Decline in Smoking During Pregnancy in New York City, 1995–2005

Cheryl R. Stein, PhD[a]
Jennifer A. Ellis, PhD[b]
David A. Savitz, PhD[a]
Laura Vichinsky, BA[b]
Sarah B. Perl, MPH[b]

SYNOPSIS

Objectives. The 1998 Master Settlement Agreement (MSA) between 46 states and four major tobacco companies increased tobacco control funding and restricted tobacco marketing. In 2002, New York City (NYC) began a comprehensive tobacco control program that raised the price of cigarettes, banned indoor workplace smoking, and increased access to cessation treatment. We examined the temporal pattern of smoking during pregnancy, including ethnic variation in smoking prevalence, relative to the implementation of the MSA and NYC's comprehensive tobacco control program using birth certificate data.

Methods. Using multiple logistic regression, we analyzed NYC birth certificate data to examine prenatal smoking during three time periods: 1995–1998 (pre-MSA), 1999–2002 (post-MSA, pre-NYC tobacco control), and 2003–2005 (post-MSA, post-tobacco control).

Results. Overall, 3.0% of 1,136,437 births included were to smoking mothers. The proportion of smoking mothers declined from 4.5% in 1995–1998 to 1.7% in 2003–2005. Compared with non-Hispanic white women, African American women had 2.46 increased odds (95% confidence interval [CI] 2.36, 2.55) of smoking during 1995–1998, and 3.63 increased odds (95% CI 3.39, 3.88) of smoking during 2003–2005, despite an absolute reduction in smoking from 10.4% to 5.0%. Puerto Rican women also smoked considerably more than non-Hispanic white women.

Conclusions. These findings document a striking temporal decline in prenatal smoking in NYC concurrent with changing tobacco control policies. Targeted efforts may be required to address the increasing disparity in prenatal smoking between non-Hispanic white and African American and Puerto Rican women.

[a]Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York, NY

[b]Bureau of Tobacco Control, New York City Department of Health and Mental Hygiene, New York, NY

Address correspondence to: Cheryl R. Stein, PhD, Department of Community and Preventive Medicine, Mount Sinai School of Medicine, One Gustave L. Levy Pl., Box 1057, New York, NY 10029-6574; tel. 212-824-7083; fax 212-996-0407; e-mail <cheryl.stein@mssm.edu>.

©2009 Association of Schools of Public Health

Cigarette smoking during pregnancy contributes to numerous pregnancy complications and adverse birth outcomes, including placental abruption, placenta previa, stillbirth, preterm birth, low birthweight, small for gestational age, and Sudden Infant Death Syndrome.[1] Smoking by pregnant women may also affect child health through adverse pregnancy outcomes, possibly contributing to asthma,[2] lowered cognitive development,[3,4] behavioral problems,[5,6] and adolescent psychiatric difficulties.[7] These negative consequences of maternal smoking are well recognized.

In 1998, the Attorneys General for 46 states, the District of Columbia, and six U.S. territories, and four major tobacco companies reached the Master Settlement Agreement (MSA). The MSA resolved lawsuits brought against the tobacco companies by the Attorneys General to recover state Medicaid costs for treating tobacco-related illness[8] and awarded $206 billion paid over 25 years to the participating states and territories.[9] In addition, the MSA prohibited advertising targeted to young people, made internal tobacco documents available to the public, and dissolved various pro-tobacco organizations. To subsidize payments owed to states, tobacco companies increased the per-pack price of cigarettes by $0.45 nationwide, the single largest increase by industry to date.[10]

Beginning in 2002, the New York City (NYC) Department of Health and Mental Hygiene (DOHMH) introduced a comprehensive tobacco control program based on the Centers for Disease Control and Prevention's 1999 Best Practices guidelines.[11] The city's comprehensive tobacco control program included a 2002 cigarette price increase through excise taxes, the 2002 passage and 2003 implementation of the Smoke Free Air Act prohibiting smoking in almost all indoor workplaces, and free, population-wide distribution of nicotine replacement therapy for smokers who want to quit.[12,13]

Nationally, from 1993 to 2000, adult smoking prevalence dropped from 25.0% to 23.3%.[14] From 1993 to 2001, NYC residents smoked at an approximately constant rate of 21.5%.[15] Following the introduction of NYC's comprehensive tobacco control program, smoking among adults declined to 19.2% in 2003 and then further to 18.9% in 2005.[12,16] There were substantial reductions in smoking by young women aged 18 to 24 years, from 23.2% in 2002 to 13.5% in 2005.[17] Smoking among public high school students also plunged, dropping from 17.6% in 2001 to 11.2% in 2005.[18]

The MSA, which prompted tobacco companies to increase cigarette prices, and NYC's comprehensive tobacco control program, which advocated for local authority to increase cigarette excise taxes, are thought to reduce smoking in part by raising the cost of cigarettes. Increasing the price of cigarettes is one of the most effective ways to reduce smoking.[19] Cigarette price increases may prevent future smokers from initiating and encourage current smokers to quit.[19,20]

Pregnant women appear to be more sensitive to price increases than the general population.[21–23] Consequently, the price increases resulting from the MSA were expected to greatly reduce smoking among pregnant women. Subsequent national analyses show, however, that prenatal smoking declined by less than half of what was expected.[24] However, given NYC's reductions in smoking among public high school students, young adult women, and the general adult population between 2002 and 2005, we anticipated that in NYC there might also be reductions in prenatal smoking. We examined the temporal pattern of smoking during pregnancy, including ethnic variation in smoking prevalence, relative to the implementation of the MSA and NYC's comprehensive tobacco control program using birth certificate data.

METHODS

Study population

To examine the association between changes in tobacco control policy and reported prenatal smoking, we used 11 years (1995–2005) of birth certificate data from the NYC DOHMH. For the period 1995–2003, we linked live births to hospital discharge data from the Statewide Planning and Research Cooperative System, although information from the hospital discharge data was not used for this analysis. Of 1,173,053 births, 1,084,882 (92.5%) were successfully linked to a hospital discharge record. Unmatched records resulted from missing personal information needed for the matching algorithm. Singleton births were more likely to be matched to a hospital discharge record than infants from a multiple gestation. Additional details on the matching methodology have been reported previously.[25] For the period 2004–2005, we used live birth records only (n=246,824), for a total of 1,331,706 births in NYC from 1995 to 2005.

Measures

We obtained all data from the NYC birth certificate file, which documents births occurring in NYC. We ascertained the dependent variable—smoking during pregnancy—from a check box provided on the birth certificate. Women were classified as prenatal smokers, nonsmokers, or unknown (n=171). Birth year, used to create the independent variable, was grouped to reflect changes in national and local tobacco control policy: pre-MSA (1995–1998), post-MSA/pre-NYC comprehensive tobacco control program (1999–2002), and

post-MSA/post-NYC comprehensive tobacco control program (2003–2005). We included maternal demographic characteristics as covariates. We categorized maternal age by decade (≤19 years, 20–29 years, 30–39 years, and ≥40 years). We determined ethnicity through self-report.[25] Ethnic groups with a high prevalence of prenatal smoking (e.g., Puerto Rican rather than broad Hispanic groups) were categorized more specifically than ethnic groups with a low prevalence of prenatal smoking (e.g., Asian/Pacific Islander rather than a specific Chinese group). We defined nativity by birth country as reported on the birth certificate. Women listing USA as their birth country were considered U.S.-born. All other women, including those listing U.S. territories such as Puerto Rico, were considered foreign-born. Number of previous live births (0, 1, 2, ≥3), trimester of prenatal care initiation (first, second, third, none), education (≤8 years, 9–12 years, ≥13 years), and borough of residence were derived directly from the birth certificate.

Statistical analysis

We restricted analyses to births with complete information on all measures (85.0% of available birth records) and performed analyses using SAS® version 9.1[26] and Stata® version 10.[27] In preliminary analyses, we examined the frequency distribution of the outcome, exposure, and other covariates. We calculated the prevalence of prenatal smoking across all levels of maternal characteristics, as well as the bivariate prevalence odds ratios (ORs) and 95% confidence intervals (CIs) to assess the relationship between the individual covariates and prenatal smoking. We also examined the bivariate ORs by time period.

Using unconditional multiple logistic regression, we estimated the association between time period and prenatal smoking. Because of the large sample size, we retained all covariates in the model without formal testing for effect modification or confounding. We calculated adjusted ORs (AORs) for the entire population, and used a time period-ethnicity product term to calculate AORs stratified by ethnicity.

The Mount Sinai Program for the Protection of Human Subjects and the NYC DOHMH Institutional Review Board approved this study.

RESULTS

Of the 1,136,437 births included in the analysis, 34,575 (3.0%) were to mothers who reported smoking during pregnancy (Table 1). The mean maternal age was 28.9 years (standard deviation = 6.3 years, range = 12–57 years). The population of women giving birth was ethnically diverse. The single largest group (non-Hispanic white women) comprised only 28.1% of the total, and the majority of women were born outside the U.S. (52.8%). The percentage of foreign-born women increased from 51.1% in 1995 to 54.3% in 2005. For most women, this was at least their second pregnancy (55.6%) and prenatal care had been initiated in the first trimester (68.2%).

The proportion of births to smoking mothers declined across the three time periods, from 4.5% in 1995–1998, to 2.9% in 1999–2002, to 1.7% in 2003–2005 (Table 1). Overall, we found minimal variation in the association between prenatal smoking and maternal age. As compared with women aged 20 to 29 years, those younger than 19 years of age were moderately more likely to smoke (OR=1.22, 95% CI 1.17, 1.27) and those aged 30 to 39 were minimally less likely to smoke (OR=0.97, 95% CI 0.95, 0.99). Women with fewer than nine years of education smoked 0.40 times less (95% CI 0.38, 0.42) than women who had nine to 12 years of school. The prevalence of smoking increased both with number of previous pregnancies and later initiation of prenatal care. Within NYC, we found regional differences in the prevalence of prenatal smoking. Women living in Staten Island smoked 2.93 times more (95% CI 2.81, 3.06) than women living in Queens.

African American (OR=2.75, 95% CI 2.69, 2.83) and Puerto Rican (OR=2.35, 95% CI 2.27, 2.42) women were substantially more likely to smoke as compared with non-Hispanic white women, and reported the highest prevalence of smoking among all ethnic groups. The concentration of smokers among U.S.-born women (82.3%) was reflected in the disparate prevalence of smoking across ethnic groups. No more than 1.0% of women in ethnic groups from either the non-Hispanic Caribbean, Mexico/Central/South America, Asia/Pacific Islands, or Africa smoked during pregnancy.

We found declines in the prevalence of prenatal smoking across the three time periods among all ethnic groups except other Hispanic (a category that includes Hispanic women from Spain, Cuba, or an unreported ancestral country; the majority are U.S.-born) and among all examined maternal subgroups except women with no prenatal care (Table 2). While tobacco use among all ethnic groups declined, the disparity between some ethnic groups widened. Compared with non-Hispanic white women, African American women had 2.46 increased odds (95% CI 2.36, 2.55) of smoking during 1995–1998, and 3.63 increased odds (95% CI 3.39, 3.88) of smoking during 2003–2005, despite an absolute reduction in smoking from 10.4% to 5.0% (Figure). Puerto Rican women and those indicating other ethnicity both exhibited a pattern similar to African American women, with greater than 50.0% reductions in smoking prevalence

Table 1. Univariate maternal characteristics and bivariate association with reported prenatal smoking, NYC, 1995–2005 (*n*=1,136,437)

Maternal characteristic	*Overall* N *(percent)*	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*
Prenatal smoking			
Smoker	34,575 (3.0)	NA	NA
Nonsmoker	1,101,862 (97.0)	NA	NA
Time period			
1995–1998	371,427 (32.7)	16,539 (4.5)	1.00
1999–2002	416,361 (36.6)	12,189 (2.9)	0.65 (0.63, 0.66)
2003–2005	348,649 (30.7)	5,847 (1.7)	0.37 (0.35, 0.38)
Maternal age (in years)			
12–19	77,387 (6.8)	2,849 (3.7)	1.22 (1.17, 1.27)
20–29	523,918 (46.1)	15,945 (3.0)	1.00
30–39	481,709 (42.4)	14,185 (2.9)	0.97 (0.95, 0.99)
40–57	53,423 (4.7)	1,596 (3.0)	0.98 (0.93, 1.03)
Ethnic ancestry			
Non-Hispanic white	319,279 (28.1)	9,448 (3.0)	1.00
African American	170,131 (15.0)	13,202 (7.8)	2.75 (2.69, 2.83)
Non-Hispanic Caribbean	82,027 (7.2)	791 (1.0)	0.32 (0.30, 0.34)
Dominican Republic	99,228 (8.7)	1,269 (1.3)	0.43 (0.40, 0.45)
Puerto Rico	108,954 (9.6)	7,275 (6.7)	2.35 (2.27, 2.42)
Mexico, Central/South America	170,477 (15.0)	809 (0.5)	0.16 (0.15, 0.17)
Other Hispanic, including Cuba	18,554 (1.6)	847 (4.6)	1.57 (1.46, 1.69)
Asia and Pacific Islands	130,682 (11.5)	432 (0.3)	0.11 (0.10, 0.12)
Africa	30,181 (2.7)	136 (0.5)	0.15 (0.13, 0.18)
Other	6,924 (0.6)	366 (5.3)	1.83 (1.64, 2.04)
Nativity[a]			
U.S.-born	536,300 (47.2)	28,461 (5.3)	1.00
Foreign-born	600,137 (52.8)	6,114 (1.0)	0.18 (0.18, 0.19)
Previous live births			
0	504,498 (44.4)	10,214 (2.0)	1.00
1	348,498 (30.7)	9,389 (2.7)	1.34 (1.30, 1.38)
2	163,920 (14.4)	6,439 (3.9)	1.98 (1.92, 2.04)
≥3	119,521 (10.5)	8,533 (7.1)	3.72 (3.61, 3.83)
Prenatal care initiation			
First trimester	775,091 (68.2)	19,644 (2.5)	1.00
Second trimester	275,711 (24.3)	9,960 (3.6)	1.44 (1.41, 1.48)
Third trimester	69,224 (6.1)	3,188 (4.6)	1.86 (1.79, 1.93)
No prenatal care	16,411 (1.4)	1,783 (10.9)	4.69 (4.46, 4.94)
Education (years)			
0–8	82,033 (7.2)	1,535 (1.9)	0.40 (0.38, 0.42)
9–12	549,743 (48.4)	25,134 (4.6)	1.00
13–17	504,177 (44.4)	7,895 (1.6)	0.33 (0.32, 0.34)
Borough of residence			
Manhattan	179,124 (15.8)	4,816 (2.7)	1.22 (1.17, 1.27)
Bronx	194,443 (17.1)	7,352 (3.8)	1.73 (1.67, 1.79)
Brooklyn	356,595 (31.4)	11,787 (3.3)	1.51 (1.46, 1.55)
Queens	257,623 (22.7)	5,717 (2.2)	1.00
Staten Island	56,430 (5.0)	3,516 (6.2)	2.93 (2.81, 3.06)
New York State (outside NYC)	60,840 (5.3)	1,059 (1.7)	0.78 (0.73, 0.83)
Outside New York State	31,392 (2.8)	328 (1.0)	0.47 (0.42, 0.52)

[a]Women listing USA as their birth country were considered U.S.-born. All other women, including those listing U.S. territories such as Puerto Rico, were considered foreign-born.

NYC = New York City

CI = confidence interval

NA = not applicable

Table 2. Maternal characteristics and bivariate association with reported prenatal smoking by time period, NYC, 1995–2005 (*n*=1,136,437)

	1995–1998		*1999–2002*		*2003–2005*	
Maternal characteristic	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*
Overall	16,539 (4.5)	NA	12,189 (2.9)	NA	5,847 (1.7)	NA
Maternal age (in years)						
12–19	1,482 (5.0)	1.16 (1.09, 1.23)	959 (3.4)	1.17 (1.09, 1.26)	408 (2.1)	1.18 (1.06, 1.31)
20–29	7,503 (4.3)	1.00	5,601 (2.9)	1.00	2,841 (1.8)	1.00
30–39	6,939 (4.5)	1.05 (1.02, 1.09)	4,997 (2.8)	0.96 (0.92, 1.00)	2,249 (1.5)	0.83 (0.79, 0.88)
40–57	615 (4.2)	0.97 (0.89, 1.06)	632 (3.2)	1.09 (1.00, 1.18)	349 (1.9)	1.04 (0.93, 1.16)
Ethnicity ancestry						
Non-Hispanic white	4,688 (4.5)	1.00	3,341 (2.9)	1.00	1,419 (1.4)	1.00
African American	6,372 (10.4)	2.46 (2.36, 2.55)	4,532 (7.3)	2.62 (2.50, 2.74)	2,298 (5.0)	3.63 (3.39, 3.88)
Non-Hispanic Caribbean	343 (1.2)	0.27 (0.24, 0.29)	292 (1.0)	0.32 (0.29, 0.37)	156 (0.7)	0.46 (0.39, 0.54)
Dominican Republic	559 (1.7)	0.36 (0.33, 0.39)	454 (1.3)	0.42 (0.38, 0.47)	256 (0.9)	0.61 (0.53, 0.70)
Puerto Rico	3,573 (8.7)	2.01 (1.92, 2.10)	2,511 (6.5)	2.31 (2.19, 2.44)	1,191 (4.1)	2.99 (2.77, 3.24)
Mexico, Central/South America	345 (0.7)	0.15 (0.13, 0.16)	299 (0.5)	0.16 (0.14, 0.18)	165 (0.3)	0.20 (0.17, 0.24)
Other Hispanic, including Cuba	268 (4.8)	1.08 (0.95, 1.22)	408 (5.2)	1.83 (1.65, 2.04)	171 (3.3)	2.39 (2.03, 2.81)
Asia and Pacific Islands	180 (0.5)	0.10 (0.09, 0.12)	160 (0.3)	0.11 (0.10, 0.13)	92 (0.2)	0.14 (0.11, 0.18)
Africa	51 (0.7)	0.14 (0.11, 0.19)	58 (0.5)	0.17 (0.13, 0.22)	27 (0.3)	0.17 (0.12, 0.25)
Other	160 (7.0)	1.60 (1.36, 1.88)	134 (5.3)	1.88 (1.59, 2.25)	72 (3.4)	2.44 (1.92, 3.10)
Nativity[a]						
U.S.-born	13,667 (7.5)	1.00	9,960 (5.1)	1.00	4,834 (3.0)	1.00
Foreign-born	2,872 (1.5)	0.19 (0.18, 0.20)	2,229 (1.0)	0.19 (0.18, 0.20)	1,013 (0.5)	0.17 (0.16, 0.18)
Previous live births						
0	4,883 (3.0)	1.00	3,595 (1.9)	1.00	1,736 (1.1)	1.00
1	4,470 (3.9)	1.34 (1.28, 1.39)	3,391 (2.6)	1.36 (1.30, 1.43)	1,528 (1.4)	1.29 (1.21, 1.38)
2	3,075 (5.7)	1.98 (1.89, 2.07)	2,306 (3.8)	1.99 (1.88, 2.09)	1,058 (2.1)	1.94 (1.80, 2.10)
≥3	4,111 (10.4)	3.78 (3.62, 3.95)	2,897 (6.7)	3.61 (3.43, 3.79)	1,525 (4.2)	3.86 (3.60, 4.14)
Prenatal care initiation						
First trimester	9,155 (3.8)	1.00	7,056 (2.5)	1.00	3,433 (1.3)	1.00
Second trimester	4,967 (4.9)	1.28 (1.23, 1.33)	3,402 (3.4)	1.36 (1.31, 1.42)	1,591 (2.2)	1.64 (1.54, 1.74)
Third trimester	1,575 (6.5)	1.72 (1.63, 1.82)	1,082 (4.2)	1.71 (1.60, 1.82)	531 (2.8)	2.11 (1.92, 2.31)
No prenatal care	842 (12.8)	3.67 (3.40, 3.95)	649 (8.2)	3.46 (3.19, 3.77)	292 (15.6)	13.51 (11.87,15.37)

continued on p. 846

Table 2 (continued). Maternal characteristics and bivariate association with reported prenatal smoking by time period, NYC, 1995–2005 (*n*=1,136,437)

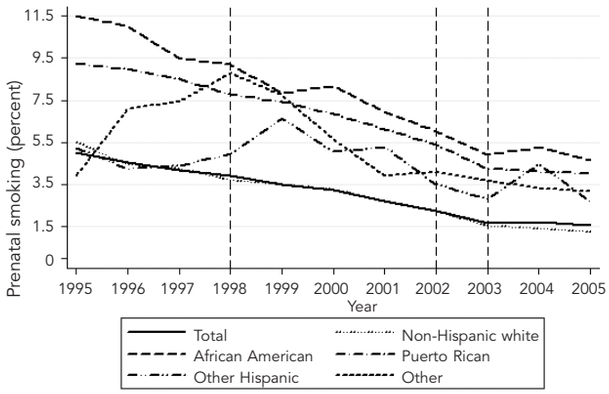
	1995–1998		*1999–2002*		*2003–2005*	
Maternal characteristic	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*	*Smoking* N *(prevalence)*	*Odds ratio (95% CI)*
Education (years)						
0–8	705 (2.7)	0.42 (0.39, 0.45)	561 (1.8)	0.40 (0.37, 0.43)	269 (1.1)	0.39 (0.35, 0.45)
9–12	12,208 (6.3)	1.00	8,695 (4.4)	1.00	4,231 (2.7)	1.00
13–17	3,629 (2.4)	0.37 (0.35, 0.38)	2,933 (1.6)	0.35 (0.33, 0.36)	1,336 (0.8)	0.30 (0.28, 0.31)
Borough of residence						
Manhattan	2,373 (4.2)	1.33 (1.26, 1.40)	1,569 (2.3)	1.09 (1.02, 1.17)	874 (1.6)	1.30 (1.18, 1.43)
Bronx	3,464 (5.4)	1.73 (1.64, 1.82)	2,655 (3.7)	1.76 (1.66, 1.87)	1,233 (2.1)	1.74 (1.60, 1.90)
Brooklyn	5,689 (4.9)	1.57 (1.50, 1.65)	4,127 (3.2)	1.49 (1.41, 1.58)	1,971 (1.8)	1.47 (1.36, 1.59)
Queens	2,753 (3.2)	1.00	2,030 (2.1)	1.00	934 (1.2)	1.00
Staten Island	1,665 (8.5)	2.82 (2.65, 3.00)	1,299 (6.4)	3.13 (2.91, 3.36)	552 (3.3)	2.80 (2.51, 3.11)
New York State (outside NYC)	455 (2.2)	0.69 (0.62, 0.76)	388 (1.7)	0.79 (0.71, 0.88)	216 (1.2)	1.01 (0.87, 1.17)
Outside New York State	140 (1.6)	0.49 (0.41, 0.58)	121 (1.1)	0.48 (0.40, 0.58)	67 (0.6)	0.50 (0.39, 0.64)

[a]Women listing USA as their birth country were considered U.S.-born. All other women, including those listing U.S. territories such as Puerto Rico, were considered foreign-born.

NYC = New York City

CI = confidence interval

Figure. Trends in prenatal smoking by maternal ethnicity, New York City, 1995–2005[a]



[a]The dashed vertical lines represent the 1998 Master Settlement Agreement, and the 2002 passage and 2003 implementation of New York City's Smoke Free Air Act.

juxtaposed to a widening disparity with smoking levels of non-Hispanic white women. The prevalence of smoking among Puerto Rican women dropped from 8.7% during 1995–1998 to 4.1% during 2003–2005, while the odds of smoking as compared with non-Hispanic white women increased from 2.01 (95% CI 1.92, 2.10) to 2.99 (95% CI 2.77, 3.24). Among women indicating other ethnicity, prevalence fell from 7.0% to 3.4%, but relative to non-Hispanic white women, the smoking OR increased from 1.60 in 1995–1998 (95% CI 1.36, 1.88) to 2.44 in 2003–2005 (95% CI 1.92, 3.10).

Overall, the odds of smoking in 2003–2005 were 0.44 (95% CI 0.43, 0.46) times less than in 1995–1998, adjusted for maternal age, ethnicity, nativity, parity, prenatal care initiation, education, and borough of residence (Table 3). Non-Hispanic white women experienced the largest adjusted drop in smoking prevalence (OR=0.34, 95% CI 0.32, 0.36) and other Hispanic women the smallest adjusted drop (OR=0.74, 95% CI 0.61, 0.91) across the three time periods.

DISCUSSION

Smoking during pregnancy, as reported on birth certificates, declined substantially in NYC from 1995 to 2005. This reduction in health risk behavior emerged concurrent to significant changes in NYC's tobacco control environment, although we cannot draw any causal conclusions from these data. The 1998 MSA and the 2002 implementation of NYC's comprehensive tobacco control program appear to have worked together to limit the prevalence of prenatal smoking, despite the fact that neither initiative directly targeted pregnant women. While the prevalence of smoking declined across all ethnic groups, a focus on reducing smoking among pregnant African American and Puerto Rican women may be needed to reverse the increase in racial/ethnic disparity in prenatal smoking, and to bring the smoking prevalence among these women to the low levels achieved by other ethnic groups.

Prior to the MSA, prenatal smokers were considered highly sensitive to cigarette price increases, more so than among the general population.[21,22,28] For every 10.0% increase in price, prenatal smoking was expected to drop by about 5.0%—a price elasticity of −0.5%.[21] Yet, a comprehensive analysis of the U.S. Natality Detail Files from 1996 to 2000 found that the degree of sensitivity to increased prices was overestimated. Nationally, maternal smoking was expected to decline by at least 6.8% after the MSA, but, in fact, after 15 months had dropped by only 2.3%.[24] Pregnant teens were slightly more sensitive to price increases than other women. Our findings, however, showed a 62.0% reduction in prenatal smoking in NYC from the pre-MSA period (1995–1998) to the post-comprehensive tobacco control program period (2003–2005). Specifically, the largest annual decline (48.7%) in maternal smoking in NYC between 1995 and 2005 occurred after the 2002 initiation of the city's comprehensive tobacco control program.

NYC's demographic composition and smoking profile are distinct from the country as a whole. In 1995, 12.3% of U.S. births were to women who reported smoking during pregnancy.[29,30] In NYC, only 5.0% of 1995 births were to prenatal smokers. National data also indicate that pregnant teens' smoking prevalence is several percentage points higher than their older counterparts, whereas in NYC, smoking among pregnant women by decade of maternal age varies by less than 1.0%. Nationally, the prevalence of prenatal smoking among non-Hispanic white women is greater than among African American women.[29]

This pattern is reversed in NYC. Staten Island, the borough with the largest proportion of non-Hispanic white women, has the highest prevalence of prenatal smoking. Also contrary to national trends, the smoking prevalence among New Yorkers with fewer than nine years of education is comparable to that among women with more than 12 years of education, reflecting the high proportion of foreign-born women with limited education. In an analysis restricted to U.S.-born women, we found that women with fewer than nine years of education were 1.69 (95% CI 1.57, 1.81) times more likely to smoke as compared with women with nine to 12 years of schooling. The extremely low prevalence of prenatal smoking among New York women in ethnic groups from the non-Hispanic Caribbean, Mexico/Central/South America, Asia/Pacific Islands, or Africa

may also result from their predominantly immigrant status and the low rate of smoking among foreign-born women.[31] NYC's unique baseline characteristics may have interacted synergistically with the MSA and comprehensive tobacco control program to reduce prenatal smoking.

Limitations

While this study appears to illustrate a strong relationship between changes in national and local tobacco control policies and declining rates of prenatal smoking in NYC, there are limitations to the strength of inference these data can offer. Using birth certificate data for this analysis presented several limitations. First, report of prenatal smoking on birth certificates underestimates true prevalence, although it is an established method of monitoring trends.[32] In North Carolina, a comparison of birth certificates and medical records found an 84.4% agreement on tobacco use during pregnancy.[33] A more recent examination in New York State showed that report of tobacco use on the birth certificate is 89.0% sensitive and 99.0% specific as compared with medical records.[34] Other studies recount less reliability between the two data sources.[35,36] While the overall strong agreement between birth certificates and medical records supports the use of the birth certificate check box, medical records are not without fault in accurately depicting prenatal smoking.[37] Underreporting of tobacco use may change over time in response to public awareness and societal pressures, but underreporting is unlikely to have increased at a sufficient rate to explain our findings.

Second, prenatal smoking was declining prior to the tobacco control policy changes associated with the MSA and NYC's comprehensive tobacco control plan.[32,38] It is possible that the reduction in maternal smoking we associated with an altered policy environment was simply an extension of the steady decline in maternal smoking evidenced nationally since 1989. In NYC, however, the notable reductions in maternal smoking in 1999 (a 10.9% drop from 1998) and 2003 (a 48.7% drop from 2002) contrasted with the mean yearly drop in prenatal smoking in NYC of 7.6% from 1995 to 2005. These timely changes in prevalence support the roles of the MSA and the city's comprehensive tobacco control program, respectively, in positively influencing the decline in maternal smoking.

Third, this was an aggregate population, not an individual-level study. Not all women giving birth in NYC were NYC residents or even U.S. residents throughout their pregnancy. Only women living and/or working in NYC are affected by the city's 2002 prohibition on indoor workplace smoking. Similarly, online or illegal cigarette purchases can be used to circumvent price and tax hikes.[39,40] The birth certificate data used in this study were insufficient to address the individual effect of changing tobacco control policies on prenatal smoking.

CONCLUSIONS

NYC reduced its relatively low level of prenatal smoking from 4.5% in 1995–1998 to 1.7% in 2003–2005. The policy changes resulting from the MSA and especially

Table 3. Multivariate association between time period and reported prenatal smoking, New York City, 1995–2005 (*n*=1,136,437)

	Adjusted odds ratio (95% CI)		
	1995–1998	*1999–2002*	*2003–2005*
Unstratified[a]	1.0	0.71 (0.69, 0.73)	0.44 (0.43, 0.46)
Stratified[b] by ethnic ancestry			
Non-Hispanic white	1.0	0.68 (0.65, 0.71)	0.34 (0.32, 0.36)
African American	1.0	0.70 (0.67, 0.73)	0.49 (0.46, 0.51)
Non-Hispanic Caribbean	1.0	0.79 (0.67, 0.92)	0.58 (0.48, 0.70)
Dominican Republic	1.0	0.77 (0.67, 0.87)	0.56 (0.48, 0.65)
Puerto Rico	1.0	0.71 (0.68, 0.75)	0.46 (0.43, 0.49)
Mexico, Central/South America	1.0	0.71 (0.61, 0.83)	0.43 (0.35, 0.51)
Other Hispanic, including Cuba	1.0	1.12 (0.95, 1.31)	0.74 (0.61, 0.91)
Asia and Pacific Islands	1.0	0.72 (0.58, 0.89)	0.47 (0.37, 0.61)
Africa	1.0	0.73 (0.50, 1.07)	0.37 (0.23, 0.59)
Other	1.0	0.76 (0.59, 0.97)	0.51 (0.38, 0.69)

[a]Adjusted for maternal age, ethnic ancestry, nativity, parity, prenatal care initiation, education, and borough of residence

[b]Fully adjusted for maternal age, ethnic ancestry, nativity, parity, prenatal care initiation, education, borough of residence, and time period/ethnic ancestry product term

CI = confidence interval

NYC's comprehensive tobacco control program may have influenced this reduction. We saw declines in maternal smoking across all subgroups defined by maternal age, ethnicity, nativity, parity, and education. Yet, despite decreased smoking prevalence among all ethnic groups, the baseline disparity between non-Hispanic white and minority women—particularly African American and Puerto Rican women—has widened. Additional attention may be needed to reduce smoking among pregnant African American and Puerto Rican women to the level that has been achieved by other ethnic groups.

This work was supported by the National Institute of Child Health and Human Development [R21HD050739-03].

REFERENCES

1. Department of Health and Human Services, Office of the Surgeon General (US). Women and smoking: a report of the Surgeon General. Rockville (MD): HHS, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health (US); 2001.
2. Goksor E, Amark M, Alm B, Gustafsson PM, Wennergren G. The impact of pre- and post-natal smoke exposure on future asthma and bronchial hyper-responsiveness. Acta Paediatr 2007;96:1030-5.
3. Julvez J, Ribas-Fito N, Torrent M, Forns M, Garcia-Esteban R, Sunyer J. Maternal smoking habits and cognitive development of children at age 4 years in a population-based birth cohort. Int J Epidemiol 2007;36:825-32.
4. Key AP, Ferguson M, Molfese DL, Peach K, Lehman C, Molfese VJ. Smoking during pregnancy affects speech-processing ability in newborn infants. Environ Health Perspect 2007;115:623-9.
5. Carter S, Paterson J, Gao W, Iusitini L. Maternal smoking during pregnancy and behaviour problems in a birth cohort of 2-year-old Pacific children in New Zealand. Early Hum Dev 2008;84:59-66.
6. Nigg JT, Breslau N. Prenatal smoking exposure, low birth weight, and disruptive behavior disorders. J Am Acad Child Adolesc Psychiatry 2007;46:362-9.
7. Indredavik MS, Brubakk AM, Romundstad P, Vik T. Prenatal smoking exposure and psychiatric symptoms in adolescence. Acta Paediatr 2007;96:377-82.
8. National Association of Attorneys General. Tobacco. Washington: National Association of Attorneys General; 2006.
9. National Association of Attorneys General. Master Settlement Agreement. Washington: National Association of Attorneys General; 1998.
10. Capehart TC Jr. Trends in the cigarette industry after the Master Settlement Agreement. In: Electronic outlook report from the Economic Research Service. Washington: Department of Agriculture (US); 2001. p. 1-10.
11. Centers for Disease Control and Prevention (US). Best practices for comprehensive tobacco control programs, August 1999. Atlanta: Department of Health and Human Services, Office on Smoking and Health (US); 1999.
12. Frieden TR, Mostashari F, Kerker BD, Miller N, Hajat A, Frankel M. Adult tobacco use levels after intensive tobacco control measures: New York City, 2002–2003. Am J Public Health 2005;95:1016-23.
13. Perl SB, Ellis JA, Vichinsky LE, Larson K, Levy J, Silver L, et al. Smoking cessation strategies in New York City: 2002–2006. In: Jeffries TC, editor. Progress in smoking and health research. New York: Nova Biomedical Books; 2007. p. 89-115.
14. Cigarette smoking among adults—United States, 2000. MMWR Morb Mortal Wkly Rep 2002;51(29):642-5.
15. New York State Department of Health. Prevalence and trends in tobacco use, cessation, and exposure to second-hand smoke among New York State adults: Behavioral Risk Factor Surveillance System. Albany (NY): New York State Department of Health; 2003.
16. Decline in smoking prevalence—New York City, 2002–2006. MMWR Morb Mortal Wkly Rep 2007;56(24):604-8.
17. Ellis JA, Perl SB, Davis K, Vichinsky L. Gender differences in smoking and cessation behaviors among young adults after implementation of local comprehensive tobacco control. Am J Public Health 2008;98:310-6.
18. Ellis JA, Metzger KB, Maulsby C, Volle SJ, Van Wye G, Kerker B, et al. Smoking among New York City public high school students. NYC Vital Signs 2006;5:1-4.
19. Liang L, Chaloupka F, Nichter M, Clayton R. Prices, policies and youth smoking, May 2001. Addiction 2003;98 Suppl 1:S105-22.
20. Pierce JP. Tobacco industry marketing, population-based tobacco control, and smoking behavior. Am J Prev Med 2007;33(6 Suppl): S327-34.
21. Evans WN, Ringel JS. Can higher cigarette taxes improve birth outcomes? J Public Economics 1999;72:135-54.
22. Gruber J, Koszegi B. Is addiction "rational"? Theory and evidence. The Quarterly Journal of Economics 2001;116:1261-303.
23. Lewitt EM, Coate D. The potential for using excise taxes to reduce smoking. J Health Econ 1982;1:121-45.
24. Levy DE, Meara E. The effect of the 1998 Master Settlement Agreement on prenatal smoking. J Health Econ 2006;25:276-94.
25. Savitz DA, Janevic TM, Engel SM, Kaufman JS, Herring AH. Ethnicity and gestational diabetes in New York City, 1995–2003. BJOG 2008;115:969-78.
26. SAS Institute, Inc. SAS®: Version 9.1.3. Cary (NC): SAS Institute, Inc.; 2002–2003.
27. StataCorp. Stata®: Release 10. College Station (TX): StataCorp; 2007.
28. Lien DS, Evans WN. Estimating the impact of large cigarette tax hikes: the case of maternal smoking and infant birth weight. J Human Resources 2005;40:373-92.
29. Mathews TJ. Smoking during pregnancy in the 1990s. Natl Vital Stat Rep 2001 Aug 28;49:1-14.
30. Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Kirmeyer S, et al. Births: final data for 2005. Natl Vital Stat Rep 2007 Dec 5;56:1-103.
31. Perreira KM, Cortes KE. Race/ethnicity and nativity differences in alcohol and tobacco use during pregnancy. Am J Public Health 2006;96:1629-36.
32. Ventura SJ, Hamilton BE, Mathews TJ, Chandra A. Trends and variations in smoking during pregnancy and low birth weight: evidence from the birth certificate, 1990–2000. Pediatrics 2003;111(5 Part 2):1176-80.
33. Buescher PA, Taylor KP, Davis MH, Bowling JM. The quality of the new birth certificate data: a validation study in North Carolina. Am J Public Health 1993;83:1163-5.
34. Roohan PJ, Josberger RE, Acar J, Dabir P, Feder HM, Gagliano PJ. Validation of birth certificate data in New York State. J Community Health 2003;28:335-46.
35. Reichman NE, Hade EM. Validation of birth certificate data. A study of women in New Jersey's HealthStart program. Ann Epidemiol 2001;11:186-93.
36. Zollinger TW, Przybylski MJ, Gamache RE. Reliability of Indiana birth certificate data compared to medical records. Ann Epidemiol 2006;16:1-10.
37. Webb DA, Boyd NR, Messina D, Windsor RA. The discrepancy between self-reported smoking status and urine cotinine levels among women enrolled in prenatal care at four publicly funded clinical sites. J Public Health Manag Pract 2003;9:322-5.
38. Ananth CV, Kirby RS, Kinzler WL. Divergent trends in maternal cigarette smoking during pregnancy: United States 1990–99. Paediatr Perinat Epidemiol 2005;19:19-26.
39. Cantreill J, Hung D, Fahs MC, Shelley D. Purchasing patterns and smoking behaviors after a large tobacco tax increase: a study of Chinese Americans living in New York City. Public Health Rep 2008;123:135-46.
40. Hyland A, Bauer JE, Li Q, Abrams SM, Higbee C, Peppone L, et al. Higher cigarette prices influence cigarette purchase patterns. Tob Control 2005;14:86-92.