bureau, and Health Resources and Services Administration.

**Measurements:** Regional-to-national rate ratios for maternal mortality and women's health provider availability, calculated per population for women of reproductive age. Provider availability was examined across occupations (obstetrician-gynecologists, internal medicine physicians, family medicine physicians, certiﬁed nurse- midwives), in service-based categories (birth-attending and primary care providers), and across the entire women's health workforce (all studied occupations).

he United States has one of the highest maternal mortality rates among developed nations, and this rate has increased markedly over the past several de- cades (1, 2). Limited access to high-quality prenatal and maternity care services contributes to mortality risks, particularly for lower-income individuals, members of racial and ethnic minority groups, and those living in rural areas distant from health care providers and facil- ities (3–9). Broader determinants of maternal mortality have been characterized into 3 categories: individual nonmedical risk factors (such as poverty and racial/eth- nic inequities), social and economic context (such as women's societal status and legality of reproductive health services), and factors related to physical environ- ment and health systems (such as number, quality, and

**T**

distribution of health workers and facilities) (10).

Core to the mission of the Health Resources and Services Administration (HRSA) is improving health out- comes and addressing health disparities by strengthen- ing access nationally to a skilled health workforce and quality health services, which are conceptually important factors for addressing maternal mortality (10 –12). For ex- ample, sufﬁcient access to obstetrician-gynecologists is critical for managing pregnancy complications and ob- stetric emergencies, and care by internists and other pri- mary care providers is important for providing compre-

**Results:** Maternal deaths per population increased nationally from 2009 to 2017 and, in 2017, were signiﬁcantly higher in the South and lower in the Northeast (*P* < 0.001) than nationally. The occupational composition and per-population availability pat- terns of the women's health workforce varied regionally in 2017. The South had the lowest availability in the nation for nearly ev- ery health occupation and category studied, and the Northeast had the highest. This exploratory analysis suggests that subna- tional levels of provider availability across a region may be asso- ciated with higher maternal mortality rates.

**Limitations:** No causal relationship was established. Nationally representative maternal mortality and health workforce data sources have well-known limitations. Low numbers of observa- tions limit statistical analyses.

**Conclusion:** Regional variations in maternal mortality rates may relate to the availability of birth-attending and primary care providers.

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hensive chronic disease management before, during, and after pregnancy (13, 14). Obstetrician-gynecologists and primary care providers both provide core health services to women, with the latter appearing to play a particularly important role in rural areas and lower– birth volume hos- pitals (15, 16). Although international studies have corre- lated health worker access and maternal mortality, studies ﬁnding a direct association between availability of health care providers for women of reproductive age and mater- nal mortality in the United States are lacking (17–22).

A pair of reports from HRSA's National Center for Health Workforce Analysis have projected future short- ages of primary care providers and women's health providers across multiple professions, both nationally and regionally (23, 24). A nationwide deﬁcit of 23 640 primary care physicians and 4930 obstetrician- gynecologists is anticipated by 2025, with shortages distributed unevenly across U.S. census regions and the South having the greatest collective workforce shortfalls. In light of these ﬁndings, this study aimed to investigate whether there may be a geographic associ- ation between increased maternal mortality rates and decreased availability of key health care providers serv- ing women of reproductive age across census regions. Preliminary identiﬁcation of such a relationship would provide support for including directed health workforce

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reinforcement as one component of a multifaceted strate- gic approach for addressing maternal mortality. For the purposes of this study, the health professions examined include allopathic and osteopathic physicians in the spe- cialties of obstetrics-gynecology, family medicine, and in- ternal medicine, as well as certiﬁed nurse-midwives. Re- gional availability patterns for nurse practitioners and physician assistants were also assessed.

**METHODS**

To examine regional differences in maternal mor- tality, national vital statistics information on births and maternal deaths was analyzed using data collected by the Centers for Disease Control and Prevention (CDC) and made publicly available through the Wide-ranging ONline Data for Epidemiologic Research (WONDER) portal (25). WONDER provides access to many health- related data sets for use in epidemiology-focused pub- lic health research and is particularly useful for studying health care trends in highly populated areas, such as states, regions, or the nation as a whole (26). WONDER data were selected for study because of the availability of more recent years of maternal mortality data than other resources, and it also matched years for which health workforce data were available. Consistent with the CDC deﬁnition, maternal mortality events occurring up to 1 year after childbirth or pregnancy termination were retrieved from WONDER using relevant cause of death codes relating to pregnancy, childbirth, or the puerperium (Appendix Table, available at [Annals.org),](http://www.annals.org/) deﬁned since 1999 in the system using the Interna- tional Classiﬁcation of Diseases, 10th Revision (ICD-10) (27, 28). Maternal deaths were tabulated by U.S. census region for the period from 2009 to 2017. Census re- gion was chosen as the geographic unit of analysis for alignment with available health workforce data and be- cause other WONDER-based studies relating physician supply to mortality have identiﬁed regional patterns, presumably due to shared socioeconomic and popula- tion characteristics within regions (29).

To determine regional maternal mortality rates,

data from the U.S. Census Bureau's American Commu- nity Survey from 2009 to 2017 were used to capture the total population of women of reproductive age (30). A common denominator of providers and maternal mor- tality events per 100 000 women aged 15 to 50 years was used for this study. Although maternal mortality is often reported in public health studies as the number of maternal deaths per a speciﬁed number (for exam- ple, 100 000) of live births, such an index would not have been appropriate for this workforce-focused study for 2 reasons. First, not all deaths attributed to pregnancy, childbirth, and the puerperium result in live births. Second, the health care providers essential to preventing and mitigating risks for maternal morbidity and mortality need to engage in the care of all women of reproductive age before or while contemplating pregnancy. For example, women with asthma or diabe- tes considering pregnancy should be engaged in com- prehensive chronic disease management before preg-

nancy to mitigate their perinatal health risks; such care is often provided by an internist (14). This analytic ap- proach ensures that provider availability is examined relative to the entire target population needing care before, during, and after pregnancy and correspond- ingly examines the rate of maternal deaths within this same population. A similar approach has been used by the CDC for provisional measurement of the U.S. fertil- ity rate and by others researching access to prenatal and pregnancy care (31, 32).

Regional differences in women's health provider availability or density were estimated as the number of per-population providers for women of reproductive age by using 2017 health workforce data from HRSA's Area Health Resources Files for each studied occupa- tion (33). Practitioners examined include obstetrician- gynecologists, family medicine physicians, and certiﬁed nurse-midwives, who directly attend deliveries, and pri- mary care providers (such as internal medicine physi- cians), who typically do not. Estimates from the litera- ture suggest that most U.S. births are attended by obstetrician-gynecologists, with family medicine physi- cians and certiﬁed nurse-midwives attending approxi- mately 9.7% and 7.9% of all births, respectively (34, 35). However, around one third of pregnant women report receiving medical care from a family physician, and nearly two thirds report receiving care from a mix of clinicians, which can include obstetrician-gynecologists, family phy- sicians, midwives, nurse practitioners, and physician assis- tants (36). The regional availability of nurse practitioners and physician assistants was considered separately in this study because data limitations prevented detailed differ- entiation of these providers by specialty area, such as pri- mary care and women's health. Further, variability in state scope of practice regulations results in inconsistent levels of autonomy regionally with respect to diagnosis, treat- ment, and prescriptive authority (37).

Women's health occupations were examined indi- vidually and collectively (“all women's health provid- ers”) to determine whether any observed differences in the effect of health workforce supply on maternal mor- tality could be ascribed to the role of a speciﬁc spe- cialty (such as obstetrician-gynecologist shortages) or overall provider access issues (such as broad workforce insufﬁciency). Additional categorical workforce group- ings were developed to assess whether workforce sup- ply effects might relate to a particular service need that can be provided by more than 1 occupation. Thus, obstetrician-gynecologists, family medicine physicians, and certiﬁed nurse-midwives were studied collectively (“direct childbirth providers”) as the group primarily re- sponsible for attending deliveries. The category “pri- mary care physicians,” which included nonsubspecialist family medicine and internal medicine physicians, was also studied.

Rate ratios were calculated to examine differences in each census region, relative to national levels, for both maternal mortality rates and women's health pro- vider density in 2017. For example, a maternal mortality rate ratio of 1 would suggest that the rate for a given census region is the same as the national rate and that

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there is no unique regional variation from the country as a whole. A rate ratio lower than 1 suggests a lower regional mortality rate than the national average, and a ratio higher than 1 suggests a higher rate. A rate ratio approach has been used by others to examine mater- nal mortality risks where risk varies geographically (38). Despite a low number of observations available for sta- tistical analysis, exploring whether regional mortality and workforce density were markedly different from the nation as a whole was central to this investigation and can suggest possible mortality–workforce rela- tionships (29). As such, further analysis with exact Poisson tests was conducted using SAS, version 9.4 (SAS Institute), and R, version 3.5.1 (R Foundation). Maternal mortality and workforce analyses were also replicated using 2016 data.

***Figure 1.*** National and regional maternal death rates, population size, and birth rates for women aged 15 to 50 y in the United States from 2009 to 2017.

**2.00**

**Maternal Deaths per 100 000 Women, *n***

**1.80**

**1.60**

**1.40**

**1.20**

**1.00**

**0.80**

**0.60**

**0.40**

**0.20**

**0.00**

# Institutional Review Board Approval

Analysis of deidentiﬁed, publicly available, population- level data does not require institutional review board approval.

# Role of the Funding Source

The study received no funding.

**RESULTS**

Analysis of death rates for women of reproductive age attributed to pregnancy, childbirth, and the puer- perium from 2009 to 2017 revealed variations between national and regional trends (Figure 1, *top*). The mater- nal mortality rate in the United States increased during this period and was 20.24% higher in 2017 than in 2009 (1.46 vs. 1.21 maternal deaths per 100 000 women aged 15 to 50 years). The nation's most populous cen- sus region, the South, had both the highest regional maternal mortality rate and the largest interval rate in- crease, being 30.40% higher in 2017 (1.84) than in 2009 (1.41). Northeast mortality rates dropped slightly during this same period (2.69%). To further examine the higher per-population mortality rate in the South, 2 other analyses were performed to assess whether the study population size and birth rates changed during the study period, nationally and across census regions. Population growth for women of child-bearing age in

**2009**

**90**

**80**

**Population (in Millions), *n***

**70**

**60**

**50**

**40**

**30**

**20**

**10**

**0**

**2009**

**6000**

**Northeast Midwest South West National**

**5000**

**Births per 100 000 Women, *n***

**4000**

**3000**

**2000**

**1000**

**0**

**2009**

**2010**

**2010**

**2010**

**2011**

**2011**

**2011**

**2012**

**2012**

**2012**

**2013**

**2013**

**2013**

**2014**

**2014**

**2014**

**2015 2016**

**2015 2016**

**2015 2016**

**2017**

**2017**

**2017**

the United States (0.82%) and the South (4.20%) was negligible to modest during the same period of study (Figure 1, *middle*). Further, a similar slight decrease in the birth rate was observed in this population during this same interval in the nation and each census region (Figure 1, *bottom*).

When examining the regional availability patterns for the various health care providers essential in the care of women of reproductive age in 2017, the overall workforce composition varied geographically (Figure 2). The Northeast had the highest provider density na- tionally for obstetrician-gynecologists, certiﬁed nurse- midwives, internal medicine physicians, and the group categories of primary care physicians and all women's health providers (Table 1). The Northeast was the 1 re- gion in the nation where internal medicine was the pre- dominantly available physician specialty overall and

Data are from the Centers for Disease Control and Prevention's WON- DER portal (23) and the U.S. Census Bureau (27). Top. National and regional deaths attributed to pregnancy, childbirth, and the puerpe- rium per 100 000 women aged 15 to 50 y from 2009 to 2017. During this period, per-population maternal death rates increased by 20.24% nationally; decreased by 2.69% in the Northeast; and increased by 17.72% in the Midwest, 30.40% in the South, and 17.47% in the West. Middle. National and regional population of women aged 15 to 50 y from 2009 to 2017. During this period, the population increased by 0.82% nationally, decreased by 3.36% in the Northeast and 4.86% in the Mid- west, and increased by 4.20% in the South and 4.10% in the West. Bottom. National and regional number of births per 100 000 women aged 15 to 50 y from 2009 to 2017. During this period, the per- population birth rate decreased by 7.42% nationally, 3.98% in the North- east, 2.06% in the Midwest, 8.57% in the South, and 12.74% in the West.

also where internal medicine physician density ex- ceeded family medicine within the ﬁeld of primary care. A preponderance of per-population family medicine physicians in the Midwest drove this region to have the

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***Figure 2.*** Regional workforce composition for women's health providers in 2017.

highest national provider density for the category of direct childbirth providers. The South had the lowest per-population availability in the nation for certiﬁed nurse-midwives and internal medicine physicians, as

**500**

**450**

**400**

**350**

**Providers per 100 000 Women, *n***

**300**

**250**

**200**

**150**

**100**

**50**

**0**

**600**

**500**

**400**

**Providers per 100 000 Women, *n***

**300**

**200**

**100**

**0**

**Northeast Midwest South**

**Region**

**Northeast Midwest South**

**Region**

**West**

**West**

**WHP DCP PCP**

**OB-GYN FM**

**IM CNM**

**NP and PA NP**

**PA**

well as for the group categories of primary care physi- cians, direct childbirth providers, and all women's health providers, and had the second lowest obstetrician- gynecologist density among the census regions. Another way to look at these ﬁndings is that there was approxi- mately 1 obstetrician-gynecologist for every 1345 women of reproductive age in the Northeast versus 1 for every 1768 women in the South. One internal medicine physi- cian was available for approximately every 418 women of reproductive age in the Northeast versus 1 for every 749 women in the South. The regional patterns of availability for nurse practitioners were generally similar in the North- east, Midwest, and South but much lower in the West. Physician assistant density was highest in the Northeast but similar in other regions.

Rate ratios were calculated to determine whether regional workforce availability differed markedly from the national level for all occupations except nurse prac- titioners and physician assistants, which was found to be the case across most physician specialties and cate- gorical workforce groupings. Notably, all regional dif- ferences in the availability of direct childbirth providers and all women's health providers are unlikely to be due to chance alone (*P* < 0.001). Further, the unique pat- terns of provider densities in the Northeast and South also reached statistical signiﬁcance.

A similar analytic approach, using rate ratios, was applied to determine whether regional maternal mor- tality rates differed markedly from the national level in 2017. The South was the only region where the esti- mated mortality rate was statistically higher than the national rate (*P* < 0.001). In contrast, the maternal mor- tality rate was signiﬁcantly lower in the Northeast than nationally (*P* < 0.001). Findings were similar when we examined 2016 provider and maternal mortality data using the same analytic approach (Table 2).

To explore whether the regional workforce pat- terns for individual provider types might be associated with those for maternal mortality, the calculated rate ratios were plotted graphically (Figure 3). In 2017, re- gional maternal mortality rates exceeded the national level only in the South. In this region, all provider rate ratios were less than 1, indicating lower levels of pro- vider availability for each studied occupation com- pared with national levels. In contrast, maternal mortal- ity rates were lower than the national level in the other 3 census regions, and provider densities exceeded the

Each occupation/specialty and grouping represent workforce avail- ability, deﬁned as the number of available providers per 100 000 U.S. women aged 15 to 50 y. CNM = certiﬁed nurse-midwives; DCP = direct childbirth providers; FM = family medicine physicians; IM = internal medicine physicians; NP = nurse practitioners; OB- GYN = obstetrician-gynecologists; PA = physician assistants; PCP = primary care physicians (includes family medicine and internal medi- cine physicians); WHP = all women's health providers.

national levels (rate ratios >1) for at least 2 of the 4 individual provider occupations in each region.

**DISCUSSION**

This investigation demonstrates that the per- population rate of deaths among women of reproduc- tive age attributed to pregnancy, childbirth, and the puerperium in the United States increased between

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***Table 1.*** Maternal Mortality Rates and Women's Health Provider Availability in 2017, by U.S. Census Region and Nationally

**Variable Rate per 100 000 Women Aged 15–50 Years (95% CI)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **National** | **Northeast** | **Midwest** | **South** | **West** |
| Maternal mortality | 1.46 (1.37–1.54) | 1.06 (0.9–1.24) | 1.42 (1.25–1.62) | 1.84 (1.69–2.00) | 1.17 (1.02–1.33) |
| Women's health provider availability  Direct childbirth providers | 206.77 (205.76–207.79) | 199.73 (197.36–202.13) | 236.97 (234.58–239.38) | 190.94 (189.36–192.53) | 211.04 (208.94–213.15) |
| Obstetrician-gynecologists | 59.65 (59.10–60.19) | 74.35 (72.90–75.81) | 58.53 (57.35–59.73) | 56.57 (55.71–57.44) | 54.72 (53.65–55.79) |
| Family medicine physicians | 137.62 (136.79–138.45) | 112.91 (111.13–114.72) | 168.78 (166.77–170.82) | 126.63 (125.34–127.92) | 146.31 (144.57–148.07) |
| Certiﬁed nurse-midwives | 9.51 (9.29–9.73) | 12.47 (11.89–13.08) | 9.66 (9.19–10.15) | 7.75 (7.43–8.07) | 10.01 (9.56–10.47) |
| Primary care physicians\* | 295.55 (294.33–296.77) | 351.89 (348.73–355.08) | 317.15 (314.38–319.94) | 260.12 (258.27–261.98) | 291.83 (289.37–294.31) |
| Internal medicine physicians | 157.93 (157.04–158.82) | 238.98 (236.38–241.60) | 148.37 (146.48–150.28) | 133.50 (132.17–134.83) | 145.52 (143.78–147.27) |
| All women's health providers | 364.71 (363.35–366.06) | 438.71 (435.18–442.27) | 385.34 (382.29–388.41) | 324.44 (322.37–326.52) | 356.56 (353.83–359.30) |

**Variable Regional–National Rate Ratio (95% CI)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **National** | **Northeast** | **Midwest** | **South** | **West** |
| Maternal mortality | 1.00 (reference) | 0.73 (0.61–0.87)† | 0.98 (0.84–1.13) | 1.26 (1.14–1.40)† | 0.80 (0.69–0.93) |
| Women's health provider availability  Direct childbirth providers | 1.00 (reference) | 0.97 (0.95–0.98)† | 1.15 (1.13–1.16)† | 0.92 (0.91–0.93)† | 1.02 (1.01–1.03)† |
| Obstetrician-gynecologists | 1.00 (reference) | 1.25 (1.22–1.27)† | 0.98 (0.96–1.00) | 0.95 (0.93–0.97)† | 0.92 (0.90–0.94)† |
| Family medicine physicians | 1.00 (reference) | 0.82 (0.81–0.83)† | 1.23 (1.21–1.24)† | 0.92 (0.91–0.93)† | 1.06 (1.05–1.08)† |
| Certiﬁed nurse-midwives | 1.00 (reference) | 1.31 (1.24–1.38)† | 1.02 (0.96–1.07) | 0.81 (0.78–0.85)† | 1.05 (1.00–1.11) |
| Primary care physicians\* | 1.00 (reference) | 1.19 (1.18–1.20)† | 1.07 (1.06–1.08)† | 0.88 (0.87–0.89)† | 0.99 (0.98–1.00) |
| Internal medicine physicians | 1.00 (reference) | 1.51 (1.49–1.53)† | 0.94 (0.93–0.95)† | 0.85 (0.84–0.86)† | 0.92 (0.91–0.93)† |
| All women's health providers | 1.00 (reference) | 1.20 (1.19–1.21)† | 1.06 (1.05–1.07)† | 0.89 (0.88–0.90)† | 0.98 (0.97–0.99)† |

\* Includes family medicine physicians and internal medicine physicians.

† Regional results differed from national results at a level unlikely to be due to chance alone (*P* < 0.001), as determined by exact Poisson tests.

1999 and 2017 but changed variably across census re- gions. The South had the highest overall maternal mor- tality rates and experienced a larger interval rate in- crease than any other census region, driving up the magnitude of the overall national-level increases ob- served. The availability patterns for the health care pro- viders essential in caring for women of reproductive age also varied by region in 2017, the most recent year studied. The South had the lowest provider density na- tionally for nearly every health occupation studied. Fur- ther, lower than national levels of provider availability

across a region seem to be associated with higher maternal mortality rates. In contrast to the ﬁndings in the South, the Northeast had higher workforce avail- ability levels for nearly all of the studied professions and a much lower maternal mortality rate. Although data limitations precluded an investigation of a po- tential relationship between the regional availability of nurse practitioners and physician assistants and maternal mortality rates, regional workforce patterns were present. These providers play an important role in delivering primary care and other health services

***Table 2.*** Maternal Mortality Rates and Women's Health Provider Availability in 2016, by U.S. Census Region and Nationally

**Variable Rate per 100 000 Women Aged 15–50 Years (95% CI)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **National** | **Northeast** | **Midwest** | **South** | **West** |
| Maternal mortality | 1.48 (1.39–1.56) | 1.26 (1.09–1.46) | 1.46 (1.28–1.65) | 1.89 (1.73–2.05) | 1.00 (0.87–1.15) |
| Women's health provider availability  Direct childbirth providers | 204.06 (203.05–205.07) | 197.77 (195.41–200.16) | 234.39 (232.02–236.79) | 188.87 (187.29–190.46) | 206.44 (204.37–208.54) |
| Obstetrician-gynecologists | 58.76 (58.22–59.31) | 73.47 (72.03–74.92) | 57.40 (56.23–58.59) | 55.90 (55.04–56.77) | 53.60 (52.55–54.67) |
| Family medicine physicians | 136.24 (135.41–137.07) | 112.49 (110.71–114.29) | 167.85 (165.84–169.88) | 125.60 (124.31–126.90) | 143.22 (141.49–144.96) |
| Certiﬁed nurse-midwives | 9.06 (8.85–9.28) | 11.82 (11.25–12.40) | 9.14 (8.68–9.62) | 7.38 (7.07–7.69) | 9.63 (9.19–10.08) |
| Primary care physicians\* | 293.51 (292.29–294.72) | 352.59 (349.44–355.77) | 316.55 (313.79–319.33) | 257.99 (256.14–259.85) | 286.06 (283.61–288.52) |
| Internal medicine physicians | 157.27 (156.38–158.16) | 240.10 (237.5–242.73) | 148.70 (146.81–150.61) | 132.39 (131.07–133.72) | 142.85 (141.12–144.59) |
| All women's health providers | 361.33 (359.98–362.68) | 437.88 (434.36–441.42) | 383.09 (380.05–386.15) | 321.27 (319.2–323.34) | 349.29 (346.58–352.01) |

**Variable Regional–National Rate Ratio (95% CI)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **National** | **Northeast** | **Midwest** | **South** | **West** |
| Maternal mortality | 1.00 (reference) | 0.86 (0.72–1.01) | 0.99 (0.85–1.14) | 1.28 (1.15–1.42)† | 0.68 (0.58–0.79)† |
| Women's health provider availability  Direct childbirth providers | 1.00 (reference) | 0.97 (0.96–0.98)† | 1.15 (1.14–1.16)† | 0.93 (0.92–0.93)† | 1.01 (1.00–1.02) |
| Obstetrician-gynecologists | 1.00 (reference) | 1.25 (1.22–1.28)† | 0.98 (0.95–1.00) | 0.95 (0.93–0.97)† | 0.91 (0.89–0.93)† |
| Family medicine physicians | 1.00 (reference) | 0.83 (0.81–0.84)† | 1.23 (1.22–1.25)† | 0.92 (0.91–0.93)† | 1.05 (1.04–1.07)† |
| Certiﬁed nurse-midwives | 1.00 (reference) | 1.30 (1.23–1.38)† | 1.01 (0.95–1.07) | 0.81 (0.77–0.85)† | 1.06 (1.01–1.12) |
| Primary care physicians\* | 1.00 (reference) | 1.20 (1.19–1.21)† | 1.08 (1.07–1.09)† | 0.88 (0.87–0.89)† | 0.97 (0.97–0.98)† |
| Internal medicine physicians | 1.00 (reference) | 1.53 (1.51–1.55)† | 0.94 (0.93–0.96)† | 0.84 (0.83–0.85)† | 0.91 (0.90–0.92)† |
| All women's health providers | 1.00 (reference) | 1.21 (1.20–1.22)† | 1.06 (1.05–1.07)† | 0.89 (0.88–0.90)† | 0.97 (0.96–0.98)† |

\* Includes family medicine physicians and internal medicine physicians.

† Denotes that regional differences occurred at a statistically signiﬁcant level (*P* < 0.001). For the Northeast, the observed regional difference in maternal mortality fell outside a level of statistical signiﬁcance by a small margin (*P* = 0.062).

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***Figure 3.*** Patterns of regional maternal mortality rates as they relate to women's health provider availability in 2017.

**1.6**



**IM (Northeast)**

**CNM (Northeast)**

**OB-GYN (Northeast)**

**FM (Midwest)**

**FM (West)**

**CNM (West) CNM (Midwest)**

**OB-GYN (Midwest)**

**IM (West) OB-GYN (West)**

**FM (Northeast)**

**IM (Midwest)**

**OB-GYN (South)**

**FM (South)**

**IM (South) CNM (South)**

**1.4**

**1.2**

**National Provider Rate Ratio**

**1**

**0.8**

**0.6**

**0.4**

**0.4**

**0.6**

**0.8**

**1 1.2 1.4**

**1.6**

**National Maternal Mortality Rate Ratio**

Region/provider pairings represent health provider availability rate ratios for the 4 health care occupations studied (OB-GYN, FM, CNM, and IM) within each of the 4 U.S. census regions (Northeast, Midwest, South, and West). CNM = certiﬁed nurse-midwives; FM = family medicine physicians; IM = internal medicine physicians; OB-GYN = obstetrician-gynecologists.

to women of reproductive age, often mitigating health care access gaps in communities facing physi- cian shortages (20, 36, 39, 40).

A recent study identiﬁed a linkage between pri- mary care physician supply and cause-speciﬁc popula- tion mortality in the United States, suggesting that di- rected efforts to bolster the health workforce where shortages exist are important for improving population health (41). A similar strategic approach might also ap- ply to domestic maternal mortality policy and would be consistent with the United Nations global strategy of addressing mortality by expanding the midwifery and obstetric workforce (42). A health literature search in MEDLINE from 1965 to January 2020, using the terms *health workforce* and *mortality*, produced 2248 results that were then examined manually for topical rele- vance. A broad array of relevant international maternal mortality studies were identiﬁed, including qualitative or mixed-methods studies, correlations between work- force and neonatal outcomes, impact studies related to health worker deployment (most commonly for mid- wives and community health workers), analyses of facility and service availability, or workforce–mortality comparisons between 2 countries (16 –22, 43– 46). One report used a multivariate analysis approach and found a marginally signiﬁcant association between per-

population maternal death rates and midwife density across Iranian provinces (47). Within the U.S.-based litera- ture, 31 studies examined health workforce–mortality link- ages for various specialty areas and conditions, 3 of which speciﬁcally examined neonatal/infant mortality and 2 of which examined maternal mortality outcomes (48 –52). Sullivan and colleagues used a multivariate analysis of WONDER data to demonstrate that maternal–fetal medicine specialist density at the state level is signiﬁ- cantly and inversely associated with maternal mortality ratios, even when socioeconomic factors are controlled for (52). Kozhimannil and colleagues examined rural– urban maternal mortality differences from 2007 to 2015 using hospital discharge data by U.S. census region, controlling for sociodemographic factors and clinical conditions, but not speciﬁcally examining or controlling for provider supply (48). On the basis of this literature review, our preliminary ﬁndings suggest that the current study is one of the few in the United States to examine the association between the availability of health care provid- ers for women of reproductive age and maternal mortality rates within this population.

This study had important limitations. The presence

of a provider in a census region does not directly trans- late to available and accessible obstetric care in a com- munity or for an individual. The extent to which family

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physicians provide obstetric care varies geographically, and the overall proportion doing so seems to be de- creasing markedly over time (36, 53–56). Obstetrician- gynecologists may subspecialize or focus their clinical care on gynecology alone, although approximately 79% are estimated to practice obstetrics (56). Further, access to health care services is a complex, multifacto- rial concept that requires available health workers and sites of care, such as medical practices and hospitals, but it is also inﬂuenced by such variables as proximity and accessibility, affordability, cultural factors, and is- sues of health equity (57).

Caution should be used in interpreting these study ﬁndings because of the small number of observations used for analysis. Further, nationally representative data sources on maternal mortality and the health workforce have many well-known limitations (58 – 60). For example, maternal deaths may not always be cap- tured accurately in national vital statistics data sets be- cause of dependence on accurate pregnancy status re- porting by death certiﬁcate certiﬁers (61). Maternal mortality rates reported here may differ from those in other studies depending on the denominators used, the ICD-10 codes included, approaches for age adjust- ment, and the population age range studied. An under- lying assumption in this investigation was that birth and delivery patterns were uniform over time across re- gions. The population of women of child-bearing age in our analysis did seem to be proportional, nationally and regionally, as did the observed birthrate decline, the latter being consistent with trends reported else- where (31). Pregnancy rates may be a more accurate measure for study than births; however, available na- tional vital statistics systems, such as the Pregnancy Risk Assessment Monitoring System, miss approximately 17% of the nation's pregnancy data (62). Nonetheless, an increase in maternal mortality in the setting of de- creasing pregnancy and birthrates would be concern- ing, particularly because demand for primary care and women's health providers is anticipated to increasingly outpace their supply in coming years (20, 21).

This study is intended to be exploratory in nature,

and further investigation into the apparent association between provider availability and maternal mortality is necessary. For instance, examining this relationship over a longer period and at a more granular geo- graphic level may be beneﬁcial. Evaluation at the rela- tively macro level of census region was selected for this study to have sufﬁcient, geographically consistent data for analysis and because other studies have noted re- gional patterns when examining associations between physician supply and mortality (29). However, county- level or rural– urban assessments may yield important insights for the communities facing the greatest chal- lenges in health care access and population health out- comes (63– 66). More than half of all rural counties lack hospital-based obstetric services, predominantly lower- income counties with fewer obstetricians and family physicians; more restrictive Medicaid eligibility thresh- olds for pregnant women; and higher percentages of

non-Hispanic Black women, who disproportionately ex- perience pregnancy complications and maternal mor- tality (3– 6, 11, 66, 67). Cities with higher proportions of uninsured and Medicaid patients tend to have the most demanding obstetrician workloads and an older overall obstetric workforce that is closer to retirement age and thus affects workforce attrition rates (68). Future inves- tigations may also consider using complex analyses that adjust for relevant socioeconomic variables, insur- ance status, and population racial/ethnic composition (3– 6, 67).

Identiﬁcation of a potential workforce–mortality re- lationship has policy relevance because the availability of health care providers serving women before, during, and after childbirth may play a role in maternal mortal- ity. Access to skilled providers is essential for managing a woman's perinatal health and handling high-risk de- liveries (12, 13). Policies to fortify the women's health workforce should prioritize alleviating the access dis- parities faced by the most vulnerable communities. The American College of Physicians advocates for correct- ing primary care workforce shortages; addressing so- cial determinants of health; and addressing urgent public health threats, such as maternal mortality, to achieve a stronger overall U.S. health care system (69). Health workforce insufﬁciencies may not directly cause maternal mortality but are a barrier to the delivery of essential services, and health professional shortage ar- eas may serve as a marker for communities with higher overall mortality risks (70). Improving access, choice, and quality of birthing facilities and health care provid- ers in primary care and obstetrics-gynecology are all likely important steps for addressing the nation's rising rates of maternal mortality. This approach aligns with HRSA's programmatic health workforce investments, in- cluding through the National Health Service Corps and Teaching Health Center Graduate Medical Education Program (71). The recent passage of the Improving Ac- cess to Maternity Care Act (P.L. 115-320) requires HRSA to identify and publish collected data on “maternity care health professional target areas” (72). This infor- mation has the potential to facilitate targeting of fed- eral, state, and other health workforce investments to the areas of greatest need. The preliminary results of this study, which found an association between re- gional maternal mortality rate variations and the avail- ability of birth-attending and primary care providers, provide a starting point from which to further explore the concept of targeted health workforce investments that address maternal mortality disparities.

From U.S. Department of Health and Human Services, Health Resources and Services Administration, Rockville, Maryland (J.E.S., A.L.S., R.A.S., M.M.W.).

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## SUPPLEMENT Maternal Mortality and Health Workforce Availability

**Disclosures:** Authors have disclosed no conﬂicts of interest. Forms can be viewed at [www.acponline.org/authors/icmje](http://www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M19-3254)

[/ConﬂictOfInterestForms.do?msNum=M19-3254.](http://www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M19-3254)

**Reproducible Research Statement:** *Study protocol:* Described in the article. Further details are available from Dr. Snyder (e-mail, [jsnyder@hrsa.gov).](mailto:jsnyder@hrsa.gov) *Statistical code:* Not available. *Data set:* Available at [https://wonder.cdc.gov](https://wonder.cdc.gov/) (WONDER), [www.census.gov/programs-surveys/acs](http://www.census.gov/programs-surveys/acs) (American Commu- nity Survey), and [https://data.hrsa.gov/topics/health-work](https://data.hrsa.gov/topics/health-workforce/ahrf) [force/ahrf](https://data.hrsa.gov/topics/health-workforce/ahrf) (Area Health Resources Files).

**Corresponding Author:** John E. Snyder, MD, MS, MPH, Health Resources and Services Administration, 5600 Fishers Lane, Rockville, MD 20857; e-mail, [jsnyder@hrsa.gov.](mailto:jsnyder@hrsa.gov)

**Current Author Addresses:** Drs. Snyder, Stahl, Streeter, and Washko: Health Resources and Services Administration, 5600 Fishers Lane, Rockville, MD 20857.

**Author Contributions:** Conception and design: J.E. Snyder,

R.A. Streeter, M.M. Washko.

Analysis and interpretation of the data: J.E. Snyder, A.L. Stahl,

R.A. Streeter.

Drafting of the article: J.E. Snyder, A.L. Stahl.

Critical revision of the article for important intellectual con- tent: J.E. Snyder, A.L. Stahl, R.A. Streeter.

Final approval of the article: J.E. Snyder, A.L. Stahl, R.A. Streeter, M.M. Washko.

Statistical expertise: A.L. Stahl, R.A. Streeter.

Administrative, technical, or logistic support: J.E. Snyder, R.A. Streeter.

Collection and assembly of data: J.E. Snyder, A.L. Stahl, R.A. Streeter.

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***Appendix Table.*** ICD-10 Codes Used for Assessments of Maternal Deaths\*

**ICD-10 Code Description**

**O00–O08: Pregnancy with abortive outcome**

O00 Ectopic pregnancy

O00.0 Abdominal pregnancy

O00.1 Tubal pregnancy

O00.2 Ovarian pregnancy

O00.8 Other ectopic pregnancy

O00.9 Ectopic pregnancy, unspeciﬁed

O01 Hydatidiform mole

O01.0 Classical hydatidiform mole

O01.1 Incomplete and partial hydatidiform mole

O01.9 Hydatidiform mole, unspeciﬁed

O02 Other abnormal products of conception

O02.0 Blighted ovum and nonhydatidiform mole

O02.1 Missed abortion

O02.8 Other speciﬁed abnormal products of conception

O02.9 Abnormal product of conception, unspeciﬁed

O03 Spontaneous abortion

O03.0 Spontaneous abortion, incomplete, complicated by genital tract and pelvic infection

O03.1 Spontaneous abortion, incomplete, complicated by delayed or excessive hemorrhage

O03.2 Spontaneous abortion, incomplete, complicated by embolism

O03.3 Spontaneous abortion, incomplete, with other and unspeciﬁed complications

O03.4 Spontaneous abortion, incomplete, without complication

O03.5 Spontaneous abortion, incomplete, without complication

O03.6 Spontaneous abortion, complete or unspeciﬁed, complicated by delayed or excessive hemorrhage

O03.7 Spontaneous abortion, complete or unspeciﬁed, complicated by embolism

O03.8 Spontaneous abortion, complete or unspeciﬁed, with other and unspeciﬁed complications

O03.9 Spontaneous abortion, complete or unspeciﬁed, without complication

O04.0 Medical abortion

O04.1 Medical abortion, incomplete, complicated by delayed or excessive hemorrhage

O04.2 Medical abortion, incomplete, complicated by embolism

O04.3 Medical abortion, incomplete, with other and unspeciﬁed complications

O04.4 Medical abortion, incomplete, without complication

O04.5 Medical abortion, complete or unspeciﬁed, complicated by genital tract and pelvic infection

O04.6 Medical abortion, complete or unspeciﬁed, complicated by delayed or excessive hemorrhage

O04.7 Medical abortion, complete or unspeciﬁed, complicated by embolism

O04.8 Medical abortion, complete or unspeciﬁed, with other and unspeciﬁed complications

O04.9 Medical abortion, complete or unspeciﬁed, without complication

O05 Other abortion

O05.0 Other abortion, incomplete, complicated by genital tract and pelvic infection

O05.1 Other abortion, incomplete, complicated by delayed or excessive hemorrhage

O05.2 Other abortion, incomplete, complicated by embolism

O05.3 Other abortion, incomplete, with other and unspeciﬁed complications

O05.4 Other abortion, incomplete, without complication

O05.5 Other abortion, complete or unspeciﬁed, complicated by genital tract and pelvic infection

O05.6 Other abortion, complete or unspeciﬁed, complicated by delayed or excessive hemorrhage

O05.7 Other abortion, complete or unspeciﬁed, complicated by embolism

O05.8 Other abortion, complete or unspeciﬁed, with other and unspeciﬁed complications

O05.9 Other abortion, complete or unspeciﬁed, without complication

O06 Unspeciﬁed abortion

O06.0 Unspeciﬁed abortion, incomplete, complicated by genital tract and pelvic infection

O06.1 Unspeciﬁed abortion, incomplete, complicated by delayed or excessive hemorrhage

O06.2 Unspeciﬁed abortion, incomplete, complicated by embolism

O06.3 Unspeciﬁed abortion, incomplete, with other and unspeciﬁed complications

O06.4 Unspeciﬁed abortion, incomplete, without complication

O06.5 Unspeciﬁed abortion, complete or unspeciﬁed, complicated by genital tract and pelvic infection

O06.6 Unspeciﬁed abortion, complete or unspeciﬁed, complicated by delayed or excessive hemorrhage

O06.7 Unspeciﬁed abortion, complete or unspeciﬁed, complicated by embolism

O06.8 Unspeciﬁed abortion, complete or unspeciﬁed, with other and unspeciﬁed complications

O06.9 Unspeciﬁed abortion, complete or unspeciﬁed, without complication

O07 Failed attempted abortion

O07.0 Failed medical abortion, complicated by genital tract and pelvic infection

O07.1 Failed medical abortion, complicated by delayed or excessive hemorrhage

O07.2 Failed medical abortion, complicated by embolism

O07.3 Failed medical abortion, with other and unspeciﬁed complications

O07.4 Failed medical abortion, without complication

O07.5 Other and unspeciﬁed failed attempted abortion, complicated by genital tract and pelvic infection

### Continued on following page

***Appendix Table***—Continued

**ICD-10 Code Description**

O07.6 Other and unspeciﬁed failed attempted abortion, complicated by delayed or excessive hemorrhage

O07.7 Other and unspeciﬁed failed attempted abortion, complicated by embolism

O07.8 Other and unspeciﬁed failed attempted abortion, with other and unspeciﬁed complications

O07.9 Other and unspeciﬁed failed attempted abortion, without complication

**O10–O16: Edema, proteinuria, and hypertensive disorders in pregnancy, childbirth, and the puerperium**

O10 Preexisting hypertension complicating pregnancy, childbirth, and the puerperium

O10.0 Preexisting essential hypertension complicating pregnancy, childbirth, and the puerperium

O10.1 Preexisting hypertensive heart disease complicating pregnancy, childbirth, and the puerperium

O10.2 Preexisting hypertensive renal disease complicating pregnancy, childbirth, and the puerperium

O10.3 Preexisting hypertensive heart and renal disease complicating pregnancy, childbirth, and the puerperium

O10.4 Preexisting secondary hypertension complicating pregnancy, childbirth, and the puerperium

O10.9 Unspeciﬁed preexisting hypertension complicating pregnancy, childbirth, and the puerperium

O11 Preexisting hypertensive disorder with superimposed proteinuria

O12 Gestational pregnancy–induced edema and proteinuria without hypertension

O12.0 Gestational edema

O12.1 Gestational proteinuria

O12.2 Gestational edema with proteinuria

O13 Gestational pregnancy–induced hypertension without signiﬁcant proteinuria

O14 Gestational pregnancy–induced hypertension with signiﬁcant proteinuria

O14.0 Moderate preeclampsia

O14.1 Severe preeclampsia

O14.2 HELLP syndrome

O14.9 Preeclampsia, unspeciﬁed

O15 Eclampsia

O15.0 Eclampsia in pregnancy

O15.1 Eclampsia in labor

O15.2 Eclampsia in the puerperium

O15.9 Eclampsia, unspeciﬁed as to time period

O16 Unspeciﬁed maternal hypertension

**O20–O29: Other maternal disorders predominantly related to pregnancy**

O20 Hemorrhage in early pregnancy

O20.0 Threatened abortion

O20.8 Other hemorrhage in early pregnancy

O20.9 Hemorrhage in early pregnancy, unspeciﬁed

O21 Excessive vomiting in pregnancy

O21.0 Mild hyperemesis gravidarum

O21.1 Hyperemesis gravidarum with metabolic disturbance

O21.2 Late vomiting of pregnancy

O21.8 Other vomiting complicating pregnancy

O21.9 Vomiting of pregnancy, unspeciﬁed

O22 Venous complications in pregnancy

O22.0 Varicose veins of lower extremity in pregnancy

O22.1 Genital varices in pregnancy

O22.2 Superﬁcial thrombophlebitis in pregnancy

O22.3 Deep phlebothrombosis in pregnancy

O22.4 Hemorrhoids in pregnancy

O22.5 Cerebral venous thrombosis in pregnancy

O22.8 Other venous complications in pregnancy

O22.9 Venous complication in pregnancy, unspeciﬁed; Gestational phlebitis NOS; Gestational phlebopathy NOS; Gestational thrombosis NOS

O23 Infections of genitourinary tract in pregnancy

O23.0 Infections of kidney in pregnancy

O23.1 Infections of bladder in pregnancy

O23.2 Infections of urethra in pregnancy

O23.3 Infections of other parts of urinary tract in pregnancy

O23.4 Unspeciﬁed infection of urinary tract in pregnancy

O23.5 Infections of the genital tract in pregnancy

O23.9 Other and unspeciﬁed genitourinary tract infection in pregnancy

O24 Diabetes mellitus in pregnancy

O24.0 Preexisting diabetes mellitus, insulin-dependent

O24.1 Preexisting diabetes mellitus, non–insulin-dependent

O24.2 Preexisting malnutrition-related diabetes mellitus

O24.3 Preexisting diabetes mellitus, unspeciﬁed

O24.4 Diabetes mellitus arising in pregnancy

O24.9 Diabetes mellitus in pregnancy, unspeciﬁed

***Appendix Table***—Continued

**ICD-10 Code Description**

O25 Malnutrition in pregnancy

O26 Maternal care for other conditions predominantly related to pregnancy

O26.0 Excessive weight gain in pregnancy

O26.1 Low weight gain in pregnancy

O26.2 Pregnancy care of habitual aborter

O26.3 Retained intrauterine contraceptive device in pregnancy

O26.4 Herpes gestationis

O26.5 Maternal hypotension syndrome

O26.6 Liver disorders in pregnancy, childbirth, and the puerperium

O26.7 Subluxation of symphysis pubis in pregnancy, childbirth, and the puerperium

O26.8 Other speciﬁed pregnancy-related conditions

O26.9 Pregnancy-related condition, unspeciﬁed

O28 Abnormal ﬁndings on antenatal screening of mother

O28.0 Abnormal hematological ﬁnding on antenatal screening of mother

O28.1 Abnormal biochemical ﬁnding on antenatal screening of mother

O28.2 Abnormal cytological ﬁnding on antenatal screening of mother

O28.3 Abnormal ultrasonic ﬁnding on antenatal screening of mother

O28.4 Abnormal radiological ﬁnding on antenatal screening of mother

O28.5 Abnormal chromosomal and genetic ﬁnding on antenatal screening of mother

O28.8 Other abnormal ﬁndings on antenatal screening of mother

O28.9 Abnormal ﬁnding on antenatal screening of mother, unspeciﬁed

O29 Complications of anesthesia during pregnancy

O29.0 Pulmonary complications of anesthesia during pregnancy

O29.1 Cardiac complications of anesthesia during pregnancy

O29.2 Central nervous system complications of anesthesia during pregnancy

O29.3 Toxic reaction to local anesthesia during pregnancy

O29.4 Spinal and epidural anesthesia-induced headache during pregnancy

O29.5 Other complications of spinal and epidural anesthesia during pregnancy

O29.6 Failed or difﬁcult intubation during pregnancy

O29.8 Other complications of anesthesia during pregnancy

O29.9 Complication of anesthesia during pregnancy, unspeciﬁed

**O30–O48: Maternal care related to the fetus and amniotic cavity and possible delivery problems**

O30 Multiple gestation

O30.0 Twin pregnancy

O30.1 Triplet pregnancy

O30.2 Quadruplet pregnancy

O30.8 Other multiple gestation

O30.9 Multiple gestation, unspeciﬁed; Multiple pregnancy NOS

O31 Complications speciﬁc to multiple gestation

O31.0 Papyraceous fetus

O31.1 Continuing pregnancy after abortion of one fetus or more

O31.2 Continuing pregnancy after intrauterine death of one fetus or more

O31.8 Other complications speciﬁc to multiple gestation

O32 Maternal care for known or suspected malpresentation of fetus

O32.0 Maternal care for unstable lie

O32.1 Maternal care for breech presentation

O32.2 Maternal care for transverse and oblique lie

O32.3 Maternal care for face, brow, and chin presentation

O32.4 Maternal care for high head at term

O32.5 Maternal care for multiple gestation with malpresentation of one fetus or more

O32.6 Maternal care for compound presentation

O32.8 Maternal care for other malpresentation of fetus

O32.9 Maternal care for malpresentation of fetus, unspeciﬁed

O33 Maternal care for known or suspected disproportion

O33.0 Maternal care for disproportion due to deformity of maternal pelvic bones

O33.1 Maternal care for disproportion due to generally contracted pelvis

O33.2 Maternal care for disproportion due to inlet contraction of pelvis

O33.3 Maternal care for disproportion due to outlet contraction of pelvis

O33.4 Maternal care for disproportion of mixed maternal and fetal origin

O33.5 Maternal care for disproportion due to unusually large fetus

O33.6 Maternal care for disproportion due to hydrocephalic fetus

O33.7 Maternal care for disproportion due to other fetal deformities; Conjoined twins

O33.8 Maternal care for disproportion of other origin

O33.9 Maternal care for disproportion, unspeciﬁed; Cephalopelvic disproportion NOS; Fetopelvic disproportion NOS

O34 Maternal care for known or suspected abnormality of pelvic organs

O34.0 Maternal care for congenital malformation of uterus

O34.1 Maternal care for tumor of corpus uteri

***Appendix Table***—Continued

**ICD-10 Code Description**

O34.2 Maternal care due to uterine scar from previous surgery

O34.3 Maternal care for cervical incompetence

O34.4 Maternal care for other abnormalities of cervix

O34.5 Maternal care for other abnormalities of gravid uterus

O34.6 Maternal care for abnormality of vagina

O34.7 Maternal care for abnormality of vulva and perineum

O34.8 Maternal care for other abnormalities of pelvic organs

O34.9 Maternal care for abnormality of pelvic organ, unspeciﬁed

O35 Maternal care for known or suspected fetal abnormality and damage

O35.0 Maternal care for (suspected) central nervous system malformation in fetus

O35.1 Maternal care for (suspected) chromosomal abnormality in fetus

O35.2 Maternal care for (suspected) hereditary disease in fetus

O35.3 Maternal care for (suspected) damage to fetus from viral disease in mother

O35.4 Maternal care for (suspected) damage to fetus from alcohol

O35.5 Maternal care for (suspected) damage to fetus by drugs

O35.6 Maternal care for (suspected) damage to fetus by radiation

O35.7 Maternal care for (suspected) damage to fetus by other medical procedures

O35.8 Maternal care for other (suspected) fetal abnormality and damage

O35.9 Maternal care for (suspected) fetal abnormality and damage, unspeciﬁed

O36 Maternal care for other known or suspected fetal problems

O36.0 Maternal care for rhesus isoimmunization

O36.1 Maternal care for other isoimmunization

O36.2 Maternal care for hydrops fetalis

O36.3 Maternal care for signs of fetal hypoxia

O36.4 Maternal care for intrauterine death

O36.5 Maternal care for poor fetal growth

O36.6 Maternal care for excessive fetal growth

O36.7 Maternal care for viable fetus in abdominal pregnancy

O36.8 Maternal care for other speciﬁed fetal problems

O36.9 Maternal care for fetal problem, unspeciﬁed

O40 Polyhydramnios

O41 Other disorders of amniotic ﬂuid and membranes

O41.0 Oligohydramnios; Oligohydramnios without mention of rupture of membranes

O41.1 Infection of amniotic sac and membranes; Chorioamnionitis

O41.8 Other speciﬁed disorders of amniotic ﬂuid and membranes

O41.9 Disorder of amniotic ﬂuid and membranes, unspeciﬁed

O42 Premature rupture of membranes

O42.0 Premature rupture of membranes, onset of labor within

O42.1 Premature rupture of membranes, onset of labor after

O42.2 Premature rupture of membranes, labor delayed by therapy

O42.9 Premature rupture of membranes, unspeciﬁed

O43 Placental disorders

O43.0 Placental transfusion syndromes

O43.1 Malformation of placenta; Abnormal placenta NOS; Circumvallate placenta

O43.2 Morbidly adherent placenta

O43.8 Other placental disorders

O43.9 Placental disorder, unspeciﬁed

O44 Placenta previa

O44.0 Placenta previa speciﬁed as without hemorrhage

O44.1 Placenta previa with hemorrhage

O45 Premature separation of placenta abruptio placentae

O45.0 Premature separation of placenta with coagulation defect

O45.8 Other premature separation of placenta

O45.9 Premature separation of placenta, unspeciﬁed

O46 Antepartum hemorrhage, not elsewhere classiﬁed

O46.0 Antepartum hemorrhage with coagulation defect

O46.8 Other antepartum hemorrhage

O46.9 Antepartum hemorrhage, unspeciﬁed

O47 False labor

O47.0 False labor before 37 completed weeks of gestation

O47.1 False labor at or after 37 completed weeks of gestation

O47.9 False labor, unspeciﬁed

O48 Prolonged pregnancy

**O60–O75: Complications of labor and delivery**

O60 Preterm delivery

O61 Failed induction of labor

O61.0 Failed medical induction of labor

O61.1 Failed instrumental induction of labor

***Appendix Table***—Continued

**ICD-10 Code Description**

O61.8 Other failed induction of labor

O61.9 Failed induction of labor, unspeciﬁed

O62 Abnormalities of forces of labor

O62.0 Primary inadequate contractions

O62.1 Secondary uterine inertia

O62.2 Other uterine inertia

O62.3 Precipitate labor

O62.4 Hypertonic, incoordinate, and prolonged uterine contractions

O62.8 Other abnormalities of forces of labor

O62.9 Abnormality of forces of labor, unspeciﬁed

O63 Long labor

O63.0 Prolonged ﬁrst stage (of labor)

O63.1 Prolonged second stage (of labor)

O63.2 Delayed delivery of second twin, triplet, etc.

O63.9 Long labor, unspeciﬁed

O64 Obstructed labor due to malposition and malpresentation of fetus

O64.0 Obstructed labor due to incomplete rotation of fetal head

O64.1 Obstructed labor due to breech presentation

O64.2 Obstructed labor due to face presentation

O64.3 Obstructed labor due to brow presentation

O64.4 Obstructed labor due to shoulder presentation

O64.5 Obstructed labor due to compound presentation

O64.8 Obstructed labor due to other malposition and malpresentation

O64.9 Obstructed labor due to malposition and malpresentation, unspeciﬁed

O65 Obstructed labor due to maternal pelvic abnormality

O66 Other obstructed labor

O66.0 Obstructed labor due to shoulder dystocia

O66.1 Obstructed labor due to locked twins

O66.2 Obstructed labor due to unusually large fetus

O66.3 Obstructed labor due to other abnormalities of fetus

O66.4 Failed trial of labor, unspeciﬁed

O66.5 Failed application of vacuum extractor and forceps, unspeciﬁed

O66.8 Other speciﬁed obstructed labor

O66.9 Obstructed labor, unspeciﬁed

O67 Labor and delivery complicated by intrapartum hemorrhage, not elsewhere classiﬁed

O67.0 Intrapartum hemorrhage with coagulation defect

O67.8 Other intrapartum hemorrhage

O67.9 Intrapartum hemorrhage, unspeciﬁed

O68 Labor and delivery complicated by fetal stress distress

O68.0 Labor and delivery complicated by fetal heart rate anomaly

O68.1 Labor and delivery complicated by meconium in amniotic ﬂuid

O68.2 Labor and delivery complicated by fetal heart rate anomaly with meconium in amniotic ﬂuid

O68.3 Labor and delivery complicated by biochemical evidence of fetal stress

O68.8 Labor and delivery complicated by other evidence of fetal stress

O68.9 Labor and delivery complicated by fetal stress, unspeciﬁed

O69 Labor and delivery complicated by umbilical cord complications

O69.0 Labor and delivery complicated by prolapse of cord

O69.1 Labor and delivery complicated by cord around neck, with compression

O69.2 Labor and delivery complicated by other cord entanglement

O69.3 Labor and delivery complicated by short cord

O69.4 Labor and delivery complicated by vasa previa

O69.5 Labor and delivery complicated by vascular lesion of cord

O69.8 Labor and delivery complicated by other cord complications

O69.9 Labor and delivery complicated by cord complication, unspeciﬁed

O70 Perineal laceration during delivery

O70.0 First-degree perineal laceration during delivery

O70.1 Second-degree perineal laceration during delivery

O70.2 Third-degree perineal laceration during delivery

O70.3 Fourth-degree perineal laceration during delivery

O70.9 Perineal laceration during delivery, unspeciﬁed

O71 Other obstetric trauma

O71.0 Rupture of uterus before onset of labor

O71.1 Rupture of uterus during labor

O71.2 Postpartum inversion of uterus

O71.3 Obstetric laceration of cervix

O71.4 Obstetric high vaginal laceration alone

O71.5 Other obstetric injury to pelvic organs

O71.6 Obstetric damage to pelvic joints and ligaments

O71.7 Obstetric hematoma of pelvis

***Appendix Table***—Continued

**ICD-10 Code Description**

O71.8 Other speciﬁed obstetric trauma

O71.9 Obstetric trauma, unspeciﬁed

O72 Postpartum hemorrhage

O72.0 Third-stage hemorrhage

O72.1 Other immediate postpartum hemorrhage

O72.2 Delayed and secondary postpartum hemorrhage

O72.3 Postpartum coagulation defects

O73 Retained placenta and membranes, without hemorrhage

O73.0 Retained placenta without hemorrhage; Placenta accreta without hemorrhage

O73.1

Retained portions of placenta and membranes, without hemorrhage; Retained products of conception following delivery, without hemorrhage

O74 Complications of anesthesia during labor and delivery

O74.0 Aspiration pneumonitis due to anesthesia during labor and delivery

O74.1 Other pulmonary complications of anesthesia during labor and delivery

O74.2 Cardiac complications of anesthesia during labor and delivery

O74.3 Central nervous system complications of anesthesia during labor and delivery

O74.4 Toxic reaction to local anesthesia during labor and delivery

O74.5 Spinal and epidural anesthesia-induced headache during labor and delivery

O74.6 Other complications of spinal and epidural anesthesia during labor and delivery

O74.7 Failed or difﬁcult intubation during labor and delivery

O74.8 Other complications of anesthesia during labor and delivery

O74.9 Complication of anesthesia during labor and delivery, unspeciﬁed

O75 Other complications of labor and delivery, not elsewhere classiﬁed

O75.0 Maternal distress during labor and delivery

O75.1 Shock during or following labor and delivery

O75.2 Pyrexia during labor, not elsewhere classiﬁed

O75.3 Other infection during labor

O75.4 Other complications of obstetric surgery and procedures

O75.5 Delayed delivery after artiﬁcial rupture of membranes

O75.6 Delayed delivery after spontaneous or unspeciﬁed rupture of membranes

O75.7 Vaginal delivery following previous caesarean section

O75.8 Other speciﬁed complications of labor and delivery

O75.9 Complication of labor and delivery, unspeciﬁed

**O85–O92: Complications predominantly related to the puerperium**

O85 Puerperal sepsis

O86 Other puerperal infections

O86.0 Infection of obstetric surgical wound

O86.1 Other infection of genital tract following delivery

O86.2 Urinary tract infection following delivery

O86.3 Other genitourinary tract infections following delivery

O86.4 Pyrexia of unknown origin following delivery

O86.8 Other speciﬁed puerperal infections

O87 Venous complications in the puerperium

O87.0 Superﬁcial thrombophlebitis in the puerperium

O87.1 Deep phlebothrombosis in the puerperium

O87.2 Hemorrhoids in the puerperium

O87.3 Cerebral venous thrombosis in the puerperium

O87.8 Other venous complications in the puerperium

O87.9 Venous complication in the puerperium, unspeciﬁed

O88 Obstetric embolism

O88.0 Obstetric air embolism

O88.1 Amniotic ﬂuid embolism

O88.2 Obstetric blood-clot embolism

O88.3 Obstetric pyemic and septic embolism

O88.8 Other obstetric embolism; Obstetric fat embolism

O89 Complications of anesthesia during the puerperium

O89.0 Pulmonary complications of anesthesia during the puerperium

O89.1 Pulmonary complications of anesthesia during the puerperium

O89.2 Central nervous system complications of anesthesia during the puerperium

O89.3 Toxic reaction to local anesthesia during the puerperium

O89.4 Spinal and epidural anesthesia-induced headache during the puerperium

O89.5 Other complications of spinal and epidural anesthesia during the puerperium

O89.6 Failed or difﬁcult intubation during the puerperium

O89.8 Other complications of anesthesia during the puerperium

O89.9 Complication of anesthesia during the puerperium, unspeciﬁed

O90 Complications of the puerperium, not elsewhere classiﬁed

O90.0 Disruption of caesarean section wound

### Continued on following page

***Appendix Table***—Continued

**ICD-10 Code Description**

O90.1 Disruption of perineal obstetric wound

O90.2 Hematoma of obstetric wound

O90.3 Cardiomyopathy in the puerperium

O90.4 Postpartum acute renal failure

O90.5 Postpartum thyroiditis

O90.8 Other complications of the puerperium, not elsewhere classiﬁed

O90.9 Complication of the puerperium, unspeciﬁed

O91 Infections of breast associated with childbirth

O91.0 Infection of nipple associated with childbirth

O91.1 Abscess of breast associated with childbirth

O91.2 Nonpurulent mastitis associated with childbirth

O92 Other disorders of breast and lactation associated with childbirth

O92.0 Retracted nipple associated with childbirth

O92.1 Cracked nipple

O92.2 Other and unspeciﬁed disorders of breast associated with childbirth

O92.3 Agalactia

O92.4 Hypogalactia

O92.5 Suppressed lactation

O92.6 Galactorrhea

O92.7 Other and unspeciﬁed disorders of lactation

**O95–O99: Other obstetric conditions, not elsewhere classiﬁed**

O95 Obstetric death of unspeciﬁed cause

O96 Death from any obstetric cause occurring more than 42 days but less than 1 year after delivery

O96.0 Death from direct obstetric cause occurring more than 42 days but less than 1 year after delivery

O96.1 Death from indirect obstetric cause occurring more than 42 days but less than 1 year after delivery

O96.9

Death from unspeciﬁed obstetric cause occurring more than 42 days but less than 1 year after delivery

O97 Death from sequelae of direct obstetric causes

O97.0 Death from sequelae of direct obstetric cause

O97.1 Death from sequelae of indirect obstetric cause

O97.9 Death from sequelae of obstetric cause, unspeciﬁed

O98 Maternal infectious and parasitic diseases classiﬁable elsewhere but complicating pregnancy, childbirth, and the puerperium

O98.0 Tuberculosis complicating pregnancy, childbirth, and the puerperium

O98.1 Syphilis complicating pregnancy, childbirth, and the puerperium

O98.2 Gonorrhea complicating pregnancy, childbirth, and the puerperium

O98.3 Other infections with a predominantly sexual mode of transmission complicating pregnancy, childbirth, and the puerperium

O98.4 Viral hepatitis complicating pregnancy, childbirth, and the puerperium

O98.5 Other viral diseases complicating pregnancy, childbirth, and the puerperium

O98.6 Protozoal diseases complicating pregnancy, childbirth, and the puerperium

O98.7 Human immunodeﬁciency (HIV) disease complicating pregnancy, childbirth, and the puerperium

O98.8

Other maternal infectious and parasitic diseases complicating pregnancy, childbirth, and the puerperium

O98.9 Unspeciﬁed maternal infectious or parasitic disease complicating pregnancy, childbirth, and the

puerperium

O99

Other maternal diseases classiﬁable elsewhere but complicating pregnancy, childbirth, and the puerperium

O99.0 Anemia complicating pregnancy, childbirth, and the puerperium

O99.1

Other diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism

O99.2 Endocrine, nutritional, and metabolic diseases complicating pregnancy, childbirth, and the

puerperium

O99.3

Mental disorders and diseases of the nervous system complicating pregnancy, childbirth, and the puerperium

O99.4 Diseases of the circulatory system complicating pregnancy, childbirth, and the puerperium

O99.5 Diseases of the respiratory system complicating pregnancy, childbirth, and the puerperium

O99.6 Diseases of the digestive system complicating pregnancy, childbirth, and the puerperium

O99.7

Diseases of the skin and subcutaneous tissue complicating pregnancy, childbirth, and the puerperium

O99.8 Other speciﬁed diseases and conditions complicating pregnancy, childbirth, and the puerperium

HELLP = hemolysis, elevated liver enzymes, low platelet count; ICD-10 = International Classiﬁcation of Diseases, 10th Revision; NOS = not otherwise speciﬁed.

\* From references 18 and 21.