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Accidental Infant Suffocation and Strangulation in Bed: Disparities and Opportunities

Joanna Drowos[1] · Aaron Fils[2] · Maria C. Mejia de Grubb[3] · Jason L. Salemi[3] · Roger J. Zoorob[3] · Charles H. Hennekens[1,3] · Robert S. Levine[1,3]

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Abstract
Objectives (a) Update previous descriptions of trends in ASSB; (b) determine if factors previously associated with ASSB are replicated by updated data; and (c) generate new hypotheses about the occurrence of ASSB and racial inequalities in ASSB mortality. *Methods* National Center for Health Statistics files (International Classification of Diseases, Tenth Edition) Code W75 to describe race–ethnicity-specific ASSB occurrence. *Results* (a) ASSB mortality continues to increase significantly; for 1999–2016, 4.4-fold for NHB girls (45.8 per 100,000 in 2016), 3.5-fold for NHB boys (53.8), 2.7-fold for NHW girls (15.8) and 4.0-fold for NHW boys (25.9); (b) F actors previously associated with ASSB (unmarried mothers and mothers with low educational attainment, low infant birth weight, low gestational age, lack of prenatal care, male infant, multiple birth, high birth order) continue to be associated with both overall ASSB and inequalities adversely affecting NHB; (c) (1) geographic differences and similarities in ASSB occurrence support hypotheses related to positive deviance; (2) lower ASSB mortality for births attended by midwives as contrasted to physicians generate hypotheses related to both medical infrastructure and maternal engagement; (3) high rates of ASSB among infants born to teenage mothers generate hypotheses related to the possibility that poor maternal health may be a barrier to ASSB prevention based on education, culture and tradition. *Conclusions for Practice* These descriptive data may generate new hypotheses and targets for interventions for reducing both ASSB mortality and racial inequalities. Analytic epidemiologic studies designed a priori to do so are required to address these hypotheses.

Keywords Accidental suffocation and strangulation in bed (ASSB) · Sudden unexpected infant deaths (SUID) · Infant mortality · Racial disparities · United States (US)

Significance

Despite increased public health efforts for education about safe sleep practices, significant increases in mortality from ASSB were present in the US between 1999 and 2016. Data reveals identical risk factor profiles for NH black and NH white infants, though in every instance, NH black rates are higher than those for NH whites. Through gaining a deeper understanding of the epidemiology, including both risk and protective factors for ASSB, public health professionals can tailor messages and programs and reach a diverse group of mothers in order to reduce mortality related to this preventable tragedy.

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✉ Joanna Drowos
jdrowos@health.fau.edu

Maria C. Mejia de Grubb
maria.mejiadeGrubb@bcm.edu

Jason L. Salemi
jason.salemi@bcm.edu

Robert S. Levine
robert.levine@bcm.edu

[1] Charles E. Schmidt College of Medicine, Florida Atlantic University, 777 Glades Road, Building 71, Suite 215, Boca Raton, FL 33431, USA

[2] University of Miami, 1320 South Dixie Highway, Coral Gables, FL 33124, USA

[3] Department of Family and Community Medicine, Baylor College of Medicine, 3701 Kirby Drive, Suite 600, Houston, TX 77098, USA

Introduction

Background/Rationale

In 2016, accidental suffocation and strangulation in bed (ASSB), accounted for 25% (900) of the approximately 3600 sudden unexpected infant deaths (SUIDs) in the United States (US) (Centers for Disease Control and Prevention [CDC] 1999). From 1999 to 2015, ASSB was described as the primary factor in the substantial increase in overall mortality from unintentional suffocation among US infants (Guo et al. 2018).

Clinical and policy initiatives to reduce the occurrence of ASSB and other sleep-related disorders have included health messaging to caregivers, education of professionals, efforts to break down barriers (such as financial inability to purchase a crib), interventions based on culture and tradition, as well as various legislative and regulatory approaches (Moon et al. 2016). While there have been some successes, mortality rates of ASSB in the US have continued to rise (Carlberg et al. 2012; Shapiro-Mendoza et al. 2006, 2009). Moreover, these same studies of US populations also show higher frequencies of ASSB among blacks and African Americans. In part, explanations for such racial disparities in ASSB have included differences in safe-sleeping practices, particularly as regards infant positioning, bed-sharing and the use of soft bedding (Moon and American Academy of Pediatrics Task Force on Sudden Infant Death Syndrome 2011).

Objectives

Continuing rises in ASSB mortality might reflect, at least in part, improved differentiation of ASSB from other causes of SUID (Shapiro-Mendoza et al. 2006, 2009). In this descriptive study we (a) update overall and race-specific trends in mortality from ASSB; (b) compare and contrast factors previously associated with ASSB; (c) formulate hypotheses about ASSB as well as racial inequalities.

Methods

Study Design: Descriptive Vital Records Study

Setting

For overall ASSB mortality regardless of race, ethnicity or sex we used National Center for Health Statistics (NCHS) Multiple Cause of Death Records from 1999 to 2016. The Multiple Cause data set reduces the likelihood of underestimation since ASSB can be included whether it is the underlying or contributory cause of death. For race–ethnicity-specific ASSB mortality, we used National Center for Health Statistics (NCHS) Linked Birth/Infant Death Records from 1999 to 2016.

Participants

All observations are population-based. We used reliable rates defined by NCHS as those based on at least 20 cases and excluded those based on less than ten cases (US Department of Health and Human Services [DHHS] 2019).

Variables

US Census Region and State of residence at the time of birth; marital status (married or unmarried); educational attainment (< high school or > high school graduate; onset of prenatal care (none, 1–3 months, 4–10 months); attendant at delivery (Medical Doctor (MD), Doctor of Osteopathy (DO) or Midwife (Certified Nurse Midwife or other Midwife); and maternal age at delivery (15–24, 25–39 years in conjunction with live birth order). Infant: birth weight (500–1499, 1500–2499, 2500–3999, > 4000 g); gestational age based on last menstrual period (20–33, 34–35, 37–41 or > 42 weeks); single or multiple birth; boy or girl; birth order (maternal age 15–24 years and live birth order = 1, 2, 3, 4, and > 5 or 6; and 25–39 years and live birth order = 1, 2, 3, 4, 5, or > 6).

Data Sources

NCHS provides Multiple Cause and Linked Birth/Infant Death Records, with details of measurements. Multiple Cause data is preferred for overall estimates since ASSB is included whether it is the underlying or contributory cause of death, thereby reducing the chance of underestimation. To address potential bias from use of death certificates alone we used Linked Birth/Infant Death Record for race- and ethnicity-specific rates. Specifically, the infant's mother provides race information for Linked files, while a funeral director or another informant provides that information for the death certificate (Matthews and MacDorman 2013).

To address bias from ethnicity, we excluded Hispanics. This is because Hispanic ethnicity is reported on the birth certificate, but race-specific Hispanic ethnicity is, to our knowledge, not reported in NCHS publications. According to Matthews and MacDorman (2013), the primary rationale is that "The vast majority of women of Hispanic origin are reported as white" (p. 2). Further they clarify that data for American Indian or Alaska Native and Asian or Pacific Islander births are not shown separately by Hispanic origin, "Because the vast majority of these populations are non-Hispanic." Finally, race-specific death certificate data within Hispanic populations have not been validated by

NCHS (Arias et al. 2016; E. Arias, personal communication April 28, 2017). NCHS does not present race-specific data for Hispanics when reports of linked birth/infant death records are reported, because of uncertainty about the validity of death certificate rates for Hispanic blacks and African Americans. Thus, the present report is primarily focused on rates for non-Hispanic Blacks (NHB) and non-Hispanic Whites (NHW).

Denominator

In the Linked file, the race of the mother, as recorded on the birth certificate, is used in both the numerator and denominator. This is likely to decrease a bias which may occur when death certificates alone are used since death certificate denominator data is the race of the mother as reported on the birth certificate, but the race of the numerator is the race of the infant as reported on the death certificate. In addition, infant mortality rates using the Linked files are reported as deaths per number of live births, while infant mortality rates using Death Certificates alone are reported as deaths per number of infants residing in the population (CDC NCHS 2019).

Validity of Data Elements

Comprehensive data on birth certificate validity are sparse (Martin et al. 2013; Northam and Knapp 2006). Specifically, infant birth weight, obstetric estimate of gestation, and live birth order are reported to be valid, in contrast to total number of prenatal visits, previous preterm birth, meconium staining, and fetal intolerance. Information about rare events such as birth defects, maternal alcohol use or smoking are considered also not validated (Salemi et al. 2017). In contrast, maternal reports about race and, to a lesser extent, ethnicity, are considered credible, but we have not been able to identify reports about the validity other maternally reported items such as maternal marital status or educational attainment.

Quantitative Variables

Infant births, infant deaths and infant mortality rates for NHBs and NHWs for the years 1999 to 2016 were obtained from Linked Birth/Infant Death Records as presented on the US Centers for Disease Control and Prevention's Wide-ranging ONline Data for Epidemiologic Research (WONDER) public internet web site. The International Classification of Diseases Tenth Edition (ICD-10) code of W75 was used to identify deaths from ASSB. Linked file death rates per 100,000 live births were stratified by race and gender. Groupings of variables generally reflected requirements for reliability (at least 20 cases in the numerator) and groupings available on WONDER. Groupings for onset of prenatal care (none, 1–3 months, 4–10 months) were broad, in part, because the reported quality of this information is variable.

Statistical Methods

Calculations included both relative (mortality rate ratios (MRR)) and absolute (mortality rate differences (MRD)) rates comparing NHBs and NHWs on a yearly basis from 1999 to 2016. Additionally, MRR's were presented to described maternal and infant characteristics between NHB and NHW infants and measured against reference groups with the lowest race-specific rates for each characteristic within NHB and NHW groups. Mortality rates and MRRs were compared by maternal place of residence according to census region and states; maternal age, marital status, and educational attainment; prenatal care; infant birth weight, gestational age, and sex; single versus multiple birth; and attendant at delivery (physician (MD/DO) or nurse midwife). Joinpoint regression analysis was used to identify and quantify trends (Kim et al. 2000). Average annual percent changes (AAPC) in race–ethnicity–sex specific rates and race–ethnicity–sex-specific mortality rate differences from 1999 to 2016 were estimated with the Joinpoint regression program (Version 4.6.0.0; National Cancer Institute 2018). Parameters were structured to produce reliable rates, and rates for MD's and DO's were combined, after finding no statistically significant differences between them. MRRs and 95% CIs were calculated with StatsDirect software (Freemantle 2000). This research was classified as exempt by the Baylor College of Medicine Institutional Review Board.

Results

Information for all infants as reported in the Linked Birth/Infant Death records was included within the NCHS guidelines of confidentiality (at least 10 cases—applicable to counts) and reliability (at least 20 cases—applicable to rates). From 2007 to 2016 there were 2414 deaths due to ASSB among NHB and 3924 among NHW. Data for maternal education were unknown or unstated for 14 NHB and 21 NHW and missing for 529 NHB and 755 NHW. Data for live birth order were unknown or unstated for 21 NHB and 15 NHW. Detailed information about reasons for exclusions, (primarily relating to stated differences in the content of the birth certificate) are available on the WONDER site.

In the US from 1999 to 2016, overall infant mortality from ASSB more than tripled (6.9 per 100,000 population in 1999 to 21.9 in 2016 [MRR = 3.2 (95% confidence interval (CI) 2.8, 6.2), $p < 0.001$]. Race–ethnicity–sex-specific infant mortality rates from ASSB (Table 1) increased from 10.4 per 100,000 live births in 1999 to 45.8 per 100,000

Table 1 Infant deaths per 100,000 live births, mortality rate ratios and mortality rate differences

Year of death	NHB		NHW		NHB:NHW mortality rate differences		NHB:NHW mortality rate ratios	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
1999	10.4	15.4	5.9	6.5	1.8	2.4	4.5	8.9
2000	15.1	14.0	3.7	7.6	4.1	1.8	11.5	6.4
2001	14.5	21.7	7.6	11.4	1.9	1.9	6.9	10.3
2002	27.1	26.2	8.0	10.6	3.4	2.5	19.1	15.6
2003	20.5	24.9	8.0	12.4	2.6	2.0	12.5	12.5
2004	27.1	27.1	10.7	14.6	2.5	1.9	16.4	12.5
2005	20.9	27.3	10.9	14.1	1.9	1.9	10.0	13.2
2006	26.8	37.8	10.9	14.9	2.5	2.5	15.9	23.0
2007	34.0	37.7	13.3	17.4	2.6	2.2	20.7	20.3
2008	33.3	37.0	15.6	19.2	2.1	1.9	17.7	17.8
2009	32.0	38.1	12.5	17.9	2.6	2.1	19.5	20.2
2010	29.4	36.9	13.2	18.1	2.2	2.0	16.2	18.8
2011	31.8	36.2	15.3	15.7	2.1	2.3	16.5	20.5
2012	34.1	44.5	14.2	21.8	2.4	2.0	19.9	22.7
2013	49.4	47.2	14.0	24.3	3.5	1.9	35.4	22.9
2014	44.4	49.6	17.1	24.6	2.6	2.0	27.3	25.0
2015	45.6	50.4	18.6	25.9	2.4	1.9	27.0	24.6
2016	45.8	53.8	15.8	25.9	2.9	2.1	30.0	27.9
AAPC[a]	9.2	8.4	7.9	9.0	10.3	7.3	0.6	− 0.5
p	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.8	0.8

Accidental suffocation and strangulation in bed, United States of America, 1999–2016

[a]*NHB* non-Hispanic Black, *NHW* non-Hispanic White

live births in 2016 among NHB female infants; from 15.4 to 53.8 for NHB male infants, from 5.9 to 15.8 for NHW white female infants, and from 6.5 to 25.9 for NHW male infants. All increases over time (expressed as AAPC) were statistically significant ($p < 0.05$). For NHB female infants, AAPC's were 9.2% (95% CI 5.4, 13.1); for NHB male infants 8.4% (95% CI 5.5, 11.4); for NHW female infants 7.9% (95% CI 2.3, 8.9); and for NHW male infants 7.9% (95% CI 4.3, 11.6). Additionally, there was a statistically significant increase in NHB:NHW mortality rate differences for both female [AAPC = 10.3 (95% CI 3.0, 18.0)] and male infants [AAPC = 7.3 (95% CI 4.1, 10.6)]. Absolute rate differences increased from 1.8 per 100,000 in 1999 to 2.9, an AAPC of 10.3% in 2016 for female infants and in 2000 to 2016 from 1.8 to 2.1 (2000 to 2016) for male infants, an AAPC of 7.3%. These apparently large disparities in race–ethnicity-specific MRRs did not achieve statistical significance.

Since detailed descriptions of study variables are consistent with previous reports, they are presented in Supplementary Table 1. This shows both NHB:NHW MRRs according to various maternal and infant characteristics as well as race–ethnicity-specific MRRs for each level of each characteristic relative to their respective reference categories for the years 2009 to 2016 inclusive. Overall, NHBs and NHWs had similar risk factor profiles and demonstrated similar trends relative to reference categories for each potential risk factor. With respect to NHB:NHW MRR's, however, mortality was significantly greater among blacks, regardless of the population subgroup with the exception of ASSB deaths to 15 to 24 year old mothers having their 5th or 6th live births. Supplementary Table 1 also shows that between 2007 and 2016, 83% (5263 of 6339) of all US infant deaths from ASSB among NHB and NHW infants occurred to mothers who resided in the Midwest and South at the time of delivery, including 88.6% for NHBs and 79.6% for NHWs. Additionally, Supplementary Table 1 shows high rates for ASSB as live birth order increases, especially among younger mothers. NHB infants who were the 4th live births for mothers ages < 15 to 24 years had the highest rate (116.7 per 100,000 live births) of all sub-groups analyzed, followed by NHB infants from the same maternal age group who were the 5th or 6th live-born infant (108.1 per 100,000 live births). Among NHW's whose mothers were 15 to 24 years of age, the ASSB rate for infants who were the 5th or 6th live birth was 87.1 per 100,000.

Table 2 shows a wide range of ASSB mortality in states with statistically reliable rates for both NHBs and NHWs. The highest rate occurred among NHBs in Michigan (126.4

Table 2 Infant mortality (per 100,000 live births) from accidental suffocation and strangulation in bed in US states with reliable rates, 2007–2016

State	NHB mortality	NHW mortality	NHB:NHW MRR
New Jersey	**20.5**	**4.4**	**4.7**
Michigan	*126.4*	*34.3*	*3.7*
Illinois	66.5	20.6	3.2
Wisconsin	58.6	20.3	2.9
Nevada	*79.4*	*27.8*	*2.9*
Pennsylvania	26.9	9.6	2.8
North Carolina	25.2	9.8	2.6
Indiana	*72.8*	*28.6*	*2.5*
Missouri	*109.8*	*44.2*	*2.5*
Minnesota	39.3	15.9	2.5
New York	**18.8**	**7.7**	**2.4**
Arkansas	26.7	12.6	2.1
Tennessee	55.2	26.9	2.1
Georgia	27.3	14.0	2.0
Virginia	**23.3**	**12.3**	**1.9**
Louisiana	*70.6*	*38.3*	*1.8*
Texas	29.6	16.3	1.8
California	**11.8**	**6.5**	**1.8**
Alabama	**22.1**	**12.7**	**1.7**
Ohio	43.6	27.2	1.6
Florida	56.8	37.0	1.5
Mississippi	65.0	45.0	1.4
South Carolina	56.4	42.2	1.3

States with reliable rates for NHW only

State	NHW
Wyoming	38.8
Maine	24.1
Kansas	21.0
Oregon	20.9
Kentucky	17.6
Colorado	17.2
West Virginia	17.0
Oklahoma	15.6
Arizona	15.3
Washington	12.4
Idaho	11.3
Nebraska	10.3
Iowa	10.1
Utah	8.9

The bold values represent the states with five lowest rates among NHB and the italic values represent the states with five highest rates among NHB. Listed in order of NHB:NHW mortality rate ratio. Totals for US as a whole: NHB = 40.5; NHW = 18.1

NHB non-Hispanic Blacks, *NHW* non-Hispanic Whites

per 100,000 live births) versus an overall rate of 39.5 for US NHBs and11.8 for NHB in California. The highest corresponding rate for NHWs occurred in Mississippi (45.0), while the lowest rate occurred in California (6.5) with an overall rate of 17.8. California also had the lowest rate for NHWs, even when considering states without reliable NHB rates. In Michigan, NHB infants who were the 4th to 6th live births for mothers ages 15 to 29, had an ASSB

infant mortality rate 259.0 for NHBs and 78.9 for NHWs (2007–2016 inclusive). For NHB infants who were the 5th or 6th live births occurring to such mothers, the rate was 301.0. Notably, two adjacent, low-income southern states had significantly different outcomes, namely Alabama (NHB = 41/185,549 = 22.1, NHW = 46/362,404 = 12.7) and Mississippi (NHB = 115/176,825 = 65.0, NHW = 93/206,819 = 45.0). The MRR for MS:AL among NHBs was 2.94 (95% CI 2.07, 4.24) and among NHWs was 3.54 (2.50, 5.08).

Table 3 shows ASSB mortality for infants of birth order > 3 according to race and maternal age. Highest mortality among NHB and NHW occurred among mothers 15–19 years of age, and ASSB mortality decreased in each successively higher age group. NHB mortality was significantly higher than NHW mortality in each age group except 15–19 years although the magnitude of relative risk at 15–19 years [1.48 (0.90, 2.48)] was higher than that for 20–24 years [1.40 (1.22, 1.61)].

Table 4 shows significantly increased risks for ASSB for attendance at delivery by an MD or DO in comparison to attendance by a midwife [NHW MRR 1.40 (1.18, 1.68)] and NHB MRR [1.73 (1.51, 2.00)]. The same is true for infants whose birth weights were less than 2500 g. Regardless of the type of attendant, however, NHB rates for ASSB exceeded those of NHW rates.

Discussion

Key Findings

In the US from 1999 to 2016, overall infant mortality from ASSB more than tripled These most recent data on morality from ASSB are consistent with previous observations about factors associated with higher rates. Both NHBs and NHWs show similar profiles of such factors. Additionally, the present report extends previous observations by showing continuing increases in mortality from ASSB through the year 2016 among NHB and NHW infants regardless of sex, with absolute racial inequalities (as expressed by NHB:NHW differences in mortality) increasing significantly. Further, the present data identify the Northwest and Southern US Census Regions as having the highest rates of ASSB, accounting for 83% of all US ASSB cases from 2007 to 2016 (88.6% of NHBs and 79.6% of NHWs).

In addition, the present data generate new hypotheses about the occurrence of ASSB and racial inequalities in

Table 3 ASSB mortality among infants of birth order ≥ 3 according to race and maternal age

Maternal age (years)	NHB			NHW		
	Deaths	Live births	Deaths per 1000 live births	Deaths	Live births	Deaths per 1000 live births
15–19	42	24,978	1.68	24	21,119	1.14
20–24	378	400,892	0.94	414	616,272	0.67
25–29	410	634,760	0.65	553	1577,498	0.35
30–34	220	520,318	0.42	357	1877,084	0.18
35–39	78	228,972	0.27	127	1,116,684	0.11
40–44	15	74,743	0.20	27	260,339	0.10

NHB non-Hispanic Blacks, *NHW* non-Hispanic Whites

Table 4 Selected characteristics of accidental suffocation and strangulation in bed (USA, 2007–2016)

Characteristic	NHB	NHW	NHB:NHW	NHW MRR's (95% confidence interval) versus reference	p	NHB MRR's (95% confidence interval) versus reference	p
Attendant at delivery (all birth weights)							
Certified nurse midwife or other midwife	29.4	13.2	2.75 (2.21, 3.42)	Reference	n/a	Reference	n/a
MD or DO	41.4	18.5	2.23 (2.12, 2.35)	1.40 (1.18, 1.68)	< 0.001	1.73 (1.51, 2.00)	<0.001
Attendant at delivery (birth weight > 2500 g							
Certified nurse midwife or other midwife	28.0	12.5	2.24 (1.79, 2.79)	Reference	n/a	Reference	n/a
Physician (MD or DO)	36.3	16.9	2.15 (2.02, 2.28)	1.30 (1.08, 1.57)	0.006	1.35 (1.19, 1.54)	<0.001

NHB non-Hispanic Black, *NHW* non-Hispanic White

ASSB by identifying factors which may be associated with increased as well as decreased risks. In this regard, geographic variation, medical attendant at delivery and birth order among young mothers may be particularly fruitful areas for further research.

These data also show extensive geographic variation in ASSB mortality among both NHB and NHW. To some extent, these may reflect socioeconomic differences. Notably, however, Alabama (NHB = 41/185,549 = 22.1, NHW = 46/362,404 = 12.7) and Mississippi (NHB = 115/176,825 = 65.0, NHW = 93/206,819 = 45.0), two adjacent, low-income southern states, also had significantly different rates of ASSB. This observed difference may be due, at least in part, to changes in ASSB mortality associated with the improved differentiation from SIDS. (Shapiro-Mendoza et al. 2006). Nonetheless, the phenomenon of positive deviance—whereby relatively low infant mortality and racial inequality occur despite contextual socio-economic vulnerability—has been previously demonstrated for overall infant mortality. Thus, it might be worthwhile for analytic epidemiologic investigations to delve more deeply into the exact reasons for geographic variation in seemingly similar socio-economic contexts (Barnes-Boyd 1995). Future investigations should extend beyond the conventional, but perhaps, incorrect wisdom that contextual socio-economic vulnerability is inevitably associated with high infant mortality or racial inequalities. In support of this possibility, interventions outside the realm of major socio-economic reform may result in dramatic reductions in sleep-related deaths. For example, the experience of the Direct On-Scene Education™ program that trains first responders to assess every home entered after every 911 call to identify whether there is an infant, and whether there is a safe sleep environment for the infant has been investigated. Through providing "Safe to Sleep Survival Kits" and portable cribs, this emergency medical service area lowered the number of sleep-related infant deaths from the highest to the lowest in all of Broward County, Florida, and this program has now been expanded to other states (Moon et al. 2016).

As regards the medical attendant at delivery, ASSB mortality was lower among both NHB and NHW infants when a midwife attended the delivery rather than a physician (MD or DO). One hypothesis generated by this observation is that it might reflect higher risk deliveries attended by an MD or DO in the context of decreasing resources for public health infrastructure. There is good evidence, for example, that pre- and post-natal visits by public health nurses may yield positive benefits to mother and child, but there is also growing concern about the precipitous decline in US public health nursing personnel (Barnes-Boyd 1995; Norr et al. 2003; Miller 2015; Olds et al. 2014; Young et al. 2014). A second hypotheses may reflect, in part, that pre- and post-partum care can be an integral part of midwife services, but physicians usually depend on others for the follow-up (Bowers et al. 2015). Maternal preferences may be a third plausible hypothesis. Nulliparous women who prefer midwives may be more likely to regard their active participation as effective and essential to the childbearing process compared to women who see their role as a passive one (Arcia 2015). Nonetheless, broader structural forces, particularly economic position and availability of birth options may be deciding factors in choice of an obstetrics provider (Miller and Shriver 2012). Analytic epidemiologic studies designed a priori to do so are necessary to confirm or deny the many hypotheses generated by these descriptive data. Future areas of study might include examining the family and cultural differences around sleep, local pediatrician practices, available social services and policies that lead to these geographic, racial and age differences, as well as continued evaluation of interventions.

Finally, with respect to birth order among young mothers, it is of interest that regardless of race, the highest rates of ASSB mortality among infants of birth order ≥ 3 occurred among infants whose mothers were teenagers. One characteristic of teenage births which, to our knowledge, has not been mentioned in connection with ASSB, is that two-thirds of births among teen-agers have been found to have a relatively short interpregnancy interval (IPI) (Mathews et al. 2004). While the present data cannot directly address IPI, it is tempting to generate hypotheses which might plausibly link IPI and ASSB. One possibility is that IPI may have adverse effects on maternal nutrition, including both iron and folate deficiencies—both of which may have adverse effects on maternal cognition, attention span, intelligence, and sensory perception functions, all of which might be plausible barriers to the effectiveness of ASSB prevention based on education, culture, or tradition (Miller 2015). Disentangling potential effects of maternal malnutrition from socio-economic vulnerability would be worthwhile even if daunting, since medical interventions to correct maternal malnutrition may be more feasible than interventions aimed at reduction/elimination of contextual social inequalities.

Limitations

The present report focuses on tabulations of aggregated infant mortality data by a variety of maternal and infant characteristics, unadjusted for possible confounding effects of other variables. Future investigations should include individual-level data to disentangle the multiple interrelationships between risk factors (Guo et al. 2018). While analyses of this type may employ a few key variables (Carlberg et al. 2012), the field may be transitioning to data sets comprising thousands of variables to identify novel latent constructs using scalable combinatorial methods (Kershenbaum et al. 2014; Gittner et al. 2017; Langston et al. 2014). Future

analysis based on individual patent data from the period linked birth/infant death records, may facilitate multivariable models that better isolate the independent contribution of each factor to overall and ASSB-specific mortality.

Interpretation

Despite several potential sources of bias we believe the most plausible interpretation of the data to be that there are increases in mortality from ASSB which appear to be greater in NHBs than NHWs. Further, these data are consistent with previous reports by demonstrating similar factors associated with increased risk. They also contribute to the formulation of many hypotheses including geographic variation, medical attendant at delivery and high birth order among teenage mothers. Analytic epidemiologic studies designed a priori to do so, are required to test these hypotheses generated, and further quantitate racial and geographic disparities in ASSB mortality.

Generalizability

The current data are population based within the US and, thus, may not be generalizable to other countries.

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