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ARTICLE

Racial differences in the impact of maternal smoking on sudden unexpected infant death

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BACKGROUND: Prenatal smoking increases the risk of Sudden Unexpected Infant Death (SUID). Whether exposure patterns and associations differ by race requires further study.

OBJECTIVES: Determine if patterns of exposure and associations between SUID and maternal smoking before and during pregnancy differ by race.

METHODS: Using U.S. National Center for Health Statistics linked birth/infant death files 2012–2013, we documented SUID by smoking duration and race. Maternal smoking history: never, pre-pregnancy only, and pre-pregnancy plus first, first, second, or all trimesters.

RESULTS: Smoking was more common in non-Hispanic White (NHW) than non-Hispanic Black (NHB) mothers and more evident for both in SUID cases. The most common exposure duration is from before and throughout pregnancy (SUID: 78.3% NHW, 66.9% NHB; Survivors: 60.22% and 53.96%, respectively). NHB vs. NHW SUID rates per 1000 live births were 1.07 vs. 0.34 for non-smokers and 3.06 and 1.79 for smokers, ORs trended upward for both with increasing smoking duration.

CONCLUSION: Fewer NHB mothers smoked, but both NHB and NHW groups exhibited a dose-response relationship between smoking duration and SUID. The most common duration was from before to the end of pregnancy, suggesting difficulty in quitting and a need for effective interventions.

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INTRODUCTION

In the United States, ~480,000 deaths occur from causes attributable to smoking [1], estimated to include 22% of the ~3500 infants who die annually from Sudden Unexpected Infant Death (SUID) [2, 3]. SUID consists of Sudden Infant Death Syndrome (SIDS), the third leading cause of infant mortality in the USA (www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm), ill-defined and unspecified causes of mortality (IUCM), and Accidental Suffocation and Strangulation in Bed (ASSB) [3, 4]. Although, by definition, SIDS and IUCM are deaths for which no cause has been found, the social, health, and behavioral factors that elevate risk are well-established and include exposure of the fetus and infant to smoking [2, 3]. Smoking in this context has been the focus of extensive study [5–16], which has documented its dose-dependent relationship with SUID [2], the increase in its adverse impact when occurring in conjunction with other established risk factors such as bed-sharing [17] and alcohol consumption [2, 6], and the mechanisms by which smoking elevates the risk of SUID [14, 18, 19].

Racial disparities in SUID also have been well-documented [20, 21]. Data from the Center for Disease Control and Prevention for 2019 report a USA SUID rate of 1.9 per 1000 live births in non-Hispanic Black (NHB) infants compared to 0.79 in non-Hispanic White (NHW) infants [22]. Higher rates of SUID in Black infants have been associated with disparities in adverse social, health, and behavioral determinants [23, 24], preterm birth [25], unsafe sleep practices [26, 27], and the social networks that influence parental behavior [28]. Concerning smoking, although cigarette consumption levels are lower for the NHB community compared to the NHW community, the former had lower quit ratios [29] and a greater risk of exposure to passive smoking [30]. Moreover, a disproportionate representation of Black women has been found to have slower nicotine metabolism [31, 32] with adverse implications for birthweight and head circumference [33]. Therefore, given the association between smoking and SUID and racial disparities in SUID rates among smokers (6.35 vs. 3.14 per 1000 live births, respectively, for NHB and NHW infants in 2019) [22], we sought to compare smoking patterns of NHB and NHW mothers to identify how differences and similarities can inform future interventions.

METHODS

Study design and population

Linked infant birth and death certificate period files for 2012 and 2013 in the United States were accessed from the National Center for Health Statistics website (http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm). Data for the 7,907,113 births from this period were pooled. We focused on non-Hispanic white, and non-Hispanic black mothers with gestational age between 24 and 42 completed weeks and birth weight between 400 and 6000 g and for whom complete information was available for all analysis

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Table 1. Out-of-hospital sudden unexpected infant death (SUID) by timing of maternal smoking by race-ethnicity, United States, 2012–2013.

	Non-Hispanic White			Non-Hispanic Black		
	Non-SUID	SUID	Total	Non-SUID	SUID	Total
Ever smoked before or during pregnancy	532,351 (16.01)	957 (50.10)	533,308 (16.03)	82,643 (9.65)	254 (23.45)	82,897 (9.66)
Never smoked	2,792,925 (83.99)	953 (49.90)	2,793,878 (83.97)	774,128 (90.35)	829 (76.55)	774,957 (90.34)
Total	3,325,276 (100.00)	1,910 (100.00)	3,327,186 (100.00)	856,771 (100.00)	1,083 (100.00)	857,854 (100.00)
Levels of Smoke Exposure						
Smoked pre-pregnancy only	123,842 (23.26)	99 (10.34)	123,941 (23.24)	20,474 (24.77)	42 (16.53)	20,516 (24.75)
Smoked pre-pregnancy and 1st trimester only	52,635 (9.88)	55 (5.75)	52,690 (9.88)	9,880 (11.96)	19 (7.48)	9,899 (11.94)
Smoked pre-pregnancy, 1st and 2nd trimesters	21,115 (3.96)	33 (3.45)	21,148 (3.97)	4,004 (4.84)	14 (5.51)	4,018 (4.85)
Smoked pre-pregnancy and 1st, 2nd, and 3rd trimesters	320,568 (60.22)	749 (78.27)	321,317 (60.25)	44,586 (53.96)	170 (66.93)	44,756 (53.99)
Smoked intermittently	14,191 (2.66)	21 (2.19)	14,855 (2.79)	3,699 (4.48)	9 (3.54)	3,708 (4.47)
Total	532,351 (100.00)	957 (100.00)	533,308 (100.00)	82,643 (100.00)	254 (100.00)	82,897 (100.00)

Source: Linked Infant Birth and Death Certificate Period Files from the National Center for Health Statistics.
Figures in cells are Ns, and column percentages are in brackets.

variables. We only included SUID cases when the infant died in the postnatal period at home and was autopsied. These restrictions led to analytic samples of 3,327,186 births to non-Hispanic white mothers and 857,854 births to non-Hispanic black mothers.

SUID was defined based on the International Classification of Disease – revision 10 (ICD-10) as an infant death at less than 365 days of age. It included ICD-10 codes of R95 (SIDS), R99 (Ill-defined and Unknown Causes), and W75 (ASSB), in keeping with the criteria for Healthy People 2020 [28]. We classified cases into six groups based on maternal smoking history: No pre-pregnancy or prenatal smoking, smoked pre-pregnancy only, smoked pre-pregnancy and during the first trimester, smoked pre-pregnancy and during the first and second trimesters, smoked pre-pregnancy and throughout pregnancy, and smoked intermittently with no clear pattern of timing.

Statistical analysis

First, we documented SUID rates per 1000 live births by smoking category and race-ethnicity. Second, we estimated unadjusted and adjusted logistic regressions of associations between smoking category and SUID, separately for non-Hispanic white and non-Hispanic black mothers. The analysis included maternal demographic and obstetric characteristics of marital status, age (<18, 18–35, >35 years), education (<high school, high school, >high school), gravida (1, 2–3, >3), infant gender, multiple births, mode of delivery (vaginal, caesarian), and gestational age (24–27, 28–31, 32–33, 34–36, 37–38, and 39–42 weeks). Because gestational age may mediate associations between exposure to maternal smoking and SUID but could also be a confounder, we estimated models both including and not including gestational age.

We used Stata 15.0 statistical software (StataCorp L.P., College Station, TX, USA) to conduct all analyses. This study met the Institutional Review Board standards for exempt review.

RESULTS

Smoking was more common in NHW than NHB mothers but more evident for both groups in SUID cases than survivors. In SUID cases, 50.1% and 23.5% of NHW and NHB mothers were smokers from the prenatal period through the third trimester, in contrast to 16.0% and 9.7%, respectively, for the non-SUID (survivor) group (Table 1).

Among mothers who ever smoked, the most common pattern was full exposure from pre-pregnancy through all three trimesters. (Table 1) This pattern of exposure in all four time periods was evident for both SUID and non-SUID cases in the NHW group (78.27% and 60.22%, respectively) and the NHB group (66.93% and 53.95%, respectively) and was more pronounced for the SUID cases.

Table 2. Out of hospital SUID death rate per 1000 live births by maternal race and smoking status[a].

Smoking status	Non-Hispanic White	Non-Hispanic Black
Never smoked	0.34	1.07
Smoked pre-pregnancy only	0.80	2.05
Smoked pre-pregnancy and 1st trimester only	1.04	1.92
Smoked pre-pregnancy, and 1st and 2nd trimesters	1.56	3.48
Smoked pre-pregnancy and 1st, 2nd, and 3rd trimesters	2.33	3.80
Smoked intermittently	1.48	2.43

[a]Based on cases included in all logistic regression models.

Table 2 reports rates of SUID per 1000 live births by race and maternal smoking status. Rates trended upward as smoking duration increased. Moreover, racial disparity in rates was evident at each degree of exposure, with the NHB group consistently demonstrating the higher rate. For example, for cases with no smoking history, the NHB rate of 1.07 per 1000 live births was three times that of 0.34 for the NHW group. The rates for smoke exposure in all four periods were 3.80 vs. 2.33, respectively.

Tables 3 and 4 report odds ratios for SUID in the NHW and NHB groups associated with increasing duration of maternal smoking during the prenatal period. No smoking was the reference group. In both racial groups, the OR's trended upward with increasing duration of exposure. However, the NHB group, whose non-smoking reference group already had a higher rate than the NHW group, rose more slowly. For example, after adjusting for marital status and education (proxies for socio-economic status), maternal age and education, gravidity, and gestational age, the aOR for the NHW group for smoking in all four time periods was 3.51 (95% CI: 3.14–3.92). The NHB group's adjusted OR for exposure in all four time periods was 2.50 (95% CI: 2.10–2.97).

Table 3. Associations between timing of maternal smoking and out-of-hospital sudden unexpected infant death, non-Hispanic Whites, United States, 2012–2013.

	Model 1[a] OR (95% CI)	Model 2[b] AOR (95% CI)	Model 3[c] AOR (95% CI)
Did not smoke	Ref.	Ref.	Ref
Smoked pre-pregnancy but not during pregnancy	2.34***	1.76***	1.77*
	(1.90–2.88)	(1.42–2.17)	(1.43–2.18)
Smoked pre-pregnancy and 1st trimester	3.06***	2.00***	2.00***
	(2.33–4.02)	(1.52–2.64)	(1.52–2.63)
Smoked pre-pregnancy and 1st and 2nd trimesters	4.58***	2.71***	2.58***
	(3.24–6.48)	(1.91–3.85)	(1.81–3.66)
Smoked pre-pregnancy and 1st, 2nd, and 3rd trimesters	6.45***	3.61***	3.51***
	(6.22–7.54)	(3.23–4.03)	(3.14–3.92)
Smoked intermittently	4.34***	2.51***	2.50***
	(2.81–6.68)	(1.62–3.88)	(1.62–3.86)
N	3,327,186	3,327,186	3,327,186

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Unadjusted odds.
[b]Adjusted for marital status, maternal age, maternal education, gravidity, infant sex, multiple birth, and Cesarean delivery.
[c]Adjusted for week of gestational age in addition to all variables in Model 2.

Table 4. Associations between timing of maternal smoking and out-of-hospital sudden unexpected infant death, non-Hispanic Blacks, United States, 2012–2013.

	Model 1[a] OR (95% CI)	Model 2[b] AOR (95% CI)	Model 3[c] AOR (95% CI)
Did not smoke	Ref.	Ref.	Ref.
Smoked pre-pregnancy but not during pregnancy	1.92***	1.65***	1.66***
	(1.40–2.61)	(1.21–2.25)	(1.22–2.27)
Smoked pre-pregnancy and 1st trimester	1.80**	1.48**	1.48**
	(1.14–2.83)	(0.94–2.34)	(0.94–2.34)
Smoked pre-pregnancy and 1st and 2nd trimesters	3.27***	2.46***	2.33***
	(1.92–5.54)	(1.45–4.19)	(1.37–3.97)
Smoked pre-pregnancy and 1st, 2nd, and 3rd trimesters	3.56***	2.55***	2.50***
	(3.02–4.20)	(2.15–3.03)	(2.10–2.97)
Smoked intermittently	2.27**	1.75**	1.74**
	(1.18–4.39)	(0.90–3.38)	(0.90–3.37)
N	857,854	857,854	857,854

Linked Infant Birth and Death Certificate Period Files from the National Center for Health Statistics.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Unadjusted odds.
[b]Adjusted for marital status, maternal age, maternal education, gravidity, infant sex, multiple birth, and cesarean delivery.
[c]Adjusted for gestational age in addition to all variables in Model 2.

DISCUSSION

In our study of a two-year national sample of USA births, we found that infants of both NHB and NHW mothers exhibited a dose-dependent relationship between SUID rates and duration of maternal smoking from prior to pregnancy through cumulative trimesters. These rates trended higher with increased exposure, demonstrating the significant contribution of smoke exposure to SUID in each racial group and the need to address this risk. A smaller percentage of NHB mothers smoked. However, among the NHB and NHW who smoked, the most common pattern was from pre-pregnancy through all trimesters, suggesting how difficult it is to quit and underscoring the need for effective interventions. Among smokers in the NHW and NHB SUID groups, 78.27% and 66.93% exhibited this pattern, as did smokers in the NHW and NHB non-SUID groups (60.22% and 53.96%, respectively). That smokers commonly continue to do so throughout the pregnancy has been reported previously [2]. Such findings underscore the importance of the recent recommendation by Hauck et al. in a study of maternal smoking in Black women that called for a more comprehensive approach to facilitating efforts to quit smoking and other substances beyond individual education [6]. This recommendation is supported by the observations that the NHB community had the lowest quit ratios for smoking across all education levels [29] and that over half of mothers who smoked in pregnancy continued to do so [34]. Of note, our study showed that only ~25% of mothers who smoked prior to pregnancy were able to stop during pregnancy, a finding that pertained to both racial groups.

Smoking interventions have had variable outcomes [5]. Promising efficacy was found in person-to-person counseling compared to health education or other passive interventions [35]. However, despite 67.5% of NHW and 72.8% of NHB smokers in a National

Health Interview Survey conducted in the USA in 2015 expressing a desire to quit, only 6.9% and 7.6%, respectively, used counseling intervention [36]. Moreover, only 60.2% and 55.7% received a health care provider's advice to quit. In a recent national survey [37], we found that while over 90% of obstetricians inquired about a patient's smoking habits before the onset of pregnancy, fewer addressed a patient's progress in quitting. These focused interactions trended downward throughout the pregnancy. Even fewer obstetricians reported discussing the risks of second-hand smoke or the specific smoking status of other members of the household. These findings underscore the need for obstetricians to take a more active role in addressing smoking.

Telephone support services to facilitate quitting reach across racial groups, but their use remains low [38]. Moreover, during the COVID-19 pandemic, calls to these services were down 27% [39].

Alternative nicotine delivery, such as vaping, has received attention as a method to limit fetal exposure, but data are not yet clear regarding safety and efficacy [5]. The American Academy of Pediatrics 2022 updated policy statement on reducing the risk of sleep-related infant death indicates that while no evidence exists on the relationship between vaping or electronic cigarette use and SUID, these devices contain nicotine, a risk factor for SUID. Therefore, their guidance regarding avoidance of smoking is now expanded to avoidance of nicotine [3].

In examining the relationship between maternal smoking and SIDS, one has to consider the potential impact of passive smoke exposure. In a previous study, we observed a high concurrence between maternal and paternal smoking in SIDS cases [40]. Postpartum smoking by both parents more than doubled the risk of SIDS [41]. According to the National Health Interview Survey for 2015 [42], NHB males smoked more than all other racial and ethnic groups. The difference in smoking rates between men and women was greater in the NHB population, 20.9% vs. 13.5%, compared to the NHW population (17.3% vs. 16.0%, respectively), suggesting that the NHB male may be an additional source of smoke exposure and a vital recipient of smoke-ending services. In our study, data on passive smoking were unavailable. However, we speculate that the greater baseline SUID rate for infants of non-smoking NHB women may be due, in part, to such a difference in exposure. The higher baseline SUID mortality rate for infants of NHB vs. NHW non-smokers also likely reflects their historically higher burden of behavioral risk factors, including bed sharing [26] and prone sleep placement [43]. Smoking in combination with bed-sharing [6, 17] raises the odds of SUID compared with smoking in its absence. Bedsharing and other risk-elevating behaviors were unavailable in our study. However, we speculate that more unsafe sleep practices in the NHB group may account for the slower increase in odds ratio in that population. In contrast, the rapid increase in odds ratio in the NHW groups with increasing smoke exposure may reflect the toxic contribution of smoking compared to a baseline group with a lower burden of other risk factors.

The mechanisms by which tobacco smoke increases the risk for SUID include the adverse impact of nicotine on areas of the brain associated with neonatal hypoxia tolerance and the capacity to arouse in response to a hypoxic challenge [14, 18, 44, 45]. In addition, a slower nicotine metabolic rate prolonging exposure has been disproportionately found in NHB populations [19, 32].

A strength of our study is that it identified similarities and differences in prenatal smoking patterns by race, potentially improving intervention strategies. A limitation of our study was that while we could control for gestational age, marital status and education, and other maternal variables, we did not have data on the number of cigarettes, unsafe sleep practices, passive smoke exposure, and postnatal maternal smoking. However, the increasing SUID risk we found with greater exposure was consistent with previous studies [2, 6, 16]. We speculate that the higher SUID rates for infants of non-smoking NHB vs. NHW mothers in the study reflect racial disparities in some of these unexamined variables.

In summary, NHB and NHW smokers exhibit a high likelihood of continuing to smoke throughout pregnancy and increasing odds ratios as usage continues through each trimester. Unique profiles in each group regarding interaction effects with other risk factors or underlying mechanisms by which exposure is prolonged may inform risk-reducing interventions. However, the overall finding is that exposure must be addressed with more effective smoke-ending interventions for both groups.

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AUTHOR CONTRIBUTIONS

TH conceptualized, and designed the study, contributed to the analysis, drafted the initial, and approved the final manuscript. OS-S acquired the data, carried out the analyses, participated in drafting the article, and reviewed and approved the final manuscript as submitted. NER contributed to and reviewed the analyses, contributed to the manuscript, and approved the final manuscript as submitted. BO contributed to the conception and design, provided essential intellectual content and suggestions for analyses, collaborated in drafting the manuscript, and approved the final manuscript as submitted. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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