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Trends in cigarette smoking: The Minnesota Heart Survey, 1980–1982 through 2000–2002

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Abstract

This paper reports population-based secular trends in smoking prevalence and tobacco exposure among smokers. The Minnesota Heart Survey (MHS) assessed smoking in probability samples in the seven-county Minneapolis–St. Paul metropolitan area. Five surveys were conducted in 1980–1982, 1985–1987, 1990–1992, 1995–1997, and 2000–2002 using similar sampling strategies and consistent protocols. Participants were metropolitan area residents of Minnesota, aged 25–74 years, with the addition of 75–84-year-olds in the last three surveys. In men, age-adjusted self-reported prevalence of current smoking steadily declined from 32.9% in 1980–1982, to 23.0% in 1995–1997, and to 20.6% in 2000–2002. In women, self-reported smoking was 31.8% in 1980–

1982, 18.5% in 1995–1997, and 19.5% in the latest survey. Age-adjusted self-reported quantity of cigarettes consumed among smokers declined over the same period. Changes from 1995–1997 to 2000–2002 were not significant. Compared with Whites, Black participants had higher levels of smoking and later onset of the decline in smoking prevalence. A decline in smoking prevalence seems to have leveled off or reversed between the two most recent survey periods (1995–1997 through 2000–2002). Focus on smoking cessation should continue, especially in the subpopulation that smokes more than the majority.

Introduction

Cigarette smoking is the single most preventable cause of disease and death in the United States, accounting for approximately 1 of every 5 deaths (440,000 people) each year (Centers for Disease Control and Prevention, 2002, 2003). This represents more than 5 million years of potential life lost, with direct medical costs attributable to smoking totaling at least US\$50 billion per year. Smoking results in more deaths each year in the United States than AIDS, alcohol, cocaine, heroin, homicide, suicide, motor vehicle crashes, and fires—combined (U.S. Department of Health and Human Services [USDHHS], 2000). One of the *Healthy People* 2010 objectives is to reduce the prevalence of cigarette smoking among adults to 12% or less (objective 27.1a; USDHHS, 2000). Some progress has been made toward that goal. For example, in 2002, 45.8 million adults (22.5%) in the United States were current smokers, with rates higher in men than women (25.2% of men and 20% of women; Husten, Jackson, & Lee, 2004). Nevertheless, relatively little information is available about the specifics of the secular trend toward less smoking.

The Minnesota Heart Survey (MHS) has previously reported significant declines in the prevalence of cigarette smoking between 1980–1982 and 1990–1992 in metropolitan Minneapolis–St. Paul residents aged 25–74 years (Arnett et al., 1998). This report updates smoking trends through the similarly conducted 1995–1997 and 2000–2002 surveys and also describes smoking trends in the Black population over the same period.

Method

The MHS is a population-based surveillance study of cardiovascular disease risk factors in probability samples of residents aged 25–74 years in the seven-county Minneapolis–St. Paul metropolitan area. Similar sampling strategies and protocols were repeated in 1980–1982, 1985–1987, 1990–1992, 1995–1997, and 2000–2002, with the addition of 75–84-year-olds in the last three surveys. Detailed methods have been reported elsewhere (Sprafka, Burke, Folsom, Luepker, & Blackburn, 1990).

A two-stage cluster design was implemented, dividing the metropolitan area into clusters containing an estimated 1,000 households each and randomly sampling 40 of these clusters in the 1980–1982 through 1990–1992 surveys, and 44 clusters in the 1995–1997 and 2000–2002 surveys (the four new clusters accommodated population growth). At each survey, in the second stage of sampling, a random sample of households was selected in each cluster to generate a sample size of about 4,000–7000 adults. Only those households with at least one age-eligible person were included. After household enumeration, age-eligible individuals

were interviewed in the home to determine sociodemographic characteristics, health attitudes and beliefs, and smoking habit. Subjects were then invited to a survey center to complete questionnaires and undergo other measurements. In the 1980–1981, 1995–1997, and 2000–2002 surveys, all age-eligible individuals in the household were invited to participate, whereas a randomly selected individual was interviewed in all other survey years.

Overall response rates for the complete survey (home interview and survey center) were 69% (1980–1982), 68% (1985–1987), 68% (1990–1992), 65% (1995–1997), and 64% (2000–2002), correcting for those refusing enumeration and non-contacts. The response rate for the home interview was 91% (1980–1982), 88% (1985–1987), 82% (1990–1992), 83% (1995–1997), and 75% (2000–2002).

Measurements

Information on smoking status and number of cigarettes smoked among smokers was obtained both during the home interview and survey center visit. Ever-smokers were defined as giving a positive response to the question “Have you ever smoked cigarettes on a regular basis, that is, more than 100 cigarettes in your lifetime?” Current smokers were defined as ever-smokers who responded positively to the question “Do you currently smoke cigarettes?” and former smokers as those ever-smokers who answered no to this question. Estimates of smoking prevalence were based on home and clinic interview data.

Serum thiocyanate (SCN) levels were measured at the clinic to allow assessment of sensitivity and specificity of self-reported prevalence. Thiocyanate is the end product of the detoxification of hydrogen cyanide in cigarette smoke and has a half-life of about 10–14 days (Galanti, 1997; Velicer, Prochaska, Rossi, & Snow, 1992). Thiocyanate was measured in samples with a Technicon AutoAnalyzer between 1980–1982 and 1995–1997 and with a Hitachi 911 in 2000–2002, in both cases using the method of Butts et al. (Butts, Kueheman, & Widdowson, 1974), a spectrophotometric detection of a colored complex formed during a reaction between thiocyanate and ferric ions. In 84 serum samples frozen at -70°C since 1995–1997, remeasurement using the Hitachi machine found reasonably close agreement at lower levels. However, the mean SCN level among those with levels of at least $80\text{ }\mu\text{mol/l}$ was not reproducible across methods. Therefore, we studied sensitivity and specificity of the self-report of current smoking versus the biochemical test standard across survey years but did not use SCN as a measure of number of cigarettes consumed. Participants with SCN levels of at least $80\text{ }\mu\text{mol/l}$ were considered confirmed smokers (the Society for Research on Nicotine and Tobacco recommends a cutpoint between 78 and $84\text{ }\mu\text{mol/l}$; Benowitz et al., 2002).

Data analyses

All analyses took into account the cluster design by adding a neighborhood cluster term as a random effect in SAS PROC MIXED; a further variance component for multiple participants from the same household added little and was dropped. Because 75–84-year-olds were first added in 1990–1992, they were analyzed separately from 25–74-year-olds. The latter were estimated as a single group and stratified by age decade. Analyses were age-adjusted and

sex-specific except those of differences between ethnic groups. In that case, due to small numbers in the Black category, both genders were included with age- and sex-adjustment. Study of validity of self-reported smoking behavior with SCN was restricted to those who completed the clinic visits. Analysis of covariance was used to test differences in age-adjusted sequential means between 1980–1982, 1985–1987, 1990–1992, 1995–1997, and 2000–2002. Statistical significance levels are given for comparison with the previous period. Trends across survey years were estimated by including a linear and quadratic term for survey year in a general linear model.

Results

Among all observed 25–74-year-olds (Figure 1), the self-reported home interview prevalence of never smoking increased with time, significantly in both men and women, while both former smoking and current smoking became less prevalent ($p < .0001$ for trend in both sexes).

In both men and women who attended the clinic visit, age, years of attained education, and percent not White increased nearly monotonically over time (Tables 1 and 2). Age-adjusted smoking prevalence was slightly lower in each survey period in those who attended the clinic than in the larger group who completed the home visit, partly because of different response rate to the clinic visit (85% of home interview nonsmokers and 78% of home interview smokers attended the clinic visit). More specifically, at the clinic visit, current smoking declined by about one-third from the 1980s to the early 2000s, with age-adjusted prevalence decreasing from 32.9% to 20.6% in men, and from 31.8% to 19.5% in women aged 25–74 years (Figure 2). The greatest absolute decline among age decades (Tables 1 and 2) occurred in men aged 25–34 years (13.8 percentage points) and in women 35–44 years of age (16.0 percentage points). Participants aged 75–84 years reported low smoking prevalence of 4%–10% between 1990–1992 and 2000–2002, with no clear time trend (data not shown).

To study validity of these time trends, we used self-report smoking and SCN measures from the clinic visit. Sensitivity of self-reported current smoking was about 86% from 1980 to 1997 but dropped to less than 76% in 2000–2002. For men, average sensitivity across all time periods was about 80%, whereas for women it was about 91%; in each gender, sensitivity was slightly lower in the most recent survey than in previous surveys. Specificity for current smoking varied little from values of 94% to 95%, for both men and women over all time periods.

Among current smokers aged 25–74 years, the overall age-adjusted number of cigarettes smoked per day declined substantially from the 1980s to the early 2000s, from 25.1 to 16.7 cigarettes/day in men, and from 21.5 to 13.2 cigarettes/day in women (Figure 2b). Blacks had a higher smoking prevalence, later onset of the downward trends in smoking, and a smaller decrease in prevalence compared with their White counterparts (Table 3, Figure 3). They nevertheless reported smoking fewer cigarettes than Whites across all survey periods.

Discussion

Data from this study suggest that smoking prevalence continued to decline through 1995–1997 but leveled off or increased slightly in 2000–2002 in the Minneapolis–St. Paul metropolitan area. Despite increased smoking prevalence in the latest survey compared with the previous period, men aged 25–34 years and women aged 35–44 years still exhibited the largest absolute declines from 1980.

Data from the National Health Interview Survey (NHIS) were compared with those from the MHS for the years 1980, 1985, 1990, 1995, and 2000 (Barnes, Adams, & Schiller, 2003). Our data are generally similar to national data from the NHIS. Among men, the prevalence of current smoking was lower than that in the NHIS; among women, the opposite pattern emerged until 2000 (Figure 3). However, a difference from NHIS data is that Blacks in Minnesota report consistently higher levels of smoking than overall rates in the United States. This discrepancy could be due to differences in methodology between the two studies, accentuated by the small sample of Blacks in Minnesota. However, the observation may reflect reality. A similar observation was made in the Coronary Artery Risk Development in Young Adults (CARDIA) study (Kiefe et al., 2001): Smoking rates were higher in Minnesota Blacks compared both with Whites in Minnesota and with Blacks in other CARDIA centers (Birmingham, Chicago, Oakland), both at initial recruitment in 1985–1986, when they were 18–30 years old, and 10 years later. The CARDIA study in Minnesota recruited at random with 50% response rate in areas of Minneapolis in which substantial numbers of both Blacks and Whites lived in 1985–1986. Therefore, Minnesota CARDIA Blacks and Whites were more closely matched on socioeconomic status than were Blacks and Whites in the MHS, and the possibility of residual socioeconomic confounding was smaller in CARDIA than in the MHS.

The limitations of the study are mainly those relating to self-reported smoking behavior. We used SCN as a gold standard for current smoking, recognizing that thiocyanate is not ideal for detecting light smoking, possibly due to contamination from dietary sources (Galanti, 1997; Velicer et al., 1992) and environmental tobacco smoke. Given the near constant sensitivity and specificity of smoking self-report relative to the SCN gold standard between 1980 and 1997, the trends across those years may be considered reliable. However, the reduced sensitivity of self-reported smoking in the 2000–2002 assessment suggests that we may have underestimated smoking prevalence somewhat in this period, even though the sensitivity is still high. We may be seeing a tendency for participants to misrepresent their smoking behavior in the most recent period, consistent with growing social pressure not to smoke.

These data arise from the Minneapolis–St Paul metropolitan area in Minnesota. This strengthens the credibility of findings by eliminating intersite differences as a source of bias; however, results are not as widely generalizable as those from the NHIS, a U.S. national survey, or CARDIA, which is a multisite study. The population sampling strategy strengthens validity of the sample. The concordance in findings between the more complete sample of participants who completed the home interview and the somewhat more limited

sample who also attended the survey center adds confidence that nonresponse bias did not lead to a qualitatively incorrect time trend in smoking.

Although MHS surveillance of smoking since 1980 provides a picture of consistently reduced smoking through 1995–1997, several public health concerns arise in the most recent data from 2000–2002. First, prevalence of smoking appears to have leveled off or even increased in the most recent survey, particularly in women. Second, although reported number of daily cigarettes smoked decreased, this reduction appears to be leveling off in women. Finally, an important but small subpopulation, namely, Blacks, was identified in whom smoking was more common than in the general population. Thus the public health imperative to quit smoking has not reached all population segments equally. In view of the known strong associations of smoking with several chronic diseases, these findings are of concern and call for renewed efforts to combat cigarette smoking (USDHHS, 2004).

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Figure 1.
Prevalence of current, former, and never smoking in the home interview.

Figure 2.

(a) Current cigarette smoking in men and women aged 25–74 years. Data are from the clinic interview only, (b) Number of cigarettes per day in men and women aged 25–74 years. Data are from the clinic interview only. * $p < .05$; ** $p < .01$; *** $p < .001$ compared with the previous period. L indicates a linear trend component, Q a quadratic trend component, $p < .05$. Numbers of participants are given in Tables 1 and 2.

Figure 3.

Prevalence of cigarette smoking in Minnesota Heart Survey (MHS) participants compared with National Health Interview Survey (NHIS) participants, 1980–2000. MHS data are from the home interview.

Table 1

Age-adjusted cigarette smoking in men of all ethnicities; data are from the clinic visit only.

Age group	1980–1982	1985–1987	1990–1992	1995–1997	2000–2002	Trend ^a
25–34 years						
Current smoker (self-report), %	37.7	*29.7	26.5	21.5	23.9	Q
Smoking amount (cigarettes per day) ^b	23.9	*20.7	18.3	*14.4	13.9	L
Number of subjects	504	646	610	235	216	
35–44 years						
Current smoker (self-report), %	34.6	31.7	28.1	26.0	21.4	L
Smoking amount (cigarettes per day) ^b	25.9	23.4	21.5	18.4	16.2	L
Number of subjects	391	642	617	293	313	
45–54 years						
Current smoker (self-report), %	34.2	*26.2	26.9	24.6	21.3	L
Smoking amount (cigarettes per day) ^b	26.4	24.7	22.6	22.7	20.3	L
Number of subjects	300	392	422	269	292	
55–64 years						
Current smoker (self-report), %	22.5	26.0	**16.9	17.4	14.6	L
Smoking amount (cigarettes per day) ^b	26.2	26.7	**19.6	18.1	17.4	L
Number of subjects	240	325	322	171	186	
65–74 years						
Current smoker (self-report), %	20.0	15.5	12.8	17.6	*7.4	L
Smoking amount (cigarettes per day) ^b	18.8	22.0	16.5	21.0	15.3	–
Number of subjects	111	184	188	138	105	
Total						
Age (years), median (SD)	41 (13)	41 (13)	42 (13)	45 (13)	45 (12)	
Mean years of education	13.7	14.0	14.2	14.1	14.5	
White, %	96.7	96.3	95.3	93.3	90.6	
Current smoker (self-report), %	32.9	*28.8	*25.2	23.0	20.6	L
Smoking amount (cigarettes per day) ^b	25.1	*23.2	**20.4	18.7	16.7	L

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Age group	1980–1982	1985–1987	1990–1992	1995–1997	2000–2002	Trend ^a
Number of subjects	1,546	2,189	2,159	1,106	1,112	

Note.

^a L indicates a linear trend component, Q a quadratic trend component, $p<.05$.

^b Among smokers according to self-report.

* $p<.05$;

** $p<.01$;

*** $p<.001$ compared with the previous period.

Table 2

Age-adjusted cigarette smoking in women of all ethnicities; data are from the clinic visit only.

Age group	1980–1982	1985–1987	1990–1992	1995–1997	2000–2002	Trend ^a
25–34 years						
Current smoker (self-report), %	35.3	**26.1	28.8	25.2	21.7	L
Smoking amount (cigarettes per day) ^b	20.6	***16.9	*14.5	**10.6	10.9	L
Number of subjects	545	693	628	271	242	
35–44 years						
Current smoker (self-report), %	38.6	***25.6	25.0	**17.9	22.6	Q
Smoking amount (cigarettes per day) ^b	23.9	***18.9	17.4	*13.8	13.0	L
Number of subjects	430	642	674	336	343	
45–54 years						
Current smoker (self-report), %	29.9	28.5	25.4	**17.2	18.2	L
Smoking amount (cigarettes per day) ^b	21.4	21.7	20.0	18.2	15.4	L
Number of subjects	322	433	467	274	355	
55–64 years						
Current smoker (self-report), %	23.9	29.0	*20.3	17.1	14.6	L
Smoking amount (cigarettes per day) ^b	19.4	18.2	15.7	16.8	14.1	L
Number of subjects	269	333	314	185	196	
65–74 years						
Current smoker (self-report), %	20.8	18.3	16.3	11.1	7.9	L
Smoking amount (cigarettes per day) ^b	16.1	15.4	15.6	11.2	14.7	–
Number of subjects	157	248	256	117	118	
Total						
Age (years), median (<i>SD</i>)	41 (13)	42 (13)	43 (13)	44 (13)	45 (12)	
Mean years of education	13.2	13.6	13.9	14.0	14.4	
White, %	95.9	95.6	95.8	93.9	90.5	
Current smoker (self-report), %	31.8	***26.1	24.9	***18.5	19.5	Q
Smoking amount (cigarettes per day) ^b	21.5	***18.7	**16.8	***13.6	13.2	L

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Age group	1980–1982	1985–1987	1990–1992	1995–1997	2000–2002	Trend ^a
Number of subjects	1,723	2,349	2,339	1,183	1,254	
Note						
^a L indicates a linear trend component, Q a quadratic trend component, $p<.05$.						
^b Among smokers according to self-report.						
* $p<.05$,						
** $p<.01$,						
*** $p<.001$ compared with the previous period.						

Table 3

Age- and sex-adjusted cigarette smoking in Black participants (aged 25–74 years); data are from the clinic visit only.

	1980–1982	1985–1987	1990–1992	1995–1997	2000–2002	Trend ^a
Current smoker (self-report), %	34.5	41.3	36.2	42.6	32.5	–
Smoking amount (cigarettes per day) ^b	18.3	*13.1	15.7	*11.6	9.4	L
Number of subjects	78	97	105	65	83	

Note.

^aL indicates a linear trend component, $p < .05$.

^b Among smokers according to self-report.

* $p < .05$ compared with the previous period.