



## Article

# International differences in the risk of death from smoking and obesity: The case of the United States and Finland



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## ABSTRACT

Despite much interest in the health risks associated with behavioral factors, little is known about whether individuals residing in different countries experience a different set of risks. International comparisons of the death risks from major behavioral factors can shed light on whether features of health systems and epidemiological histories modify the health effects of risky behaviors. We used nationally representative samples and mortality linkages spanning the 1971–2014 period from the United States and Finland to examine cross-national differences in the risks of death from cigarette smoking and obesity. We evaluated both current and former smoking and current and prior obesity. In 1990, the approximate midpoint of our study, the death risks from current smoking were about 55% higher in U.S. women compared to Finnish women, but similar for men in the two countries. Death risks from smoking significantly increased over the period for women in both countries and there was no parallel increase in risks among men. Death risks from obesity did not significantly differ in the two countries and no significant trend in the risks were detected in either country. Reasons for the relatively high and increasing risks from smoking among American women warrant further evaluation.

## 1. Introduction

Cigarette smoking and obesity exert large tolls on health in high-income countries (Mokdad, Marks, Stroup, & Gerberding, 2004; National Research Council, 2011). Since 1980, obesity levels have risen in nearly all parts of the world (Finucane et al., 2011). In 2013, approximately 20% of adults in high-income countries were estimated to be obese (defined as a body mass index (BMI)  $\geq 30$  kg/m<sup>2</sup>) (Ng et al., 2014a). The prevalence of cigarette smoking, in contrast, has generally been on the decline in high-income countries, at least since the 1970s (Pampel, 2010). Nonetheless, in 2012 approximately 30% of men and 20% of women in high-income countries were estimated to currently smoke cigarettes (Ng et al., 2014b). Many nonsmoking adults today have smoked in the past and the prevalence of current and former smoking combined exceeds 50% in many high-income countries (Zatoński, Przewoźniak, Sulkowska, West, & Wojtyła, 2012). Both obesity and smoking individually play a major role in explaining the low life expectancy ranking of the United States relative to European countries (National Research Council, 2011; Preston & Stokes, 2011)

and in contributing to within-country mortality differentials by socioeconomic status (Martikainen et al., 2014; Mehta, House, & Elliott, 2015; Stringhini et al., 2010).

We examined the question of whether individuals residing in different countries face a different risk of death from cigarette smoking and obesity using a comparative case of the United States and Finland. International comparisons can reveal whether risk factors are operating similarly on mortality under different circumstances. A comparative framework, for example, can provide insights into how features of health systems and cohort behavioral histories modify the riskiness of behavioral factors.

International comparisons are also valuable for studies evaluating the population-level number of deaths attributable to a behavioral risk factor because these studies often rely on estimates of death risks from the behavioral factor under investigation (Preston & Stokes, 2011; Rostron, 2011). In such studies, death risks are not always available for the country that is the focus of the investigation. It is not uncommon for studies to apply a set of risks from another country to estimate population-level attributable deaths in the country of interest (Gallus

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et al., 2011; Martelin, Mäkelä, & Valkonen, 2004; Neubauer et al., 2006; Preston & Stokes, 2011; Rodu & Cole, 2004). International comparisons of the risks can aid in assessing whether risks estimated from one dataset or country may be generalizable to other contexts.

In this study, we provide a specific comparison of the United States with Finland. Our comparison of the two countries is guided by theoretical and practical concerns. While both countries' GDP is higher than average for OECD nations, the United States is also characterized by higher levels of poverty and income inequality compared to Finland (OECD, 2016a, 2016b, 2016c). The countries also differ in their healthcare delivery systems and in their behavioral histories, which we review below. These contextual differences provide for an informative comparison. From a practical standpoint, both countries possess a long running series of nationally representative health surveys that contain information on socio-demographic and behavioral risk factors and that are linked prospectively to death records. These surveys and linkages date back to the 1970s in each country. Furthermore, surveys in each country contain information about body weight histories, which as we elaborate below, are useful in addressing key biases arising in the estimation of death risks from obesity. Body weight histories have been rarely collected in nationally representative surveys. All surveys also have information on past and current smoking behavior and socio-demographic characteristics of respondents.

### 1.1. The risks of death from cigarette smoking

The mortality risks from cigarette smoking have been recognized for over sixty years (Doll & Hill, 1954). These risks are usually ascertained from estimates made based on survey data that are linked to prospective death records. Recent estimates from a nationally representative survey in the United States applicable to the 1987–2003 period indicate that at age 65 current cigarette smokers face a risk of dying that approaches three times that of never smokers (Mehta & Preston, 2012). Studies from various European countries pertaining to various periods and adult ages report that smokers have a two- to three-fold higher death rate compared to never smokers (Doll, Peto, Boreham, & Sutherland, 2004; Prescott et al., 1998; Shavelle, Paculdo, Strauss, & Kush, 2008).

The estimated death risks from smoking appear to increase as the smoking epidemic evolves in a population. At least for the United States, there is evidence that the relative risks have been rising, perhaps since the 1960s. Thun, Day-Lally, Calle, Flanders, and Heath (1995) observed a rise in the relative risks from smoking among women between the 1960s and 1980s in the U.S. Cancer Prevention Study I (1959–1965) and II (1982–1986). Rising risks have also been observed in the United Kingdom (Doll et al., 2004; Pirie, Peto, Reeves, Green, & Beral, 2013), Japan (Sakata et al., 2012), and New Zealand (Hunt, Blakely, Woodward & Wilson, 2005). One explanation for these trends is that as the smoking epidemic evolves later birth cohorts begin smoking at an earlier age and more intensively than earlier birth cohorts (Mehta & Preston, 2012; Sakata et al., 2012; Thun et al., 2013, 1997a). Other explanations include changes in the tar and nicotine composition of cigarettes smoked (Jemal, Chu, & Tarone, 2001; Thun et al., 1997b) and social selectivity into smoking (Mehta & Preston, 2012). The latter refers to the fact that smoking has become more concentrated among those with low socioeconomic status (Mackenbach, 2006; Pampel, 2010).

Because the smoking epidemic evolved and receded at different times across countries (Pampel, 2010), it is likely that the death risks from smoking differ across countries. By international standards, U.S. men began smoking early with peak smoking occurring for the cohorts born around 1915–1920 (Preston & Wang, 2006). Finnish men also picked up smoking relatively early with peak smoking observed for the 1911–25 cohorts (Martelin, 1984; Martikainen, Ho, Preston, & Elo, 2013). In most countries, women tended to pick up smoking later than men with U.S. women being some of the earliest adopters. Peak

smoking occurred for U.S. women in the 1940–45 cohort (Preston & Wang, 2006) and for Finnish women in cohorts born in the 1950s (Martelin, 1984). While smoking began earlier in the United States compared to other high-income countries, it also declined faster (Cutler & Glaeser, 2006; Pampel, 2010). The national-level differences in smoking uptake and quitting also may influence cross-national differences in the relative risks of death from former smoking as they could imply cross-national differences in time since quitting, an important determinant of mortality among former smokers (Ho & Elo, 2013).

### 1.2. The risks of death from obesity

Compared to cigarette smoking, there is far less consensus about the magnitude of the death risks from obesity (Berrington de Gonzalez et al., 2010; Flegal, Kit, Orpana, & Graubard, 2013; Prospective Studies Collaboration, 2009). Estimates of the risks from obesity have varied widely with several studies indicating that risks are limited only to more severe levels of obesity (e.g., see Mehta & Chang, 2011a for a review). This uncertainty has resulted in uncertainty around estimates of the population-level impact of obesity such as the number of obesity-attributable deaths (Flegal et al., 2013; Mehta & Chang, 2009; Stokes, 2014).

Like that of cigarette smoking, estimates of the risk of death from obesity are normally based on observational studies and are subject to selection biases inherent in such studies. One major source of bias arises from the fact that illness often precipitates weight loss. The biases this ordering may cause is commonly referred to as “reverse causality” (although it is also referred to as disease confounding). If disease confounding is inadequately accounted for, it will normally result in downwardly biased risk estimates. These biases may be stronger at middle and older ages where disease prevalence is high compared to at younger ages. Adjustment for disease presence in statistical models or otherwise excluding individuals with pre-existing illnesses entirely from the analysis may not adequately account for this bias (Mehta, 2015).

Inclusion of a measure of weight status at an age prior to age at the time of the survey can be beneficial in fully characterizing the risks from obesity. When available, such information is typically obtained by asking survey respondents to report their body weight at earlier ages or times. A weight status measured earlier in life and well before the start of mortality follow-up is also likely to be more robust to reverse causality because it may be more reflective of life-long weight dynamics prior to the onset of weight loss induced by disease. Preston, Mehta and Stokes (2013) showed that among a U.S. sample of adults aged 50–74 at time of survey, BMI at age 25 was more strongly predictive of subsequent mortality than BMI present at the time of survey even when both variables were assessed simultaneously in a regression model. A similar finding was observed for Finnish adults by Mehta et al. (2014).

The selective and confounding processes that can bias estimates of the risks of death from obesity when BMI is measured at the start of the follow-up may operate to a different degree in different populations. This difference potentially complicates the interpretation of international comparisons of the risks of death from obesity. To account for this potentially important complication, we use survey data from Finland and the United States that include information on both current and retrospective reports of body weight, which allows us to compare estimates of the risks of death from high BMI pertinent to the start of the mortality follow-up and BMI pertinent to an earlier age. If the risks are similar across the estimates in the two countries, such a result would provide evidence for the proposition that underlying biological processes associated with obesity are responsible for the increased death risks rather than the result of selective confounding.

1.3. The U.S. and Finnish context

The United States is distinct among high-income countries in having a large private health care sector with a considerable proportion of the population under age 65 without health insurance. In contrast, Finland is a Northern European welfare state with universal health insurance coverage. Both countries are similar in that they have experienced substantial improvements in life expectancy at age 50 since 1970 with Finland experiencing among the largest gains of all high-income countries (National Research Council, 2011). In contrast, while mortality improved the U.S. experienced a worsening ranking in life expectancy relative to other high-income countries during this period (National Research Council, 2011). Life expectancy in the United States increased from 70.7 years in 1970 to 78.9 years in 2010 (from Human Mortality Database, [www.mortality.org](http://www.mortality.org)). The corresponding figures for Finland are 70.3 (1970) and 80.0 (2010) (Human Mortality Database). Both Finland and United States have also experienced large reductions in coronary heart disease mortality since the 1960s, a cause of death that has been clearly linked to the behavioral factors that we investigate in this paper (Levi, Lucchini, Negri, & La Vecchia, 2002; Pajunen et al., 2004; Salomaa et al., 1996).

The behavioral histories of the two countries differ. We partly demonstrate these differences using our own tabulations from nationally representative surveys in the two countries (Tables 1 and 2). The United States is often characterized as having the highest obesity levels among OECD countries (Preston & Stokes, 2011). In the 1970s, the United States and Finland had similar obesity prevalence. Around 19–20% of women (Table 1) and 12–14% of men (Table 2) were obese. By the 2000s, the two countries had diverged with U.S. men and women displaying a higher prevalence than their Finnish counterparts: 36% vs. 24% among women (Table 1) and 32% to 21% among men (Table 2).

Since the 1970s, U.S. and Finnish men have shared a somewhat similar smoking profile. In contrast, there have been differences among women in the two countries. Smoking attributable mortality is a useful indicator to compare the smoking histories of the two countries as it reflects prior smoking patterns. The estimates of smoking attributable fraction of deaths among men at ages 50 and above in 1980 were higher in Finland (29%) than in the United States (24%), but the reverse was true by 2003; 19% in Finland versus 24% in the United States (Preston, Gleit, & Wilmoth, 2010). Among women, the contribution of smoking to mortality at ages 50 and above has always been higher in the United States than in Finland. In 1980, smoking

**Table 1**  
Descriptive characteristics for women at time of survey by country; ages 30–69.

Characteristic	United States			Finland	
	NHANES 1+2 1971–1980	NHANES 3 1988–1994	NHANES 1999–2004	Mini-Finland 1978–1980	Health 2000 2000–2001
<b>Women</b>					
Age, years (mean)	51.3 (51.0, 51.6)	49.0 (48.5, 49.6)	48.4 (47.9, 49.0)	49.1 (48.7, 49.5)	50.0 (49.6, 50.4)
Smoking status, %					
Current	29.7 (28.5, 31.0)	23.9 (21.9, 25.8)	22.4 (20.5, 24.3)	13.8 (12.6, 15.1)	25.0 (23.4, 26.5)
Former	16.4 (15.4, 17.4)	26.3 (24.3, 28.3)	26.1 (24.2, 28.1)	10.0 (8.9, 11.1)	21.3 (19.8, 22.7)
Never	53.8 (52.5, 55.2)	49.8 (47.5, 52.1)	51.5 (49.2, 53.7)	76.2 (74.6, 77.7)	53.8 (52.0, 55.5)
BMI category, %					
Obese, 30.0+	19.8 (18.7, 20.9)	29.7 (27.6, 31.8)	35.9 (33.8, 38.1)	18.7 (17.3, 20.1)	23.6 (22.1, 25.1)
Overweight, 25.0–29.9	30.8 (29.6, 32.1)	30 (27.9, 32.1)	29.6 (27.5, 31.6)	35.7 (34.0, 37.4)	35.8 (34.1, 37.5)
BMI 20.0–24.9	49.4 (48.1, 50.8)	40.3 (38.1, 42.6)	34.5 (32.4, 36.6)	45.6 (43.8, 47.3)	40.7 (38.9, 42.4)
Educational attainment, %					
0–8 years	19.7 (18.6, 20.7)	6.5 (5.4, 7.6)	2.6 (1.9, 3.4)	66.3 (64.6, 67.9)	7.6 (6.7, 8.6)
9–12 years	56.9 (55.6, 58.3)	54.3 (52.0, 56.6)	36.8 (34.6, 38.9)	18.0 (16.6, 19.3)	39.4 (37.6, 41.1)
13+ years	23.4 (22.2, 24.5)	39.2 (36.9, 41.4)	60.6 (58.4, 62.8)	15.8 (14.5, 17.1)	53.0 (51.2, 54.8)
Sample size, number	5207	1828	1890	3041	3039
Person-years	63,888	28,325	12,507	70,737	31,919
Deaths	774	374	89	1,146	155
Age-adjusted death rate <sup>a</sup>	11.6 (10.7, 12.4)	12.7 (11.4, 14.0)	8.7 (6.8, 10.5)	10.9 (10.3, 11.6)	5.4 (4.5, 6.3)
Mortality linkage end date	Dec 31, 1992	Dec 31, 2013	Dec 31, 2013	Dec 31 2008	Dec 31 2014

Note: 95% confidence limits shown in parentheses.

<sup>a</sup> Per 1000 person-years. Age adjusted using as standard the mean age distribution (5-year age groups) of the four country-sex combinations.

**Table 2**  
Descriptive characteristics for men at time of survey by country; ages 30–69.

Characteristic	United States			Finland	
	NHANES 1+2 1971–1980	NHANES 3 1988–1994	NHANES 1999–2004	Mini-Finland 1978–1980	Health 2000 2000–2001
<b>Men</b>					
Age, years (mean)	51.0 (50.6, 51.3)	49.6 (49.0, 50.2)	49.2 (48.6, 49.7)	47.1 (46.7, 47.5)	49.5 (49.1, 49.9)
Smoking Status, %					
Current	37.3 (35.9, 38.6)	29.7 (27.5, 31.8)	25.9 (23.9, 27.9)	35.1 (33.3, 36.9)	35.3 (33.5, 37.1)
Former	38.1 (36.7, 39.5)	39.9 (37.6, 42.2)	34.9 (32.7, 37.0)	34.8 (33.0, 36.6)	34.0 (32.2, 35.7)
Never	24.6 (23.4, 25.8)	30.4 (28.2, 32.6)	39.3 (37.0, 41.5)	30.1 (28.4, 31.8)	30.7 (29.0, 32.4)
BMI Category, %					
Obese, 30.0+	13.9 (12.9, 14.8)	23.7 (21.7, 25.7)	32.2 (30.1, 34.3)	11.7 (10.5, 12.9)	21.3 (19.8, 22.8)
Overweight, 25.0–29.9	47.0 (45.5, 48.4)	44.2 (41.8, 46.6)	43.1 (40.9, 45.4)	46.5 (44.7, 48.4)	47.5 (45.6, 49.3)
BMI 20.0–24.9	39.2 (37.8, 40.6)	32.1 (29.9, 34.3)	24.7 (22.7, 26.6)	41.8 (39.9, 43.6)	31.2 (29.5, 33.0)
Educational Attainment, %					
0–8 years	22.0 (20.9, 23.2)	9.1 (7.7, 10.4)	3.9 (3.0, 4.8)	65.3 (63.5, 67.0)	9.3 (8.2, 10.4)
9–12 years	46.9 (45.5, 48.4)	45.1 (42.8, 47.5)	36.9 (34.7, 39.1)	13.3 (12.0, 14.6)	43.9 (42.0, 45.7)
13+ years	31.0 (29.7, 32.3)	45.8 (43.4, 48.2)	59.2 (57.0, 61.4)	21.4 (19.9, 23.0)	46.8 (45.0, 48.7)
Sample size, number	4753	1699	1867	2729	2792
Person-years	55,367	26,339	12,254	58,484	28,636
Deaths	1134	450	133	1260	284
Age-adjusted death rate <sup>a</sup>	21.4 (20.1, 22.7)	17.5 (16.0, 19.0)	14.5 (10.3, 18.7)	21.7 (20.5, 22.8)	11.3 (9.9, 12.7)
Mortality linkage end date	Dec 31, 1992	Dec 31, 2013	Dec 31, 2013	Dec 31 2008	Dec 31 2014

Note: 95% confidence limits shown in parentheses.

<sup>a</sup> Per 1000 person-years. Age adjusted using as standard the mean age distribution (5-year age groups) of the four country-sex combinations.

attributable fraction of deaths at ages 50 and above in the United States was 7% compared to 2% in Finland; by 2003 the respective percentages were 24% versus 5% (Preston et al., 2010). The patterns in smoking attributable mortality are reinforced by prevalence data. In both the 1970s and early 2000s, a higher percentage of American women were either current or former smokers compared to Finnish women (Table 1): 46% vs. 24% in the 1970s and 49% vs. 46% in the early 2000s.

#### 1.4. Present study

We used data from multiple nationally representative health surveys from Finland and the United States that include information on smoking, weight status and socio-demographic characteristics. We used the pooled sample of individual-level data to estimate the risks of death from smoking and BMI pertinent to either the start of the mortality follow-up or at an earlier age, adjusting for age, sex, and educational attainment. In addition to the cross-national comparison of the risks from obesity and smoking, we evaluated whether these risks had changed over time since the 1970s in both countries, and whether

these trends varied between the two countries.

## 2. Data and methods

### 2.1. United states

We used data from the National Health and Nutrition Examination Survey (NHANES) I (1971–1974), II (1976–1980), III (1988–1994) and 1999–2004 waves. NHANES are a series of cross-sectional health surveys conducted by the National Center for Health Statistics (NCHS) that sampled from the non-institutionalized U.S. population. Each survey has been linked by the National Center for Health Statistics to death records contained in the National Death Index (NDI). NDI death linkages through 1992 for NHANES I and II, and through 2013 for NHANES III and 1999–2004 were used. Deaths occurring to individuals who became institutionalized after the time of survey are captured in death records. We restricted the samples to non-Hispanic whites (Elo, Martikainen, & Smith, 2006). The combined NHANES data analyzed included 17,244 individuals, 198,680 person-years of follow-up, and 2954 deaths.

## 2.2. Finland

The Mini-Finland Health Survey of 1978–1980 and the Finnish Health 2000 Survey were used. Both surveys are nationally representative and have been used extensively to investigate the health status and health risks of the Finnish population (Aromaa, Heliövaara, Impivaara, Knekt, & Maatela, 1989; Aromaa & Koskinen, 2004; Heliövaara et al., 1993). These samples represent both institutionalized and non-institutionalized individuals with participation rates exceeding 90%. Each dataset is linked to the Finnish Mortality Registry through a personal identification number, beginning at the time of each survey through 2008 for the Mini-Finland and 2014 for the Health 2000. Specific details of the sampling strategies of Mini-Finland and Health 2000 have been published previously (Aromaa et al., 1989; Aromaa & Koskinen, 2004; Heliövaara et al., 1987). The combined Finnish data analyzed included 11,601 individuals, 189,776 person-years of follow-up, and 2845 deaths.

## 2.3. Age range

We included adults ages 30–69 at time of each survey. Age 30 was the lower bound as it is the youngest age contained in Health 2000. Those ages 70 and over at time of survey were excluded to reduce potential biases from “reverse causation” in the BMI-mortality association, which is likely to be stronger at older compared to younger ages (Mehta & Chang, 2011a). The oldest recorded age at death was 98. All analyses incorporated sampling weights provided in each dataset.

## 2.4. Behavioral measures

Cigarette smoking was classified into never, former, and current smoking based on respondents’ reports of current and past smoking behavior. Clinically measured height and weight were taken at time of survey in each of the surveys and used to calculate body mass index (BMI, kg/m<sup>2</sup>). The following weight status categories were used: BMI 20–24.9, overweight (BMI: 25.0–29.9), obesity (BMI: 30.0+). We eliminated from the analyses those with a BMI < 20.0, who represent approximately 6% of the original sample, to reduce potential biases from reverse causality arising from low body weight (Joshy et al., 2014). In additional models, we treated BMI as a linear variable as described in more detail below under Statistical Approach. We also evaluated BMI pertinent to early adulthood that was identified from a question asking respondents about body weight at an age prior to age at survey. This retrospectively reported information was available in three of the datasets: NHANES III, NHANES 1999–2002 and the Finnish Health 2000. In NHANES, information on weight at age 25 was collected and in Health 2000 weight at age 30.

## 2.5. Statistical approach

The outcome was death from any cause. After pooling datasets from both countries, we estimated a set of multivariate discrete-time linear probability models on a person-year file. The main advantage of using a linear model over a proportional hazard or logistic model to address our research questions is that linear models naturally produce measures of risk difference, which have been argued to have a greater relevancy for public health policy than risk ratios (VanderWeele & Knol, 2014). In a comparative context, risk differences, as opposed to risk ratios, are insensitive to risk levels in the reference category (often the non-exposed group). Least-squares models with robust Huber-White standard errors were estimated (Cheung, 2007). Models were stratified by sex.

Model 1 was:

$$p = \alpha + \sum_i \beta^*Age_i + \beta^*Year + \beta^*Year^2 + \beta^*USA + \beta^*Ob + \beta^*Current + \beta^*Former + \beta^*Ob^*USA + \beta^*Current^*USA + \beta^*Former^*USA + \beta^*Year^*USA + \beta^*Year^2^*USA + \sum_j \beta^*Educ_j;$$

where  $p$  is the probability of dying in a one-year interval,  $Age_i$  are 5-year wide age categories (representing age at exposure),  $Year$  is calendar year,  $USA$  is a 0/1 indicator for country,  $Ob$  is an indicator for obesity (BMI $\geq$ 30),  $Current$  and  $Former$  refer to current and former smoking. Country-specific coefficients for the behavioral variables were obtained by multiplying each behavioral variable with  $USA$  (line 3 of Model 1). Similarly, multiplicative interactions between calendar year and  $USA$  were included (line 4 of Model 1).  $Educ_j$  in Model 1 represents indicators for three educational categories (0–8 years, 9–12 years, and 13+ years). In both countries, the prevalence of smoking and obesity differ by educational attainment (Sainio, Martelin, Koskinen, & Heliövaara, 2007; Wang & Beydoun, 2007).

Model 2 adds to Model 1 a two-way product term between each behavioral factor and calendar year and a three-way product term of behavioral factor, calendar year, and  $USA$ . These terms allow the coefficients of the behavioral factors to vary by calendar-year in a country-specific fashion.

A number of preliminary analyses informed the specification of Models 1 and 2. These preliminary analyses revealed no statistically significant differences (at the  $p=.05$  level) in death risks between those in the BMI 20.0–24.9 range and those classified as overweight (BMI: 25.0–29.9). Therefore, we used as a reference category for obesity those with a BMI of 20.0 to 29.9. We used the Bayesian Information Criteria (BIC) to examine the preferred specification for modelling age and year. We found that a categorical classification of age was preferred to models that specified age as linear or quadratic. A quadratic function of calendar year was preferred over a linear or categorical specification. We found significant interactions ( $p < .05$ ) between obesity and current and former smoking indicating that the risk factors are synergistic (super-additive) in their effects on mortality. Therefore, we also present results stratified by obesity and smoking status (shown in Appendices 1 and 2).

We additionally present models with alternative specifications of BMI including models that incorporate historical BMI (Models 3–6). In Model 3 we treated BMI at time of survey as a linear term whereby those whose BMI value was 30 or less were assigned a value of zero, and those whose BMI value was greater than 30 were assigned a value of their BMI minus 30 (Preston et al., 2013). Inclusion of a quadratic term for BMI did not improve model fit. In Models 4–6, we examined coefficients for BMI pertaining to early adulthood, which was constructed from a retrospective question asking respondents about their weight at age 25 (U.S. data) or 30 (Finnish data). We set the threshold value of this variable to BMI=25, rather than BMI=30, because initial analyses implementing linear splines indicated that the incremental effect of early adulthood BMI in the 25.0–29.9 range was similar to that in the 30.0+ range.

## 3. Results

Descriptive characteristics in Tables 1 and 2 were discussed in the Introduction. Briefly, obesity levels in the two countries were similar in the 1970s and then diverged over time with U.S. men and women becoming more obese than their Finnish counterparts by the 2000s. American women were more likely to be current or former smokers than Finnish women in all periods, while men in the two groups shared a similar smoking profile.

Table 3 shows the coefficients for smoking and obesity and their time trend. We begin with results for current and former smoking. The coefficients in Table 3 are in units of deaths per 1000 person-years.



**Table 3**

Coefficients from linear regression models predicting the risk of death in a single year (expressed as deaths per 1000 person-years); ages 30–69 at time of survey. Sources: U.S. NHANES I, II, III and 1999–2004; Mini-Finland, and Finnish Health 2000

Characteristic	Women		Men	
	Model 1	Model 2	Model 1	Model 2
<i>Current smoking</i>				
USA	10.25 <sup>***†</sup> (8.55, 11.94)	9.91 <sup>***†</sup> (8.22, 11.59)	14.57 <sup>***</sup> (12.45, 16.69)	14.52 <sup>***</sup> (12.33, 16.72)
Finland	6.55 <sup>***</sup> (4.76, 8.33)	4.54 <sup>***</sup> (2.20, 6.88)	15.07 <sup>***</sup> (12.95, 17.19)	15.59 <sup>***</sup> (12.88, 18.31)
Annual change				
USA		0.30 <sup>***</sup> (0.14, 0.46)		0.09 (-0.10, 0.28)
Finland		0.22 <sup>**</sup> (0.06, 0.37)		-0.06 (-0.26, 0.14)
<i>Former smoking</i>				
USA	3.77 <sup>***</sup> (2.07, 5.47)	3.71 <sup>***</sup> (1.94, 5.49)	2.52 <sup>*</sup> (0.61, 4.34)	2.73 <sup>**</sup> (0.70, 4.76)
Finland	2.40 <sup>**</sup> (0.63, 4.16)	0.85 (-1.53, 3.24)	1.85 (-0.08, 3.77)	4.17 <sup>***</sup> (1.72, 6.62)
Annual change				
USA		0.06 (-0.09, 0.22)		-0.09 (-0.26, 0.09)
Finland		0.16 <sup>*</sup> (0.01, 0.32)		-0.28 <sup>**</sup> (-0.46, -0.10)
<i>Obesity at survey</i>				
USA	5.02 <sup>***</sup> (3.32, 6.71)	5.00 <sup>***</sup> (3.20, 6.81)	5.54 <sup>***</sup> (3.18, 7.89)	5.31 <sup>***</sup> (2.67, 7.95)
Finland	4.36 <sup>***</sup> (2.31, 6.41)	4.42 <sup>***</sup> (1.91, 6.94)	6.16 <sup>***</sup> (3.33, 8.99)	8.90 <sup>***</sup> (4.57, 13.23)
Annual change				
USA		0.00 (-0.15, 0.15)		0.06 (-0.15, 0.28)
Finland		-0.01 (-0.18, 0.16)		-0.27 (-0.54, 0.01)

Note: Models include controls for age (5-year wide categories), calendar year and year-squared, and educational attainment (0–9 years, 9–12 years, and 13+ years). Year is centered at 1990 and the coefficients for behavioral factors in Model 2 pertain to 1990. 95% confidence limits shown in parentheses.

\*\*\* p < .001.  
\*\* p < .01.  
\* p < .05.

† Indicates that coefficients differ significantly (p < .05) between United States and Finland.

Cigarette smoking is significantly (p < .05) riskier for American women compared to Finnish women (Model 1: β=10.25 vs. 6.55). However, in both populations the risk is rising, by an annual increase of 0.30 deaths per 1000 person-years for American women and 0.22 deaths per 1000 person-years for Finnish women. The level of annual increase was not significantly different across the two countries. The risks associated with former smoking were not statistically different among women in the two countries (β=3.77 (USA) and 2.40 (Finland)). However, Model 2 indicates that the risks associated with former smoking has been increasing over time only among Finnish women, by 0.16 deaths per

1000 person-years per year.

Among men, the risks associated with current and former smoking were not statistically different in the two countries. Model 1 indicates that the risks of current smoking were higher in men compared to women (men: β=14.57 (USA) and 15.07 (Finland)). However, the trend for current smoking for both U.S. and Finnish men was virtually flat. A significant decline in the risks associated with former smoking was detected among Finnish men, by 0.28 deaths per 1000 person-years per year.

Table A1 shows estimates of death risks from smoking in analyses stratified by obese status. Consistent with findings shown in Table 3, American women appear to suffer higher risks from cigarette smoking compared to Finnish women regardless of obesity status. Similarly, the risks among both sets of women appear to be increasing over time regardless of obesity status. Findings for men also suggest that stratification by obese status does not result in a different pattern from that observed in Table 3.

The bottom portion of Table 3 shows results for obesity pertinent to the time of the survey. Among both women and men, the risks from obesity were highly similar in the two countries. For example, among women the risks in deaths per 1000 person-years were 5.02 in the United States and 4.36 in Finland (Model 1). Among men, the risks were 5.54 in the United States and 6.16 in Finland (deaths per 1000 person-years, Model 1). Among women, there was virtually no trend in the risk in either country. Among men, the trend in the risk for the United States was flat (β=0.06), but the trend for Finland is suggestive of a declining risk (β=-0.27) with a p-value of 0.06. Stratification by smoking status did not reveal a substantively different pattern (Table A2).

Note that for purposes of exposition we did not allow the risks from the behavioral factors to vary by age in Models 1 and 2. Therefore, the coefficients shown in Table 3 represent an average for adults over age 30. However, there is evidence that the risks from smoking and obesity vary by age (Mehta & Preston, 2012; Mehta, 2015). Alternative models that included linear terms for age and age-squared and interactions between age and the behavioral factors produced similar conclusions as those just described, both with respect to the cross-national comparisons of risks and trends in the risks (results not shown).

Models 3–6 of Table 4 show results for linear BMI at time of survey and during early adulthood. Each unit increase in BMI at time of survey is associated with an increase of between 0.70 and 1.33 deaths per 1000 person-years (Model 3). The coefficients were not significantly different across the two countries for either sex. The goal of Models 4–6 were to evaluate BMI pertaining to early adulthood and were restricted to the U.S. NHANES 3 and 1999–2004 and Finnish Health 2000 in which early adulthood BMI data was available. Both sexes were combined and the sample was restricted to ages 40–69 at time of survey. Model 4 included only BMI at time of survey to obtain results for this variable with the restricted analytic sample. Model 5 included only BMI pertaining to early adulthood. Each measure of BMI was significantly and positively associated with death risks in both countries. The risks appear higher in the United States than in Finland, but these comparisons were not statistically significant (p > 0.05). Model 6 included both BMI indicators. Each of the four coefficients was positive indicating that both BMI indicators contributes to death risk independent of the other. However, coefficients for Finland were not statistically significant.

**4. Discussion**

At least three key findings emerged from our study. First, the death risks from current cigarette smoking rose over the 1971–2013 period for both American and Finnish women. There was no parallel increase among men. Second, American women experienced higher risks from

**Table 4**  
Linear BMI pertaining to time at survey and during early adulthood. Coefficients from linear regression models predicting the risk of death in a single year (expressed as deaths per 1000 person-years).

Characteristic	All Data <sup>a</sup>		U.S. NHANES 3+1999–2002, Finnish Health 2000,		
	Model 3 (Women)	Model 3 (Men)	Model 4 (Both Sexes)	Model 5 (Both Sexes)	Model 6 (Both Sexes)
	<i>Linear BMI at survey</i>				
USA	0.70*** (0.44, 0.95)	1.15*** (0.69, 1.60)	1.04*** (0.65, 1.42)		0.78*** (0.34, 1.22)
Finland	0.95*** (0.53, 1.37)	1.33*** (0.56, 2.11)	0.65* (0.12, 1.18)		0.38 (-0.26, 1.02)
<i>Linear BMI during early adulthood</i>					
USA				1.30*** (0.67, 1.93)	0.85* (0.14, 1.55)
Finland				1.02** (0.29, 1.75)	0.78 (-0.10, 1.66)

Note: Models include controls for age (5-year wide categories), calendar year and year-squared, current and former smoking, and educational attainment (0–9 years, 9–12 years, and 13+ years). Model 3 included those 30–69 at time of survey and Models 4–6 included those 40–69 at time of survey. BMI during early adulthood (Models 4–6) was based on retrospective reports of body weight at age 25 (U.S. NHANES 3, 1999–2002) or age 30 (Finnish Health 2000). 95% confidence limits shown in parentheses.

\*\*\* p < .001.

\* p < .05.

\*\* p < .01.

<sup>a</sup> NHANES 1,2, 3, and 1999–2004, Mini-Finland, and the Finnish Health 2000.

smoking compared to Finnish women. Third, for both women and men the risks from obesity appear to be similar in the United States and Finland and no trend in the risk was detected in either country.

In a combined analysis of men and women aged 50–74, Mehta and Preston (2012) found an approximate 1% annual increase in the relative risks of death from current smoking in the U.S. National Health Interview Survey (period 1987–2006) and NHANES (period 1971–2006). Thun et al. (2013) showed that the relative risks of death from smoking among U.S. women aged 55–85 rose from 2.1 to 2.8 between 1982–1985 and 2000–2010 in the first and second Cancer Prevention Studies with no parallel increase among men. As men have historically experienced higher relative risks of death from smoking compared to women, Thun et al. (2013) find that the relative risks of death from smoking have, over time, converged for men and women. Our results confirm that such a convergence is reflected in a nationally representative white population and on an additive risk difference scale: in 1990 the estimated risks from current smoking were 9.9 (women) and 14.5 (men) deaths per 1000 person-years and by 2013 they were 13.8 (women) and 15.7 (men).

We find that a similar phenomenon is occurring in the Finnish population: the risks of death from smoking are rising among Finnish women, but not among Finnish men, leading to a male-female convergence of risks over time. As indicated, in both countries women picked up smoking later than men and the convergence of the risks from smoking may reflect a parallel convergence in male-female smoking patterns over time as the smoking epidemic “matures”

(Mehta & Preston, 2012; Thun et al., 2013). We also documented that American women suffer higher risks from smoking compared to Finnish women. It is unlikely that differences in smoking intensity at time of survey between the two populations of women is the main explanatory factor as Finnish women over this period appear to smoke more intensively than American women (Table A3). Potential explanations that could be investigated include differences in smoking duration and at age of initiation (the smoking epidemic among Finnish women may not have reached full maturity) and in medical care for smoking-related diseases. In addition, the finding that the risks associated with former smoking in Finland have been changing, increasing for women and declining for men, indicate changes in quitting patterns over time as the smoking epidemic evolves.

Despite intense scrutiny of the harms from smoking, we are not aware of a prior study that has investigated, using data at the individual level, whether the risks of death from smoking differ across countries. We believe that such comparisons are best assessed on an additive or risk difference scale as we have done. One meta-analysis of 26 studies incorporating populations in the United States, Europe, and Asia concluded that the relative risks of death from smoking did not appear to “vary significantly” by the study population (Shavelle et al., 2008). Our results suggest that at least for the United States and Finland there are significant differences in the risks.

Our comparative study also contributed additional evidence regarding the risks of death from obesity, a topic that has engendered much controversy in recent years. In the 1970s, obesity prevalence in the United States and Finland was similar. However, over time obesity increased at a much faster pace in the United States. Among the groups examined, Finnish women had the slowest increase in obesity prevalence, rising 7 percentage points (from 18% to 25%) between the late 1970s and 2000. Despite these epidemiological differences, our findings suggest a remarkable consistency in the two countries regarding the risks from obesity.

Much of the controversy in the obesity-mortality association has focused on the downwardly biasing effects of reverse causation: a bias caused by weight loss due to illness (Hu, 2008; Mehta & Chang, 2009). This selection bias may operate to a differing degree in the U.S. and Finland if the underlying populations have a different distribution of health states. Our study attempted to account for this bias by examining BMI pertaining to early adulthood, which is thought to be more robust to reverse causation compared to BMI at time of survey (Preston et al., 2013). Our findings suggest that both BMI at time of the survey and in early adulthood are positively associated with the risk of dying, whether assessed separately or jointly. This pattern was evident in both the United States and Finland. In addition, the indication that the coefficients for BMI pertaining to early adulthood are larger than the coefficients for BMI at time of survey (Model 6) in both populations suggests that inclusion of earlier life BMI is as important as current BMI to death risks. The main limitation of our approach is that our indicator of earlier life BMI was based on retrospective reports.

Similar to our study, the Prospective Studies Collaboration pooled individual-level data to investigate the association between BMI and mortality (Prospective Studies Collaboration, 2009). Data were drawn from national and convenience samples from 57 datasets from Western Europe and the United States. The study reported no statistically significant heterogeneity across the studies in the relative risks of ischemic heart disease death from high BMI. Unlike the PSC (2009) study, we accounted for confounding by educational level, quantified time trends in the risks, and included BMI in early adulthood in addition to BMI at time of survey.

We did not find evidence that the risks of death from obesity were changing in either country. Previously, Mehta and Chang (2011b) reported declines over two time periods (1971–1987 and 1988–2006) in the relative risks of death from obesity in the United States for individuals of all race/ethnicities at ages 50–74 at study entry in the

NHANES 1 and NHANES 3 (Mehta & Chang, 2011b). Our study was limited to whites and used a different entry age range of 30–69 and additional NHANES datasets (we included NHANES 2). Mehta and Chang (2011b) also observed declining relative risks over time in the U.S. National Health Interview Survey and the Framingham Heart Study. Declining relative risks, however, have not been documented universally and our study raises further uncertainty on this question. Calle, Teras, and Thun (2005) reported no decline in the relative risks of death from obesity among adult nonsmokers between 1982 and 1998 in the U.S. Cancer Prevention Study II. Yu (2012) also using NHANES, examined age, period, and cohort variations in the relative risks from obesity and found evidence that the relative risks increased in earlier compared to more recent cohorts. We are not aware of any existing studies on other high-income countries examining whether risks of death from obesity are changing. Given the diverging findings and lack of research in other countries, additional studies of this question are warranted.

The role of medical care in reducing the death risks from obesity is also understudied. At least in the United States, evidence suggests that over time the obese population may have disproportionately benefitted from improved control of cardio-metabolic risk factors as, for example, high cholesterol (Gregg et al., 2005). Other research indicates that healthcare providers may have become more aggressive in risk-factor control for obese patients compared to non-obese patients (Chang, 2010). Cross-national comparisons in cardio-metabolic risk factor control and quality of care among the obese may yield insights into whether some nations have been successful in reducing the death risks from obesity through medical interventions. Our findings suggest that at least between the United States and Finland, two countries with distinct healthcare delivery systems, the death risks from obesity are highly similar.

This study had limitations not already discussed. While our study encompassed cohorts born approximately between 1901 and 1974 in the United States and 1908 and 1971 in Finland, due to the irregularity of the timing of survey collection, we did not have complete coverage of all cohorts born during these periods. In addition, we had available only two entry cohorts from Finland (1978–1980 and 2000–2001) and three from the United States (1971–1980, 1988–1994, and 1999–2002). The prevalence of smoking among Finnish women in the late 1970s was low and the study may have low statistical power for this population during the early period of our study. There were also relatively few deaths after 2000 in both countries. As we relied on

cross-sectional data, changes in smoking status and body weight occurring after the survey were not observed and may influence the cross-national and inter-temporal comparisons. We controlled for educational attainment, which is associated with both smoking and obesity and with mortality, in all models. Nonetheless, the risks from smoking and obesity may also be influenced by other unobservable forms of social confounding. Our analysis did not model the time-varying relations among the risks (e.g., smoking status and BMI earlier in life determining BMI later in life), and relevant approaches using longitudinal data may better clarify such relationships (Banack & Kaufman, 2016; Cao, 2015).

We documented a slower rise in the prevalence of obesity among Finnish women compared with the other country and sex groups. Interestingly, this was the only group to experience increasing smoking prevalence over this period. Smoking and obesity often negatively correlate across individuals, a relationship that may be partly attributable to the appetite suppressing effects and increased metabolic demands associated with nicotine (Audrain-McGovern & Benowitz, 2011). Further research would be required to understand the role of changes in smoking behaviors in changes in obesity levels.

Our findings are relevant for studies evaluating the population attributable risk fractions (PAFs) associated with smoking and obesity. For example, many studies have provided estimates of PAF due to smoking in the United States and in many European countries. Most often, relative risks from the U.S. Cancer Prevention Study II are used to estimate PAF regardless of the country under investigation (Gallus et al., 2011; Martelin et al., 2004; Neubauer et al., 2006; Rodu & Cole, 2004). Our findings indicate that there may be relevant differences in the death risks from smoking across populations and periods and these should be accounted for where possible.

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**Appendix A**

See Tables A1–A3.

**Table A1**

Stratification by obese status. Coefficients from linear regression models predicting the risk of death in a single year (expressed as deaths per 1000 person-years); ages 30–69 at time of survey.

Sources: U.S. NHANES I, II, III and 1999–2004; Mini-Finland, and Finnish Health 2000

Characteristic	Model 1: No time trends		Model 2: Time trend	
	Non-obese	Obese	Non-obese	Obese
<b>Women</b>				
<i>Current smoking</i>				
USA	9.27 <sup>***†</sup> (7.45, 11.09)	14.18 <sup>***</sup> (9.83, 18.53)	9.16 <sup>***†</sup> (7.35, 10.98)	12.82 <sup>***</sup> (8.29, 17.35)
Finland	6.05 <sup>***</sup> (4.17, 7.94)	8.98 <sup>***</sup> (3.91, 14.06)	4.15 <sup>***</sup> (1.73, 6.56)	7.31 <sup>†</sup> (0.09, 14.53)

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Table A1 (continued)

Characteristic	Model 1: No time trends		Model 2: Time trend	
	Non-obese	Obese	Non-obese	Obese
Annual change USA			0.27** (0.09, 0.44)	0.34 (-0.04, 0.71)
Finland			0.21† (0.04, 0.37)	0.18 (-0.26, 0.63)
Former Smoking USA	2.67** (0.87, 4.48)	6.85*** (2.77, 10.92)	2.76** (0.90, 4.62)	6.55** (1.78, 11.31)
Finland	1.79 (-0.05, 3.63)	5.31† (0.39, 10.22)	1.06 (-1.49, 3.61)	-0.14 (-6.61, 6.33)
Annual change USA			0.03 (-0.14, 0.20)	0.08 (-0.31, 0.47)
Finland			0.09 (-0.08, 0.26)	0.48† (0.09, 0.86)
<b>Men</b>				
Current Smoking USA	13.68*** (11.43, 15.93)	19.49*** (13.46, 25.51)	13.76*** (11.44, 16.08)	19.13*** (12.51, 25.76)
Finland	14.53*** (12.31, 16.76)	19.22*** (12.50, 25.94)	14.90*** (12.11, 17.70)	22.56*** (12.44, 32.68)
Annual change USA			0.06 (-0.14, 0.27)	0.01 (-0.53, 0.54)
Finland			-0.04 (-0.25, 0.17)	-0.32 (-0.98, 0.34)
Former Smoking USA	2.31† (0.21, 4.42)	3.04 (-1.53, 7.61)	2.62† (0.42, 4.81)	1.85 (-3.50, 7.20)
Finland	1.48 (-0.54, 3.49)	4.62 (-1.45, 10.69)	3.36** (0.88, 5.84)	11.15* (1.58, 20.73)
Annual change USA			-0.17 (-0.36, 0.03)	0.18† (-0.24, 0.60)
Finland			-0.24† (-0.43, -0.05)	-0.62† (-1.24, -0.01)

Note: Note: Models include controls for age (5-year wide categories), calendar year and year-squared, and educational attainment (0–9 years, 9–12 years, and 13+ years). Year is centered at 1990 and the coefficients for behavioral factors in Model 2 pertain to 1990. 95% confidence limits shown in parentheses.

\*\*\* p < .001.

\*\* p < .01.

\* p < .05.

† Indicates that coefficients differ significantly (p < .05) between United States and Finland.

**Table A2**

Stratification by smoking status. Coefficients from linear regression models predicting the risk of death in a single year (expressed as deaths per 1000 person-years); ages 30–69 at time of survey.

Sources: U.S. NHANES I, II, III and 1999–2004; Mini-Finland, and Finnish Health 2000

Characteristic	Never smokers		Former smokers		Current smokers	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
<b>Women</b>						
<i>Obesity at survey</i>						
USA	4.01*** (1.96, 6.06)	4.21*** (2.01, 6.41)	6.97*** (2.99, 10.95)	6.75** (2.17, 11.34)	6.65** (2.53, 10.76)	6.37** (2.21, 10.53)
Finland	5.05*** (2.47, 7.64)	5.43*** (2.49, 8.37)	4.58* (0.05, 9.11)	2.11 (-4.13, 8.36)	2.72 (-1.94, 7.38)	4.50 (-2.45, 11.46)
<i>Annual change</i>						
USA		-0.06 (-0.24, 0.12)		0.04 (-0.34, 0.42)		0.09 (-0.28, 0.46)
Finland		-0.05 (-0.26, 0.16)		0.21 (-0.16, 0.57)		-0.17 (-0.60, 0.27)
<b>Men</b>						
<i>Obesity at survey</i>						
USA	3.74* (0.46, 7.03)	3.83 (-0.22, 7.87)	5.47** (1.70, 9.24)	4.04 (-0.08, 8.16)	9.15*** (3.79, 14.52)	9.53*** (3.94, 15.13)
Finland	4.13 (-0.19, 8.44)	4.78 (-1.72, 11.27)	7.90*** (3.21, 12.59)	12.21** (4.81, 19.61)	8.23** (2.69, 13.76)	11.16** (3.08, 19.25)
<i>Annual change</i>						
USA		-0.01 (-0.31, 0.28)		0.29 (-0.06, 0.64)		-0.13 (-0.62, 0.36)
Finland		-0.06 (-0.51, 0.39)		-0.43 (-0.89, 0.03)		-0.30 (-0.82, 0.22)

Note: Note: Models include controls for age (5-year wide categories), calendar year and year-squared, and educational attainment (0–9 years, 9–12 years, and 13+ years). Year is centered at 1990 and the coefficients for behavioral factors in Model 2 pertain to 1990. 95% confidence limits shown in parentheses.

\*\*\* p < .001.

\*\* p < .01.

\* p < .05.

**Table A3**

Smoking intensity among current smokers at time of survey by country and sex; ages 30–69.

Characteristic	United States			Finland	
	NHANES I+II 1971–1980	NHANES III 1988–1994	NHANES 1999–2004	Mini-Finland 1978–1980	Health 2000 2000–2001
<i>Women</i>					
Cigarettes per day, % < 10	39.9 (37.4,42.3)	33.4 (28.9,37.9)	45.1 (40.1,50.2)	38.6 (33.9,43.3)	27.9 (24.1,31.6)
10–19	49.6 (47.1,52.1)	52.9 (48.2,57.6)	48.8 (43.8,53.9)	38.4 (33.7,43.1)	47.7 (43.5,51.8)
20+	10.5 (9.0,12.1)	13.7 (10.4,16.9)	6 (3.6,8.4)	23 (19.0,27.1)	24.5 (20.9,28.0)

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Table A3 (continued)

Characteristic	United States			Finland	
	NHANES I+II 1971–1980	NHANES III 1988–1994	NHANES 1999–2004	Mini-Finland 1978–1980	Health 2000 2000–2001
<b>Men</b>					
Cigarettes per day, %					
< 10	20.0 (18.2,21.9)	26.4 (22.5,30.3)	30.5 (26.1,34.8)	12.8 (10.6,14.9)	14.5 (12.0,17.0)
10–19	56.4 (54.1,58.7)	48.8 (44.4,53.2)	54.7 (50.0,59.4)	37.2 (34.2,40.3)	29.9 (26.6,33.1)
20+	23.5 (21.6,25.5)	24.8 (21.0,28.6)	14.8 (11.4,18.1)	50 (46.8,53.2)	55.6 (52.1,59.1)

Note: 95% confidence intervals shown in parentheses. Estimates reflect sample weighting. 95% confidence limits shown in parentheses.

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