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Disparities in Maternal Child and Health Outcomes Attributable to Prenatal Tobacco Use

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Abstract

Objectives—Previous estimates of smoking-attributable adverse outcomes, such as preterm births (PTBs), low birth weight (LBW) and Sudden Infant Death Syndrome (SIDS) generally do not address disparities by maternal age, racial/ethnic group or socioeconomic status (SES). This study develops estimates of smoking-attributable PTB, LBW and SIDS for the US by age, SES and racial/ethnic groupings.

Methods—Data on the number of births and the prevalence of PTB, LBW and SIDS were used to develop the number of outcomes by age, race/ethnicity, and SES. The prevalence of prenatal smoking by age, race/ethnic and education and the relative risk of outcomes for smokers were used to calculate smoking-attributable fractions of outcomes.

Results—Prenatal smoking among ages 15-24 is above 12%, with 20-24 year olds representing at least 35% of PTB, LBW SIDS cases. Women with a high school education or less represented more than 50% of PTB and LBW births, and 44% of SIDS cases. While non-Hispanic Whites had the majority of smoking-attributable outcomes, non-Hispanic Blacks represented a disproportionately high percentage of PTBs (18%), LBW births (22%), and SIDS cases (13%).
Conclusions: Reducing prenatal smoking has the potential to reduce adverse birth outcomes and costs with long-term implications, especially among the young, non-Hispanic Blacks and those of lower SES. Stricter tobacco control policies, especially higher cigarette taxes, higher minimum purchase ages for tobacco and improved cessation interventions can help reduce disparities and the cost to insurers, especially public costs through Medicaid.

Keywords

smoking; attributable; maternal; preterm; disparities

Introduction

Numerous studies (1-3) document the causal relationship between cigarette smoking during pregnancy and adverse maternal and child health (MCH) outcomes, such as preterm births (PTBs), low birth weight (LBW) and Sudden Infant Death Syndrome (SIDS). A recent study (2) estimates that 12.5% of PTB, 13.1% of full term births with LBW and 23.3% of SIDS are attributable to smoking.

In addition to pain and suffering, PTB, LBW and SIDS carry both financial and social costs for the family from the initial medical fees to ongoing supportive care. Medical expenses in the first year for preterm or LBW babies include treatment for lower and upper respiratory infections, otitis media, asthma, and respiratory distress syndrome (4). PTB and LBW also lead to increased public expenditures. In 2008, 21% of pregnant women covered by Medicaid smoked during the last three months of their pregnancy, compared to 6% of women privately insured (5). Medicaid is the payer in 48% of births (6), and pregnancy related hospitalizations and neonatal stays accounted for 50% of all Medicaid hospitalizations in 2008 (7).

Previous studies generally do not estimate the effects of prenatal smoking by age of the mother, racial/ethnic group or socioeconomic status. Variations in maternal smoking by age were considered in a study for Brazil (8), but results showed little variation across age groups. In the US, however, there are considerable variations in smoking prevalence by age (9-11), as well as by racial/ethnic group and socioeconomic status (SES) (12, 13). In addition to having some of the highest smoking rates, women age 18-24 have among the highest fertility rates (14). Salihu et al. (15) found that smoking-attributable risk varied considerably across racial/ethnic groups.

Knowledge about the effects of maternal smoking by age, SES and racial/ethnic groupings may help target interventions aimed at reducing prenatal smoking and reducing health disparities. The purpose of this study is to develop estimates of smoking-attributable PTB, LBW and SIDS and plausible ranges for the US by age, SES and racial/ethnic groupings.

Methods

We multiply smoking-attributable fractions (SAFs) based on the attributable-fraction formula originally described by Levin (16, 17) by the total number of adverse outcomes. The SAFs are calculated as:

$$\text{SAF} = [(p(ns) + p(s) * (RR) - 1) / [p(ns) + p(s) * (RR)]] \quad (2)$$

where:

p(ns) = Proportion of pregnant women who are nonsmokers during pregnancy

p(s) = Proportion of pregnant women who are smokers during pregnancy, and

RR = Relative risk of outcome by prenatal smokers relative to prenatal nonsmokers.

Since the estimates for maternal smoking prevalence and relative risks are subject to uncertainty, we provide upper and lower bounds.

To determine the number of adverse MCH outcomes, the prevalence of each outcome is multiplied by the population of women giving birth.

Prenatal Smoking

Prenatal maternal smoking as reported on birth certificates (BC) was obtained from the CDC WONDER database, which is collected through partnerships between states and the National Center for Health Statistics (NCHS). The 2003 BC revision asks for the number of cigarettes smoked before pregnancy and during each of the three trimesters. Women who reported using any number of cigarettes at any point in the pregnancy are classified as smokers (18). Those states that did not use the compatible BC are coded as “not reported” and omitted from the estimates.

Analyzing data from 8 states that both participated in the CDC PRAMS survey and used the 2003 BC, Tong et al. (10) found higher smoking prevalence reported in the PRAMS; the combined data (PRAMS and BC) were 35% higher than reported on the BC only. They also found that the BC data understated smoking prevalence by 65% for the <20 (13.7% in NCHS vs. 20.3% in PRAMS and 22.6% combined), by 35% for the 20-24 age group (16.7% vs. 20.4% in PRAMS and 22.5% combined), by 27% for the 25-29 age group (13.2% vs 15.5% vs. 16.7%), and by 30% for the 30 and above group (6% vs 7.5% vs 7.8%). Similarly, for education, the combined estimate compared to the BC alone was 31.9% higher for those had had received less than 12 years of education 28.7% higher for those who had received 12 years of education, and 46.3% higher for those with some college or more. For the BC by race, the combined estimate was 75.0% higher for Hispanics, 31.1% higher for non-Hispanic Whites, 38.5% higher for non-Hispanic Blacks, and 49% for other.

Using cotinine measures, Dietz et al. (19) found overall that 22.9% (95% CI 11.8, 34.6) of pregnant smokers did not disclose smoking status compared to 9.2% (95% CI: 7.1, 11.2) of non-pregnant smokers. By age, 44.1% of the 20-24 age group, 11.4% in the 25-29 and 9.7% in the 30-44 age group did not disclose smoking status. They also found that Mexican Americans were least likely to disclose, but found very little difference in disclosure among the education groups.

To establish the range for smoking prevalence, the NCHS estimate acts as the lower level estimate. For the midlevel estimate (ME), we adjust the NCHS estimate upward in accordance with correction factors by age from Tong et al. (10). Additional nondisclosure rates by age found testing for cotinine (19) and potentially not detected in the BC and PRAMS is used to obtain an upper level estimate.

Adverse Maternal and Child Health Outcomes

To calculate the general prevalence of adverse birth outcomes, we obtained estimates for the prevalence of PTB and LBW in the general population from the NCHS and use the most recently available annual SIDS rate (20). Since many pre-term births also involve LBW, we only include full term births (>36 months) for LBW to avoid overlap. To convert the prevalence estimates of PTB, LBW, and SIDS into the number of cases for each outcome in the US, we multiply the prevalence rate by the number of births reported by the NCHS.

Relative Risk for Maternal and Child Health Outcomes Associated with Maternal Smoking

To examine the relative risks of smoking during pregnancy, we focused on structured reviews, especially the 2004 Surgeon General's Report (SGR, (3)). However, since the SGR only reports studies through the year 2003, we also considered studies published after that date.

Preterm birth (PTB) is frequently the result of other pregnancy complications such as placenta previa, placental abruption, or premature rupture of the membranes (PROM), and is typically defined as a birth prior to 37 weeks gestation or at least 4 weeks before the estimated date of delivery. Studies (2, 21-23) indicate an OR of about 1.4 for PTB by pregnant smokers, with a range of 1.2-1.6.

Low birth weights (LBW) are generally defined as birth weight < 2500 grams. Typically, PTB are lower in weight than full-term births merely as a result of having a shorter gestation period. The 2004 SGR (3) estimated RR's ranging from 1.5 to 2.5. The ORs from other recent studies (24-29) fall into this range, with one study (2) distinguishing LBW from PTB births. We estimated a relative risk of 2.3 with a range of 1.9 to 3.0.

Sudden Infant Death Syndrome (SIDS) refers to the death of an infant for whom there is no prior illness identified and no apparent reason for the death. Studies have found a strong (1, 24, 30) and dose dependent (2) relationship between prenatal smoking and SID. A recent review found that SIDS risk from smoking increased from 2.9 to 3.9 since the Back to Sleep program (31). Our best estimate is 2.5 with the SGR (3) range of 1.4 to 4.

Table 1 summarizes the best estimates and the ranges of relative risks used to estimate the smoking-attributable fractions.

Results

Table 2 reviews the percent of births and prevalence of adverse birth outcomes by age, education, and race/ethnicity. Table 3 shows the different rates of prenatal smoking by age groups, education attainment, and race/ethnicity in 2011. The overall prevalence of maternal prenatal smoking for those states using the 2003 BC definition was 8.6%, which is shown in the lower bound (LB) column. The midlevel estimate (ME) for smoking prevalence is in line with overall prevalence reported in PRAMS (32). Data on tobacco use for age, education, and race was omitted for 20.2% of births due to states' use of incompatible BC.

Regarding outcome prevalence, Table 2 shows that the youngest and oldest age groups have the highest prevalence of PTB and LBW. With the uniform prevalence rate across ages, the number of SIDS cases follows fertility patterns.

Prenatal Smoking by Age

While the prenatal smoking percentages decline across all age groups between 2000 and 2011, the pattern of prevalence across the age groups has remained consistent. The 15-19 and the 20-24 age groups report the highest tobacco use followed by the 25-29 age group, with those age groups having more than twice as high of prevalence as for those above age

25. Beginning in the 20-24 age group, tobacco use declines steadily along the older age groups. For smoking-attributable birth outcomes, the 20-24 and 25-29 year age groups have the highest number of adverse smoking-attributable outcomes across all categories. Based on our midlevel estimates of smoking attributable cases (Table 3), the 20-24 year group represents 36% of PTB, 39% of LBW cases and 35% of SIDS cases; the 25-29 age group represents 25% of PTBs, 25% of LBW, and 28% of SIDS.

Prenatal Smoking by SES or Education

Those with a high school education or less represent about 44% of births. Those who had some high school but did not graduate had the highest general prevalence of PTB and LBW, while those with Bachelor's and Master's degrees along with those with no high school education had the lowest prevalence of PTB.

Women who attended some high school but did not graduate had the highest prevalence of prenatal smoking, followed by high school graduates and women with some college. Those with a Bachelor's or higher degree had the lowest prevalence. The group with the highest numbers in all smoking-attributable outcome categories was high school graduates, which accounted for 31% of PTBs, 42% of LBW births, and 28% of SIDS cases. Next were women who did not complete high school with 29% of PTBs, 21% of LBW births, and 17% of SIDS cases. Those with a Bachelor's degree or higher had fewer LBW births than women with some college but no degree.

Prenatal Smoking Race/Ethnicity

For overall prevalence of birth adverse outcomes, non-Hispanic Blacks had the highest rates of PTB and LBW. The next lowest group was women whose race/ethnicity is unknown or not stated. Hispanic women had the third highest prevalence for PTB and LBW. SIDS cases follow fertility patterns.

Non-Hispanic Whites had the highest prenatal smoking prevalence and Hispanics had the lowest. However, the gap in smoking prevalence for Hispanics and non-Hispanic Whites or Blacks decreased over the range of prevalence estimates. Based on the lower bound, there were 6.6 non-Hispanic Whites and 3.7 non-Hispanic Blacks for every Hispanic smoker. Based on the upper bound, however, the ratio shrank to 4.2 and 2.5 respectively.

Non-Hispanic Whites and Blacks had the highest numbers of smoking-attributable outcomes. Using midlevel estimates, non-Hispanic Whites represent 73% of PTBs, 68% of LBW births, and 75% of SIDS cases. While representing about 13% of the total population, non-Hispanic Blacks represented 18% of PTBs, 22% of LBW births, and 13% of SIDS cases.

Discussion

We found substantial variation in smoking-attributable adverse outcomes by age and by racial/ethnic and SES groups. The highest prevalence was in the 20-24 age group due to high fertility rates as well as high smoking rates. By comparison, the 25-29 age group had the highest fertility rate (107.2/1000) and similar PTB prevalence, but a much lower

smoking prevalence. The 15-19 and the 30-34 age group had similar estimates for smoking attributable outcomes; however, the 15-19 age group had only 33% as many births as the 30-34 age group, but double the smoking prevalence compared to the older group (11.0% versus 5.4%). The highest rates and numbers of smoking-attributable outcome were among Blacks and non-Hispanic whites. Women who had some high school or had completed high school have the highest rates of smoking-attributable outcomes. Those completing high school had high smoking and fertility rates. When the total number of cases both for each education class is summed (and similarly for race), the estimate is greater than when one estimate is calculated for all pregnant smokers (first row of Table 3), suggesting that disaggregated estimates may understate smoking-attributable MCH outcomes.

Our results indicate that prenatal smoking may explain a substantial portion of the high prevalence rates of LBW and PTB among the youngest age groups and Blacks (33, 34) and the high rates of SIDS among Blacks and those of low SES (33, 34). Policies targeted at increasing cessation for the younger age groups and low SES groups can have a significant impact on reducing the overall smoking-attributable birth outcomes.

The high rates of mortality and morbidity arising from PTB and LBW impose an immense burden on medical, educational and social services and on families from the loss of household and labor productivity (35, 36). A high proportion of medical costs occur during the initial hospitalization at delivery, which often involves longer stays, greater risk of health complications, and treatment in the NICU. A recent study of the IOM (37) found that the medical costs of PTB were \$35,400 in 2005\$ which, when adjusted to 2014\$ using a medical care price index (www.BLS.gov), is \$51,060, and an additional \$4,154 in costs of early intervention and special education and \$13,700 in lost household and labor productivity (adjusted using a consumer price index to 2014\$). Applying our mid-level estimate of smoking-attributable PTBs and assuming that smoking-attributable PTBs have the same costs as those of other PTBs, total costs of \$1.1 billion are incurred over the lifetime of infants of mothers who smoked while pregnant each year. For LBW, Schmitt et al.(38) estimated excess neonatal medical costs of about \$26,000 in 2014\$. Similar estimates were obtained by Russell et al. (39), who also found that 42% of the costs for PTB and LBW were paid by Medicaid. Applying our estimate of smoking-attributable LBWs, total costs of \$370 million are incurred per year in neonatal medical costs alone due to prenatal smoking

While we focus on adverse outcomes that occur at or after the birth of the child, other smoking-related prenatal outcomes exist such placenta previa, placental abruption, spontaneous abortion, ectopic pregnancy, infertility and delayed conception (1, 3). In addition, congenital malformations and respiratory conditions have been associated with smoking. All of these outcomes contribute to additional physical and emotional suffering as well as financial costs that should also be considered when evaluating the social and financial costs of prenatal smoking.

Well-targeted policies can reduce the PTB, LBW and SIDS (40). Studies (41-45) have consistently found that higher cigarette taxes reduce the prevalence of prenatal smoking and the number of LBW, PTB and SIDS cases, and two studies (42, 43) found the highest price sensitivity for younger pregnant women. Medicaid policies supporting pharmacotherapy and

behavioral therapy (46, 47) and more generally behavioral interventions (48, 49) have been found effective in reducing prenatal smoking. Other potentially effective policies are raising the minimum legal purchase age for tobacco to 21 (50), and media campaigns and graphic health warnings directed at discouraging maternal smoking.

Limitations and Suggested Future Work

Our estimates are subject to limitations. They do not distinguish when smoking occurred during pregnancy. Research has indicated that smoking during the last trimester may have the most impact on birth outcomes, implying a smaller impact on women who quit in the first trimester (51, 52). Since the NCHS database categorizes smokers as smoking at any point during the pregnancy, we may overestimate the smoking-attributable outcomes. We also do not include the dose-dependent association between smoking and adverse live birth outcomes that has been described in some studies (2, 3, 25, 27, 53-55)

Another limitation is that we apply the same relative risks of prenatal smoking by age, race and SES, due to lack of studies differentiating these effects. A Dutch study (28, 29) found that the least educated women who more often smoking had a higher risk of LBW, small for gestational age and PTB than highly educated women, suggesting that we may be underestimating the effects for low SES groups. To measure SES, we used education due to its availability in NCHS, but also based on data from the U.S. Census Bureau which shows high correlation with income levels (56). A limitation of using education as a proxy for SES is the association between age and education, i.e., younger women completing less education because their schooling is incomplete. Nevertheless, whether due to age or education, earnings potential is likely to be lower and prenatal smoking higher for younger than older women.

Because of the overlap in diagnosis between LBW babies and PTB, we have included in LBW only those births of more than 36 weeks gestation. The designation SGA may be a more accurate reflection of fetal growth than just weight. However, determining relative differences between PTB, LBW, and small for gestational age as drivers of health complications is beyond the scope of this study. Also, some studies differentiate preterm and very preterm (<33 weeks gestation), and higher risks have been found for very preterm in some of the recent studies.

Another limitation of our analysis lies in our adjustment factors for midlevel estimates and upper bounds. For the lower to midlevel estimate adjustment, we relied on analysis of 2008 data (10). While this analysis is the most recent available, analysis of 2011 may have yielded different adjustment factors. Regarding the adjustment for the upper bound, we relied on analysis using 1999-2006 data (19), which did not distinguish whether the nondisclosure in the study included or was in addition to nondisclosure in the NCHS and PRAMS databases. Therefore, we may have overestimated the upper bound for smoking prevalence by double counting some nondisclosure in our adjustment factors. In addition, we do not consider other tobacco products, such as smokeless, little cigars and hookah, and our estimates may fail to differentiate the confounding effect of post-delivery from prenatal smoking on SIDS.

Finally, the omitted data for states that did not use the compatible BC in 2011 may contribute to either an over- or under-estimation of smoking prevalence. Two of the states with the highest smoking rates (West Virginia and Arkansas) were omitted, but their absence may be balanced by the omission of states with low smoking prevalence such as Hawaii and New Jersey. Nevertheless, these data gaps must be considered when interpreting the results.

Conclusion

In summary, reducing prenatal smoking has the potential to reduce adverse birth outcomes which have important long-term implications in terms of pain and suffering and higher costs. These smoking-attributable outcomes disproportionately affect those at younger ages, non-Hispanic Blacks and those of lower socioeconomic status. By reducing prenatal smoking among these groups, disparities in health outcomes by race and SES can be reduced. With the recent emphasis on prevention and well-baby care in the Affordable Care Act, there is potential to increase the attention to this problem. In particular, those formerly uninsured and likely to be most susceptible to prenatal smoking due to their relatively low income should have greater access to health care providers. Our results indicate that, by reducing smoking among young mothers and those of low SES, the cost to insurers associated with childbirth, especially the public expenditures through Medicaid, can be reduced.

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Table 1

Summary of relative risks of maternal and child health outcomes associated with maternal smoking

Outcome	Best estimate and range	Surgeon General's Report ^a	Other Estimates
Preterm Birth	1.4 (1.2-1.6)	AOR:	1.59 (1.13-2.25) ^b 1.19 (1.17-1.20) ^c AOR: 1.5 (1.4-1.6) 27 weeks ^d 1.4 (1.4-1.4) 28-33 weeks ^d 1.2 (1.2-1.3) 34-36 weeks ^d
Low Birth weight, Gestational age > 36 months	2.3 (1.9-3.0)	ORs: 1.5-2.5	AOR: 2.3 (2.3-2.5) ^d OR: 3.35 (2.92-3.85) ^e
Sudden Infant Death Syndrome	2.5 (1.4-4.0)	ORs: 1.4 - 3.0	AOR: 2.7 (2.4, 3.0) ^c

OR = odds ratio, AOR= adjusted odds ratio

^a DHHS (2004)^b Anderka et al. (2010)^c Aliyu et al. (2009)^d Dietz et al. (2010)^e Chertok et al. (2011)

Table 2

Percent of live births and prevalence of birth outcomes

Category	All Births	Prevalence of birth outcome in population		
	%	PTB (%) [*]	LBW (%) [*]	SIDS (n) ^{**}
AGE				
<15	0.1	21.0	3.7	2
15-19	8.3	13.5	3.6	170
20-24	23.4	11.7	3.2	477
25-29	28.5	10.7	2.5	582
30-34	25.0	11.1	2.4	509
35-39	11.7	13.1	2.6	239
40-44	2.8	15.5	3.2	56
45-49	0.2	26.5	5.1	4
<49	100.0	11.7	5.2	2040
EDUCATION				
8th grade or less	4.7	12.5	2.6	691
9-12, no diploma	13.9	13.9	3.6	9131
High school grad or GED	25.3	12.5	3.1	12411
Some college, no degree	21.0	11.7	2.7	8338
Associate degree	7.5	11.0	2.3	1725
Bachelor's degree	18.0	9.6	2.1	854
Master's degree	7.6	9.7	2.2	165
Doctorate or Professional Degree	2.1	10.1	2.3	34
Total	100.0	11.7	3.0	2009
RACIAL/ETHNIC GROUP				
Hispanic	23.2	11.6	2.4	474
Non-Hispanic White	54.3	10.5	2.3	1108
Non-Hispanic Black	14.7	16.8	4.5	300
Non-Hispanic other races	7.1	10.8	3.3	144
Origin unknown or not stated	0.7	12.8	3.0	14
Total	100.0	11.7	2.7	2040

Notes: PTB=Preterm birth, LBW=Low birth weight, SIDS= Sudden infant death syndrome

^{*} Data for PTB and LBW from the National Center for Health Statistics for 2012^{**} Number of SIDS cases based on the 2010 rate of 51.6/100,000 live births (18) from the National Center for Health Statistics

Smoking prevalence and estimated number of smoking-attributable outcomes by age group, education, and race/ethnicity

Table 3

Category	Smoking Prevalence (%)			Preterm births (n)			Births with low birth weight (n)			SIDS (n)		
	ME	LB	UB	ME	LB	UB	ME	LB	UB	ME	LB	UB
OVERALL	11.6	8.6	14.2	20,217	7,709	35,795	14,216	7,794	23,996	302	233	359
AGE												
<15	3.4	2.1	5.0	12	4	33	6	3	21	0	0	0
15-19	18.2	11.0	26.2	3018	970	6010	2265	1069	4042	36	7	74
20-24	17.9	13.3	25.8	7224	2830	14742	5601	3163	10203	101	24	210
25-29	11.0	8.6	12.2	5075	2068	8532	3525	2037	5642	82	19	159
30-34	7.1	5.4	7.8	2997	1178	5096	1933	1071	3172	49	11	98
35-39	5.6	4.3	6.1	1330	520	2229	815	448	1327	18	4	37
40-44	5.5	4.2	6.0	362	142	601	231	127	374	4	1	9
45-49	3.4	2.7	3.8	28	10	47	17	9	28	0	0	0
Total	11.8	8.5	13.8	20046	7722	37291	14393	7928	24810	292	67	582
EDUCATION												
8th grade or less	4.9	4.3	6.0	439	198	805	282	178	504	6	2	14
9-12, no diploma	18.0	15.9	22.1	5074	2368	8819	3634	2441	5833	60	17	112
High school grad or GED	16.3	13.3	20.0	7514	3236	13147	5255	3263	8549	99	26	190
Some college, no degree	10.6	9.9	13.1	3886	1874	6951	2627	1799	4446	58	16	119
Associate degree	6.4	6.0	7.9	804	384	1464	508	341	893	13	4	29
Bachelor's degree	1.4	1.3	1.7	365	172	679	255	166	474	7	2	17
Master's degree	0.6	0.6	0.7	67	32	125	49	32	93	1	0	3
Doctorate or professional degree	0.4	0.4	0.5	13	6	24	10	6	18	0	0	1
Total	14.2	8.6	17.4	18162	8270	15709	7320	25816	20809	358	68	701
RACIAL/ETHNIC GROUP												
Hispanic	3.3	1.9	4.8	1301	398	850	365	1842	850	21	4	57
Non-Hispanic White	16.7	12.7	20.2	17469	5666	10669	5070	16841	10669	266	54	479

Category	Smoking Prevalence (%)			Preterm births (n)			Births with low birth weight (n)			SIDS (n)		
	ME	LB	UB	ME	LB	UB	ME	LB	UB	ME	LB	UB
Non-Hispanic Black	9.8	7.1	12.0	4385	1382	3493	1581	5888	3493	45	8	90
Non-Hispanic other races	5.1	3.4	6.2	664	204	627	274	1121	627	11	2	25
Origin unknown or not stated	6.5	4.4	7.9	98	30	70	31	124	70	1	0	3
Total	12.5	8.5	15.4	23917	7680	41627	17041	7959	28522	355	67	696

SIDS= Sudden Infant death Syndrome; ME = midlevel estimate; LB = lower bound; UB = upper bound; The smoking prevalence of prenatal smokers are the percent of women having live births who self-reported tobacco use during pregnancy out of all live births in states using the compatible BC form. 20.2% of live births were in states not using compatible BC forms out of all births and are omitted from these calculations.