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County-level Variation in Infant Mortality Reporting at Early Previabable Gestational Ages

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Abstract

Background: Infant mortality rate (IMR), or number of infant deaths per 1000 livebirths, varies widely across the US. While fetal deaths are not included in this measure, reported infant deaths do include those delivered at previable gestations, or < 20 weeks gestation. Variation in reporting of these events may have a significant impact on IMR estimates.

Methods: This retrospective analysis used US National Center for Health Statistics 2007–2013 data from 2391 US counties. Counties were categorized by US region, demographic characteristics, and state-level fetal death reporting requirements. County percentage of fetal deaths among all 17–20 week fetal and infant deaths was evaluated using multivariable linear regression. County-level characteristics were then included in multivariable linear regression to determine the associated change in county IMR.

Results: County percentage of deaths at 17–20 weeks reported as fetal ranged from 0% to 100% (mean 63.7%). Every 1 point increase in this percentage was associated with a 0.02 point decrease in county IMR (95% confidence interval (CI) 0.02, 0.03). When county IMRs were recalculated holding the percentage of fetal vs. infant deaths at 17–20 weeks constant at 63.7%, results suggest that the predicted gap in county IMR between Northeast and Midwest regions would narrow by 0.45 points.

Conclusions: Variable reporting of previable fetal and infant deaths may compromise the validity of county IMR comparisons. Improved consistency and accuracy of fetal and infant death reporting is warranted.

Keywords

infant mortality; previable; fetal death; infant death; variation

The infant mortality rate (IMR), or number of deaths before 1 year for every 1000 livebirths, is considered a key health indicator for a given community or region. As of 2014, the US IMR of 5.82 has declined below the Healthy People 2020 goal of 6.0, representing a roughly 10% decrease over the last decade. However, wide IMR variation across the US has persisted, with generally higher rates in the Southern and Midwestern US compared with other regions of the country (most recent high of 8.24 for Mississippi and a low of 4.30 for California). Such geographic variation is likely related to multiple factors including maternal health, prenatal care quality and access, and socio-economic conditions.

However, variation in how infant deaths are reported may also be a significant contributor. Based on World Health Organisation standards, a livebirth with infant death includes delivery of any product of human conception showing initial evidence of life, regardless of gestational age. Conversely, fetal death, which does not contribute to the IMR, is characterised by absent signs of life at delivery, to be distinguished from transient cardiac contractions, fleeting respiratory efforts or gasps. Given the challenges of these distinctions, classification of these events as either infant or fetal deaths may be uniquely vulnerable to potential error or bias. Additionally, under the Born-Alive Infants Protection Act (BAIPA) of 2002, whether or not a very early previable livebirth with infant death is reported may depend on provider or parental discretion. This issue is further compounded by state variation in birthweight and gestational age requirements for fetal death reporting.

Ultimately, variation in the reporting of previable gestation deaths likely reflects a combination of legislative policy and hospital practices, cultural norms in attitudes towards pregnancy termination and neonatal resuscitation, as well as social, economic, and religious views. Here, we sought to describe the extent to which local variation in reporting previable gestation fetal and infant deaths contributes to regional IMR variation. Using national data, we assessed county-level variation in death event reporting at 17–20 weeks gestation. We hypothesised that higher reported IMRs for counties in the Southern and Midwestern US would be associated with a higher proportion of previable gestation deaths reported as infant rather than fetal.

Methods

This was a retrospective population-based cohort analysis using county-level data from the National Center for Health Statistics (NCHS) on US infant live-births/deaths and fetal deaths from 2007 to 2013. This study was approved by the National Association for Public Health Statistics and Information Systems research review committee. Our analysis included counties in all 50 states plus Washington D.C. that reported at least one fetal death or infant death at 17–20 weeks during the study timeframe (17 weeks being the lower limit for livebirth data provided by NCHS). Surveillance data on elective and therapeutic abortions, which are not issued fetal death certificates, are maintained separately and therefore were not included in this analysis. We focused on deliveries at 17–20 weeks due to their

unequivocal mortality risk and the variability of state fetal death reporting requirements at this gestational age range. To avoid possible error in gestational age documentation, those infants with a reported gestational age of 17–20 weeks but who died after 24 h of life were excluded from consideration.

For counties meeting inclusion criteria, our primary outcome was the percentage of total reported death events at 17–20 weeks (fetal deaths plus infant deaths within 24 h of livebirth) that were reported as fetal deaths for each county in aggregate over the 7-year study period. We also assessed infant mortality rates by county using aggregate total infant livebirths and deaths. Gestational age was derived from the clinical gestational age estimate in the birth certificate or fetal death record consistent with current NCHS reporting given its improved accuracy over the combined gestational age estimate.

Using the Federal Information Processing Standard code which uniquely identifies each US county, counties in the sample were classified as either metropolitan or non-metropolitan based on the 2006 NCHS urban-rural classification scheme. Counties were also categorised into one of four US regions – Northeast, Midwest, South, and West – based on state groupings by the US Census Bureau. Given known disparities in fetal and infant mortality rates by maternal race and other characteristics, we also aggregated the following maternal demographic characteristics reported for each county using all livebirths occurring during the study period: per cent non-Hispanic black, per cent who smoked during pregnancy, and per cent with any documented prenatal care. Using data available from the US Census Bureau American Community Survey, counties with greater than 20% of residents living below the federal poverty level were classified as high poverty counties. Finally, counties were categorised based on state-level legal standards for vital registration of a fetal death. Twenty-five states restrict the requirement for reporting fetal deaths to those 20 weeks gestation, and three additional states (New Mexico, South Dakota, Tennessee) plus Washington D.C. include a restriction of birth-weight 500 g. Counties in these states (plus Washington D.C.) were categorised separately from those in the remaining 22 states with more expanded fetal death reporting requirements (Arkansas, Colorado, Georgia, Hawaii, New York, Rhode Island, Virginia, Pennsylvania, Kansas, Arizona, Delaware, Idaho, Kentucky, Louisiana, Massachusetts, Mississippi, Missouri, Montana, New Hampshire, South Carolina, Wisconsin, and Michigan); these states require reporting of fetal deaths either at all gestations or potentially below 20 weeks gestation based on birthweight cutoffs of 350–400 g.

Differences in reporting of infant and fetal deaths at 17–20 weeks were assessed based on county-level characteristics using Chi-square and *t*-test comparisons as well as multivariable linear regression. Next, the association between this percentage and county IMR was evaluated using multivariable linear regression adjusting for county-level characteristics. Finally, we generated predicted values for each county's IMR assuming the true fetal vs. infant death rate at 17–20 weeks is constant and using the average percentage reported as infant deaths across included counties. County-level characteristics were then included in multivariable linear regression models to determine the associated change in county IMR. Because all variables were based on aggregated data at the level of the county, there were no observations with missing values. All models were adjusted for clustering by state using

robust variance estimation, and collinearity of model parameters was assessed using variance inflation factors.

Results

From the original dataset of 3141 counties across 50 US states plus Washington D.C., 2391 counties with at least one fetal death or infant birth/death within 24 h at 17–20 weeks were included (Figure 1). Compared with counties included in the analysis, excluded counties had fewer total livebirths over the 7-year period (mean 819 births vs. 11 676 births), were more likely to be non-metropolitan (89.7% vs. 57.6%), and less likely to be in the Northeast (0.8% vs. 8.8%), all P -values <0.001 . Fewer excluded counties had expanded fetal death reporting requirements (38.9% vs. 46.4%). Total infant livebirths in the analytic sample were 27 918 252, of which 175 337 were linked to an infant death, yielding a total IMR for the sample of 6.28. Of these infant deaths, 9.3% (16 391) were infants delivered at 17–20 weeks. Additionally, 37 516 fetal deaths at 17–20 weeks were reported.

At a county level, the percentage of all reported fetal deaths that were at 17–20 weeks gestation ranged from 0% to 100%, with a mean 13.2%, s.d. 12.9%. The percentage of all reported infant deaths that were at 17–20 also ranged from 0% to 100%, with a mean 8.8%, s.d. 10.5%. On average, the majority of all death events (fetal and infant) at 17–20 weeks were reported as fetal (county mean 63.7%, range 0–100% with s.d. 32.4%). As shown in Table 1, raw differences in these percentages were observed by region, with counties in the Northeast having a higher incidence of both fetal and infant deaths at 17–20 weeks compared with other regions. In multivariable linear regression accounting for county-level demographics and clustering by state, percentage of reported infant deaths at 17–20 weeks gestation was persistently higher in Northeast counties compared with other regions, P -values <0.05 (data not shown).

As also shown in Table 1, there were significant regional differences in the percentage of 17–20 week events reported as fetal rather than infant deaths, ranging from 55.0% among Midwest counties to 73.8% among Northeast counties. After adjusting for other county characteristics, counties in the Midwest still had a significantly lower percentage of events at 17–20 weeks reported as fetal deaths (rather than infant deaths) compared with other regions (Table 2).

Effect on observed county IMR

As shown in Table 3, every 1 percentage increase in deaths at 17–20 weeks reported as fetal was associated with a 0.02 point decrease in county IMR. Accounting for the effect of this variation in death reporting, counties in the US South were associated with a higher IMR by 0.81 points (95% CI 0.07, 1.54) compared to the Northeast. No significant difference in IMR was observed for other regions of the country, including the Midwest. Non-metropolitan counties and those with higher poverty rates, higher percentage of non-Hispanic black mothers, lower percentage receiving prenatal care, higher smoking rates, and lower total birth volumes were associated with higher IMRs.

Predicted county IMRs if previable infant and fetal death percentages were constant

A predicted IMR value for each county was calculated based on the average percentage of 17–20 week deaths reported as an infant livebirth and death across all included counties (average 36.3%). The average change in county total IMR based on these predicted values was an increase of 0.10 compared with the observed county IMR. Counties in the Midwest had a 0.18 point decrease in the predicted vs. observed IMR on average (predicted IMR 6.44 vs. observed IMR 6.62). Conversely, in the Northeast, predicted IMR was 0.41 points higher than observed on average, in the South predicted IMR was 0.22 points higher, and in the West predicted IMR was 0.04 points higher. This difference persisted after multivariable adjustment as shown in Table 4. Counties in the Midwest had a difference between observed and predicted IMR that was 0.45 points higher (95% CI 0.15, 0.74) than those in the Northeast, suggesting a gap between Northeast and Midwest county IMRs that may be attributable to reporting differences at 17–20 weeks. No other regional differences were significant.

Sensitivity analyses

Given the potential uncertainty regarding assessments of viability and livebirth status for deliveries at later gestations, we repeated analyses after increasing the gestational age interval up to 23 weeks. Unlike in the primary analysis, we observed no regional differences in the percentage of deliveries at 17–23 weeks reported as a fetal death after multivariable adjustment (Midwest compared with Northeast, –6.3%, 95% CI –14.9%, 2.3%). Finally, because of the possibility that New York was primarily driving regional differences as a highly populous Northeastern state with mandated reporting of all fetal deaths, we repeated analyses of 17–20 week gestation events excluding the state of New York; findings were similar to those observed in the primary analysis.

Comment

Variation in previable event reporting at the state and local level has the potential to exert a significant influence on IMR estimates.¹⁰ We demonstrated wide county variability in fetal and infant death reporting at 17–20 weeks gestation, with counties in the Northeast reporting the highest volume of fetal and infant deaths in this gestational age range on average. Adjusting for birth volume and other county characteristics, those in the Midwest reported more 17–20 week deliveries as livebirths compared with other US regions. Findings of our sensitivity analysis including up to 23 weeks gestation indicate that this variation is specific to the very early previable gestational age range. Taken together, these data suggest that regional differences in fetal and infant death rates at 17–20 weeks may relate to differences in reporting frequency of these events but also potentially in how such events are classified. For every 10% increase in the percentage of 17–20 week deaths reported as fetal, county IMR decreased by 0.2 deaths per 1000 livebirths – a substantial effect size given that the Healthy People 2020 goal was an IMR reduction of 0.7 over 14 years. When we accounted for this variation in multivariable modelling, regional differences in IMR were observed for the US South but not for the Midwest. If the true percentage of deliveries at 17–20 weeks resulting in a liveborn infant vs. fetal death is assumed to be constant, our analysis suggests

that counties in the Midwest are more prone to reporting a higher IMR than would be expected.

As researchers and public health providers increasingly focus efforts on population health, IMR is often used as a key measure at the county level to assess community health status, socio-economic conditions, and health care access and quality. Consistent with prior literature, our analysis demonstrates disparities in county IMR by rural status, demographics, and county size, all of which illustrate the very real impact of place on reproductive health and wellness. However, our findings also suggest that there are limitations to the validity of IMR comparisons across the US due to differences in how previable gestation deaths are reported. We demonstrate significant regional influences on fetal and infant death reporting, and also that smaller counties tend to report a higher percentage of previable deaths as fetal. At a local level, at least one prior study of data from a single state has demonstrated that hospital of birth may independently contribute to variable reporting of deaths as either fetal or infant, and that minimising this variability would substantially impact the state's IMR. Prior research has also demonstrated wide differences across US states in reporting of fetal and infant deaths for those weighing <500 g and delivered at 20 weeks. At a national level, trends in US fetal and infant death reporting have been suggested as a contributor to a previously observed increase in the US IMR. This issue likely influences the validity of international IMR comparisons, as the US reports a higher percentage of livebirths at previable gestations compared to other high-income countries (including Finland, Denmark, and Canada).

Limitations of this population-based, nationally representative study include the omission of smaller, more rural counties due to insufficient delivery volume. However, because omitted counties were more likely to be in the Midwest compared with the Northeast, any bias this may introduce in terms of regional effects would be more likely towards the null. It is also possible that bias was introduced by deriving our analytic sample based on documented gestational age estimates, which may be more likely to be missing for those infants delivered at early previable gestations. However, overall missing rate for clinical gestational age estimates in vital statistics is <0.5% for all live birth records. Additional limitations include a lack of information on local health care systems by county to help explain the observed variation in fetal and infant death reporting. Additional limitations are known inaccuracies of vital statistics data, which are a function of both data quality as well as the skill level of the staff members responsible for gathering and entering this information. NCHS has historically relied on calculated gestational age estimates using the date of last menstrual period, but recently shifted to using the more clinically reliable clinical/obstetrical-based gestational age estimates for the purposes of reporting. Furthermore, analyses were limited to those infant deaths with a linked live birth certificate, which potentially introduces bias from missing or erroneous data.

There are several policy and practice implications of our findings. First, clinicians may benefit from further education on standard definitions of fetal and infant death to ensure consistency and accuracy of reporting. Such clarity is particularly important given increasing survival of infants <24 weeks gestation and the dynamic definition of viability, which likely contributes to variability regarding classification and initial management of these deliveries.

Further research to elicit provider beliefs, practices, and knowledge regarding previable fetal and infant death reporting would provide greater insight into the observed regional variability, which would be lessened considerably by standardising requirements for fetal death reporting across states. Additionally, geographic comparisons of perinatal mortality – which combines fetal mortality and livebirths with only brief survival – may more meaningfully reflect true differences in community health status than IMR alone. However, even definitions of perinatal mortality can be variable and may warrant further standardisation. Finally, the epidemiology and pathophysiology of previable birth at 17–20 weeks are known to be similar compared with preterm birth at later gestations. Given the substantial contribution of extremely early deliveries to infant mortality, further studies of screening and treatment strategies for their prevention are important.

Conclusion

Wide variation in reporting of fetal and infant deaths at 17–20 weeks gestation likely contributes to differential IMRs reported across the US. Adjusting for known factors to influence pregnancy outcomes, counties in the Midwest are more likely than other regions to report a higher IMR than would be expected based on their percentage of previable deliveries reported as an infant death. Further research into cultural, health systems, and provider-level factors that influence previable fetal and infant death reporting may provide greater insight into these observed regional differences.

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Figure 1.

Flowchart of sample derivation. Grey box represents the analytic sample after exclusion of counties with no infant or fetal death events at 17–20 weeks gestation.

Table 1.

Unadjusted comparison of reported fetal and infant deaths by region

	Northeast	Midwest	South	West	P-value
17–20 week fetal deaths as percentage of all fetal deaths	16.8%	13.7%	12.1%	13.7%	<0.01
17–20 week infant deaths as percentage of all infant deaths	10.7%	9.9%	8.1%	7.5%	<0.01
Fetal deaths as percentage of all events at 17–20 weeks	73.8%	55.0%	67.4%	62.8%	<0.01
Mean county infant mortality rate (deaths/1000 livebirths)	5.80	6.62	7.76	5.78	<0.01

Table 2.Percentage of county deaths at 17–20 weeks gestation reported as fetal^a

Difference in percentage of deaths reported as fetal (95% confidence interval)	
US Region	
Northeast	1.00 (Reference)
Midwest	−17.02 (−27.94, −6.10)
South	−5.00 (−15.88, 5.87)
West	−9.01 (−20.12, 2.11)
Expanded fetal death reporting standard	6.88 (−1.39, 15.15)
Non-metropolitan	0.32 (−2.63, 3.27)
Total county livebirths	
<1500	2.85 (−1.41, 7.12)
1500	1.00 (Reference)

^aMultivariable linear regression model adjusted for county-level demographics: maternal race for all livebirths, maternal smoking among all livebirths, and documented prenatal care among all livebirths. Models also adjusted for clustering by state using robust variance estimation.

Table 3.Effect of 17–20 week fetal death reporting on county infant mortality rate (IMR)^a

	Point difference in county IMR (95% confidence interval)
Percentage of 17–20 week deaths reported as fetal ^b	–0.02 (–0.03, –0.02)
US Region	
Northeast	1.00 (Reference)
Midwest	0.34 (–0.32, 1.01)
South	0.81 (0.07, 1.54)
West	0.16 (–0.5, 0.82)
Expanded fetal death reporting standard	0.16 (–0.2, 0.51)
Non-metropolitan	0.39 (0.12, 0.66)
Total county livebirths	
<1500	0.69 (0.33, 1.05)
1500	1.00 (Reference)

^aMultivariable linear regression model adjusted for county-level demographics: maternal race for all live births, maternal smoking among all live births, and documented prenatal care among all live births. Models also adjusted for clustering by state using robust variance estimation.

^bPoint estimates represent the increase or decrease in IMR for every one percent increase in the predictor.

Table 4.

Difference in county infant mortality rate (IMR) if fetal and infant death percentages assumed constant at 17–20 weeks^a

Difference between observed and predicted IMR (95% confidence interval)	
US Region	
Northeast	1.00 (Reference)
Midwest	0.45 (0.15, 0.74)
South	0.16 (−0.17, 0.48)
West	0.23 (−0.08, 0.53)
Expanded fetal death reporting standard	−0.34 (−0.63, −0.06)
Non-metropolitan	0.03 (−0.05, 0.12)
Total county livebirths	
<1500	−0.02 (−0.18, 0.14)
1500	1.00 (Reference)

^aPredicted IMR for each county was calculated based on an average of 36.3% of deaths at 17–20 weeks gestation reported as an infant death. Multivariable linear regression models adjusted for clustering by state using robust variance estimation.