Explaining Low Mortality among U.S. Immigrants Relative to Native-Born Americans: The Role of Smoking

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ABSTRACT: In many developed countries, immigrants live longer – that is, have lower death rates at most or all ages – than native-born residents. This paper tests whether different levels of smoking-related mortality can explain part of the "healthy immigrant effect" in the United States, and part of the related "Hispanic paradox": the tendency for U.S. Hispanics to outlive non-Hispanic whites. Using data from vital statistics and the national census, the authors calculate U.S. lung-cancer death rates in 2000 for the foreign- and native-born populations, and for the Hispanic and non-Hispanic-white populations. The authors then use a simple, novel indirect estimation technique to extrapolate total smoking-related mortality for each group in that year: Total smoking-related deaths are equal to the number of lung-cancer deaths attributable to smoking, divided by the fraction of smoking-related deaths that are lung cancer, based on imported estimates of never-smoker lung cancer and national smoking-related mortality. The authors find that smoking can explain 58% of migrants' advantage in life expectancy at 50 among men, and 71% of migrants' advantage among women. Smoking explains 88% of the difference in life expectancy at 50 between U.S. Hispanic and non-Hispanic-white men, and 75% of this Hispanic advantage among women.

[Medical Subject Headings: epidemiologic methods, health status disparities, lung neoplasms, minority health, mortality, smoking, vital statistics]

INTRODUCTION:

In many developed countries, including Australia,[1] Canada,[2] Germany,[3] and the United States,[4] immigrants tend to outlive native-born residents, with lower death rates at most or all ages. Scholars have been puzzled by this "healthy immigrant" (or "healthy migrant") effect, as it runs counter to the otherwise persistent trend for richer and better-educated populations to live longer. In the U.S., for example, immigrants are not only worse educated, less wealthy and more likely to live in poverty,[5] but they often have poorer access to health care as well. For similar reasons scholars have been perplexed by the "Hispanic paradox": a tendency for U.S. Hispanics to live longer and healthier lives than non-Hispanic whites, despite lower socioeconomic status.

There have been several hypotheses to explain the healthy immigrant effect. Some scholars find evidence for migrant self-selection. They argue that people who are relatively healthy – either in observable characteristics, like the ability to perform manual labor, or in unobservable characteristics, like adaptability to new social situations – find it easier settle in new countries than other people who are not as healthy.[6] Others point to selection in return migration – a so-called "salmon-bias effect," where unhealthy migrants are more likely than healthy ones to go back to their places of origin.[7, 8] Finally, some researchers believe that lifestyle choices play an important role too, arguing in particular that immigrants may keep healthier diets in their host country than native-born residents. A recent study of adolescent behavior[9] shows that first-generation California minority immigrants, for example, eat more fruit and vegetables and drink

less soda than the state's non-Hispanic white adolescent population. Foreign-born adults in the U.S. also have lower rates of obesity than native-born Americans.[10]

[[FIGURE 1 ABOUT HERE]]

We believe smoking habits may contribute to immigrants' relatively good health, at least in the United States. Data from the U.S. Current Population Survey show that native-born Americans are much more likely to smoke than immigrants. In the late 1990s, 24.7% of native-born men and 22.6% of native-born women were smokers, compared to just 19% and 13.4% of foreign-born men and women.[11] Furthermore, the people who are dying of smoking-related disease today – almost always people in middle age or older – most likely took up smoking as teens or young adults in the 1950s through 1970s. This was a period of relatively heavy tobacco use in the U.S. NCHS figures put smoking prevalence in the mid-1960s at 51% among adult men, and 33% among adult women.[12] We suspect that this heavy smoking in the past may lead to higher smoking-related mortality today than we would observe in countries where smoking became common only later.

MATERIALS AND METHODS

We use a novel indirect method to estimate the contribution of cigarette smoking to adult mortality disparities observed between U.S. immigrants and native-born Americans, and between U.S. Hispanics and non-Hispanic whites. Following previous research on smoking-related mortality[13-16], we take the death rate from lung cancer as a marker of accumulated smoking damage within a population. We then extrapolate total smoking-related mortality from lung-cancer mortality.

We first calculate U.S. all-cause mortality for the year 2000, tabulating age-specific death rates by sex for four subpopulations: foreign-born, native-born, Hispanic, and non-Hispanic white (Figure 1). We take rate numerators (deaths) from the Multiple Cause-of-Death Public-Use Microdata files, available from NCHS. These data include decedents' race, ethnicity and place of birth, as recorded on each person's death certificate. From a total of 2,407,193 deaths in 2000, we drop 363 entries without a recorded age and 14,378 with missing place of birth. We follow the death certificate classification of "Hispanic" and "non-Hispanic white." We consider anyone born outside the 50 U.S. states and the District of Columbia to be "foreign-born," and anyone born inside to be "native-born" (even if the territory was not a state when the decedent was born, as in the case of Alaskans born before 1959, for example). We take our rate denominators (population counts) from the U.S. 2000 Census 5% Public Use Microdata Sample (PUMS) Files. These data, too, provide individual-level records on race, ethnicity, and place of birth.

Using these same two data sources, we then calculate age- and sex-specific death rates in 2000 for lung cancer only, using as our numerator the number of deaths indicated on death certificates as attributable to lung cancer (ICD10 codes C33-C34). Not all lung cancers are caused by smoking, and lung cancer is not the only deadly smoking-related condition. However, if we know both the proportion of lung cancers caused by smoking (*P*) and the proportion of smoking-related mortality that is lung-cancer mortality (*Q*), we can estimate total deaths attributable to smoking (D_s) as follows:

$$D_s = P \times D_L / Q$$

where D_L is the number of lung-cancer deaths. A great deal of epidemiological work has focused on these two proportions that we call here *P* and *Q*, and our computations borrow heavily from this earlier body of work.

P is simply as the attributable risk, the proportion of lung-cancer mortality that would not have occurred in the absence of smoking:

$$P = (M_L - M_L^*) / M_L$$

where M_L is the observed population lung-cancer death rate, and M_L^* is the lung-cancer death rate among members of that population who have never smoked. It can be difficult to get

precise M_L^* values by age and sex, since lung-cancer deaths are so rare among never-smokers. However, Michael Thun and colleagues[17] have recently produced exactly these estimates, pooling together rates from several different sources, including both of the U.S. Cancer Prevention Studies, the Nurses' Health Study and the Women's Health Study, as well as major non-U.S. trials and cohort studies. We use the pooled estimates among never-smoker whites (both in the U.S. and abroad) as our baseline risk for lung-cancer mortality that is not due to smoking, and then calculate *P* by age and sex for each subpopulation. Values of *P* range from a low of 0.45 among Hispanic women aged 50-54 to a high of 0.94 both among native-born men aged 65-75 and among non-Hispanic white men aged 65-75. (See Appendix A.) As expected, values of *P* are generally higher for men than for women; men smoke more, so a higher proportion of their lung cancers are caused by smoking.

We calculate *Q* from CDC tabulations of smoking-related mortality from 1997 to 2001.[18] During those years, the CDC estimates that lung cancer caused 32% of all smoking-related deaths among men and 29% of all smoking-related deaths among women, with the bulk of deaths instead due to other conditions, including heart disease, chronic obstructive pulmonary disease, and cancer of other organs. In our calculations, therefore, we take *Q* as .32 for men and .29 for women. These imported estimates are very similar to those obtained earlier by Peto et al.[13, 14] across developed countries.

RESULTS

In 2000 native-born Americans had significantly higher lung-cancer death rates than U.S. immigrants, and non-Hispanic whites had significantly higher rates than U.S. Hispanics (Figure 2). We estimate, as a result, that total smoking-related mortality was also higher among native-born Americans and non-Hispanic whites than among U.S. immigrants and Hispanics. Smoking explains a higher proportion of the mortality disparities among people in their 60s or 70s, the age range in which most smoking deaths occur, than it explains among U.S. residents who are older or younger (Figures 3 & 4; Appendix B).

[[FIGURES 2, 3, & 4 ABOUT HERE]]

We use Arriaga's method[19] to decompose the difference in life expectancy at age 50 into two components: a component due to smoking and a component due to other factors. We find that smoking accounts for 58% of migrants' advantage in life expectancy at 50 among men, and 71% among women. Similarly, smoking explains 88% of the difference in life expectancy at 50 between U.S. Hispanic and non-Hispanic-white men, and 75% of the difference between Hispanic and non-Hispanic-white women (Table 1).

[[TABLE 1 ABOUT HERE]]

DISCUSSION

We find that low mortality from cigarette smoking is the main reason for immigrants' and Hispanics' longevity advantage in the U.S. in 2000. While previous studies have documented lower smoking prevalence among U.S. immigrants compared to native-born Americans, and among Hispanics compared to non-Hispanic whites,[20] to our knowledge none of these earlier studies have calculated the contribution of cigarette smoking to observed mortality disparities.

Like other demographers and epidemiologists,[13-16] we are satisfied that lung-cancer deaths are the most reliable available marker of a population's – or subpopulation's[21] – smoking behavior. Our method to extrapolate total smoking-related deaths from lung-cancer deaths is very similar to the more commonly employed Peto-Lopez method,[13] and it is equally imprecise. Our technique is somewhat simpler, since it ignores age variation in the cause-of-death distribution. It also cannot be done without existing estimates of never-smoker lung-cancer mortality and the cause-of-death distribution for smoking-related deaths. Our main advantage, however, is the possibility for straightforward sensitivity checks. We can test very easily what happens when we relax assumptions about *P* and *Q* for a population, whereas the Peto-Lopez method assumes that never-smoker lung-cancer risks do not change from one population to the next (as they may, for example, with differences in genetic susceptibility or in exposure to other carcinogens), and that two different populations with the same lung-cancer death rate will have the same proportions of other smoking-related deaths attributable to smoking. In practice,

though, our best estimates of smoking-related mortality, above, are quite similar to those generated using Peto-Lopez. (See Appendix C.)

We consider there to be three main sources of uncertainty in our results. Each is considered below, with an assessment of how it might change the overall finding. To test the robustness of our results we then give alternative projections in which we relax some of the initial assumptions.

First, our method assumes that death certificates (and thus the NCHS Multiple Cause-of-Death data) contain complete and correct information on decedents' cause of death, place of birth, and race and ethnicity. This may not be true. Furthermore, Hispanic status is identified slightly differently in the Census (where it is given by self-report) than it is in death data (where reports are made by a third party). However, though race and ethnicity misclassification on death certificates may be more common among immigrants and Hispanics than among native-born non-Hispanics,[22] the magnitude of this bias does not appear to be great,[23] and we see no obvious reason that these classification errors should also vary systematically and greatly by cause of death. As a result, errors in place of birth and ethnicity recorded on death certificates may cause us to overestimate slightly both the healthy immigrant effect and the Hispanic paradox, but it should not bias our estimates of the *proportion* of these disparities that are caused by smoking – provided that we believe the direction of the disparities is correct. We are confident that it is. Cohort study results[24] and death data from the Social Security

Administration[22] are extremely unlikely to suffer the same misclassification errors, and both show a clear Hispanic and immigrant advantage.

Second, it is possible that our results suffer from what has been termed salmon bias, a tendency for sick migrants to leave the U.S. before they die. Recent research suggests that salmon bias can explain only a small fraction of migrants' and Hispanics' overall mortality advantage,[8] and, again, it is not clear that immigrants' decision to leave the country would vary greatly by cause of death, so that our estimated proportions of the disparities due to smoking may still be unbiased. Nevertheless, we can test for salmon bias by reviewing not just lung-cancer mortality, but also lung-cancer incidence. These data are not available by place of birth, but they do exist by ethnicity. National Cancer Institute figures show that, for both men and women, age-adjusted lung-cancer incidence is lower among Hispanics than among non-Hispanic whites (56% as high among men, and 45% as high among women).[25] This suggests that Hispanics do not merely die less often from smoking-related disease; they likely have less smoking-related disease in the first place.

Third, there is some uncertainty in the estimates of *P* and *Q*. Even using Thun's pooled data on never-smokers' lung-cancer mortality, there are some groups in our analysis – for example, women aged 50-54 – for whom never-smoker lung cancer is rare, so that it becomes hard to measure death rates with precision. This means that *P*, the proportion of lung cancer due to smoking, will also be hard to determine precisely for that group.

For simplicity, our method has assumed that in the absence of smoking all U.S. subpopulations would have the same lung-cancer death rates. We chose to approximate this rate with the never-smoker lung-cancer rates of developed-world whites, compiled by Thun et al., in part because of the very large number of U.S. immigrants who are white Hispanics, but also because whites have the lowest rates of any of race reviewed by Thun et al. Using these rates therefore generates the most conservative overall estimates of the proportion of the healthy immigrant effect and Hispanic paradox that are due to smoking. If we were to assume instead that immigrants had the baseline lung-cancer risk of either blacks or Asians in Thun et al.'s analysis, we would estimate that smoking explains a much larger proportion still of migrants' mortality advantage.

For our estimate of *Q*, the proportion of smoking-related deaths that are lung cancer deaths, we import numbers directly from the CDC. These figures are based on excess mortality among smokers and on some assumptions about co-morbidity between smoking-related disease and other illness. In practice, however, this is extremely difficult to do. Cohorts from past smoking studies were rarely representative of the national population, and it remains almost impossible to control fully for confounders that correlate smoking with diseases that are not actually caused by smoking.[26] Furthermore, there is no way to judge whether these *Q* values are likely to be constant across age or across populations in which smoking-related mortality has not been studied directly. For example, it is possible that the fraction of smoking-related mortality due to lung cancer in fact differs between native- and foreign-born populations – because, say, risk of smoking-related heart disease depend on different baseline risks for heart disease.

However, we feel that constant *Q* across subpopulations is not unreasonable as a first approximation. We are reassured by the fact that *Q* values for men and women are so similar, despite the sexes' very different age patterns of cardiovascular disease.

Because of possible errors in our assumptions, it is worth checking the sensitivity of results to variation in the input figures. We feel that, in practice, any statistical uncertainty in our smoking-related death rates – that is, uncertainty that comes from random sampling – will be trivial compared to what one might call the substantive uncertainty: uncertainty about whether basic assumptions hold when they cannot be tested given available data. We therefore ignore statistical uncertainty. Instead, we examine several different scenarios in which we relax the assumptions of our method: allowing different cause-of-death distributions (i.e. different values of *Q*) for different subpopulations, allowing immigrants and Hispanics to have different baseline never-smoker lung-cancer rates from non-Hispanic whites (yielding different values of *P*), and adjusting for possible salmon bias (by scaling death rates by any remaining difference in the ratio of mortality to incidence – a rough approximation of case-fatality, which is not available by ethnicity –observed between Hispanics and non-Hispanic whites). (See Appendix C.) Many of these scenarios are no doubt highly implausible. Nevertheless, our estimates of the contribution of smoking to mortality disparities do not change wildly. In short, though one may doubt the precision of figures we use to estimate smoking-related mortality, we remain quite confident in our conclusion: Smoking is a major cause of the U.S. healthy immigrant effect and of the related Hispanic paradox.

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Figure 1: Death rates (log scale), U.S. in 2000

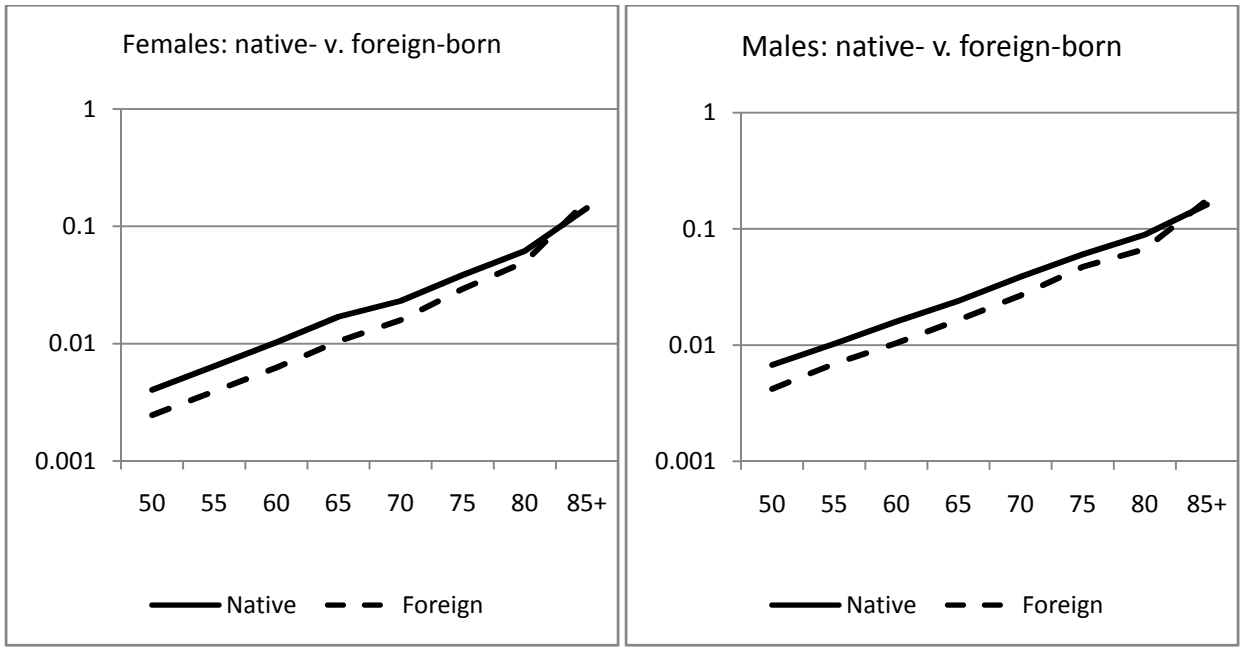


Figure 2: Lung-cancer death rates (log scale), U.S. in 2000

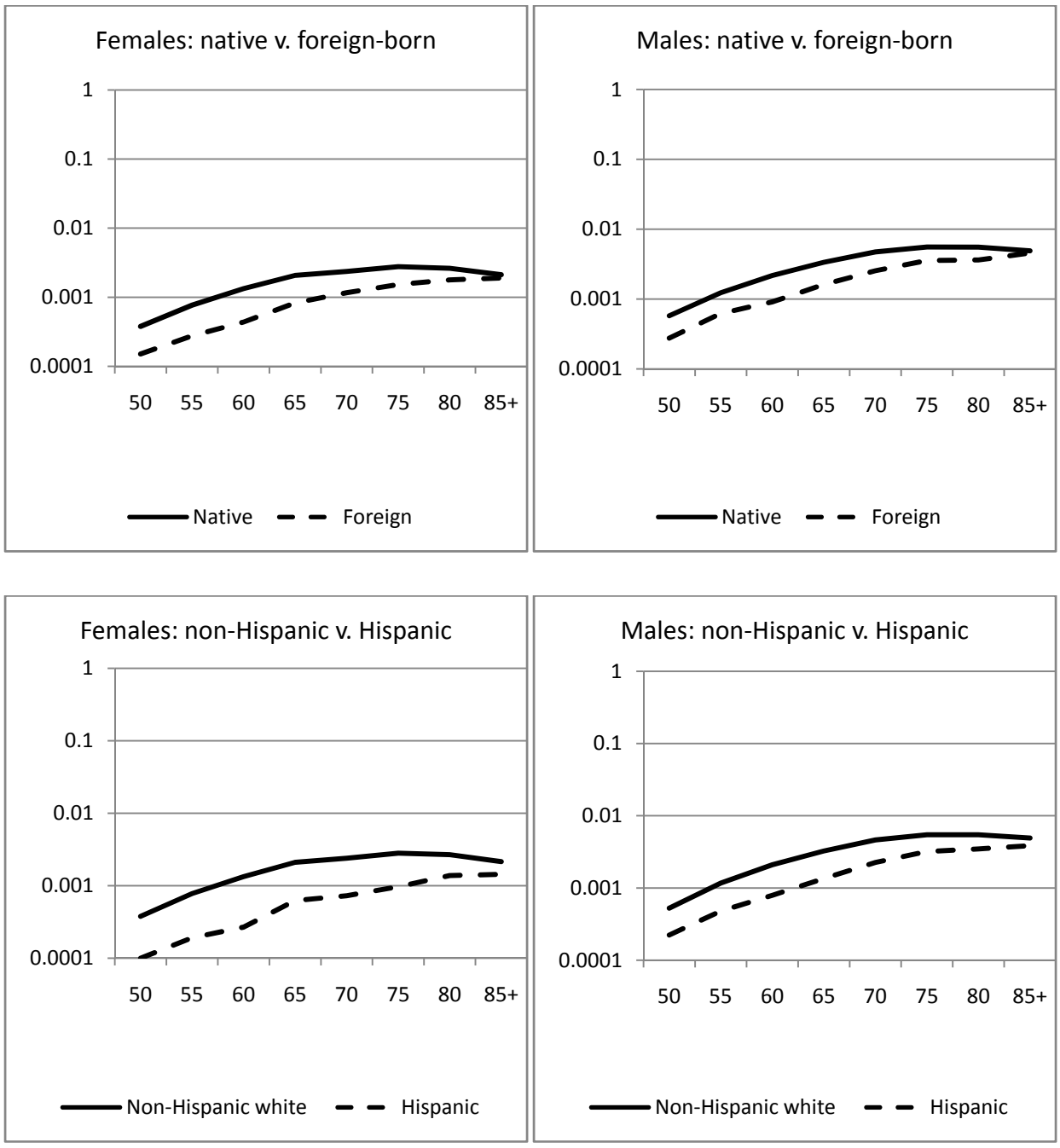
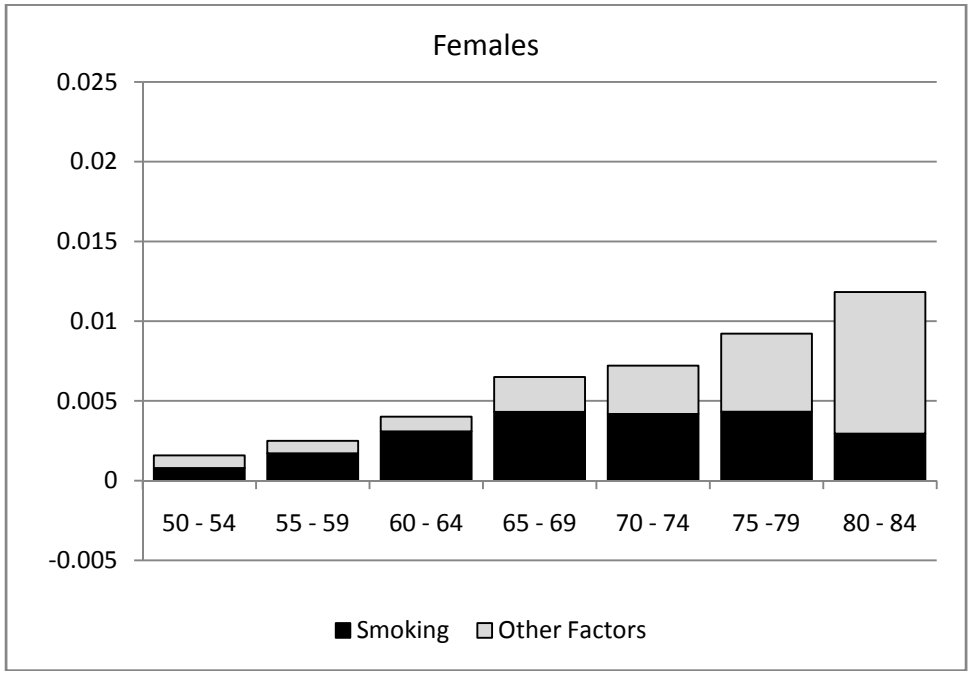


Figure 3: Difference in death rates (native-born minus foreign-born) attributable to smoking and attributable to other causes, U.S. in 2000



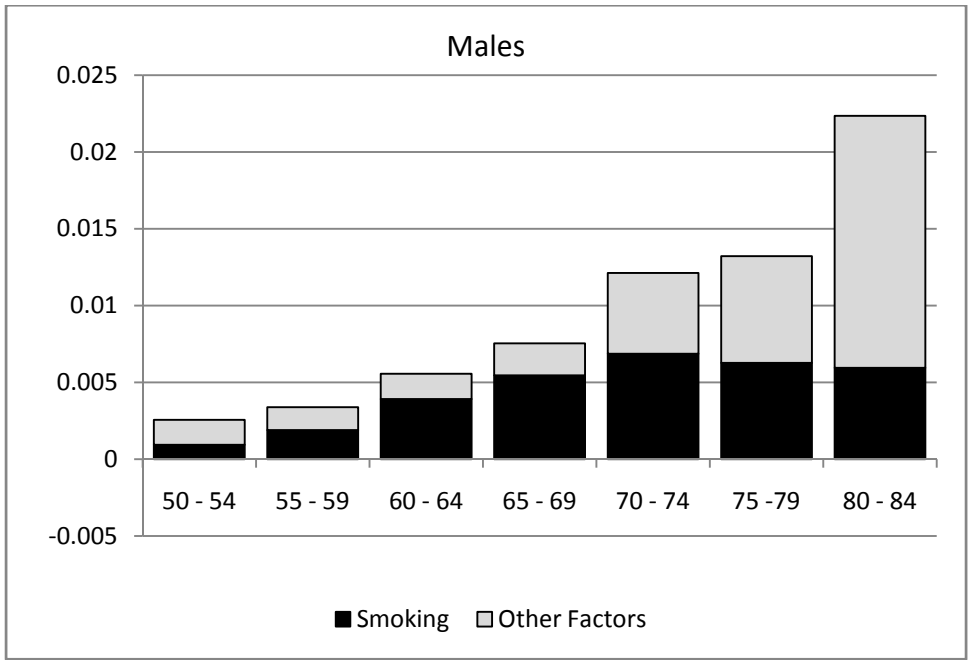
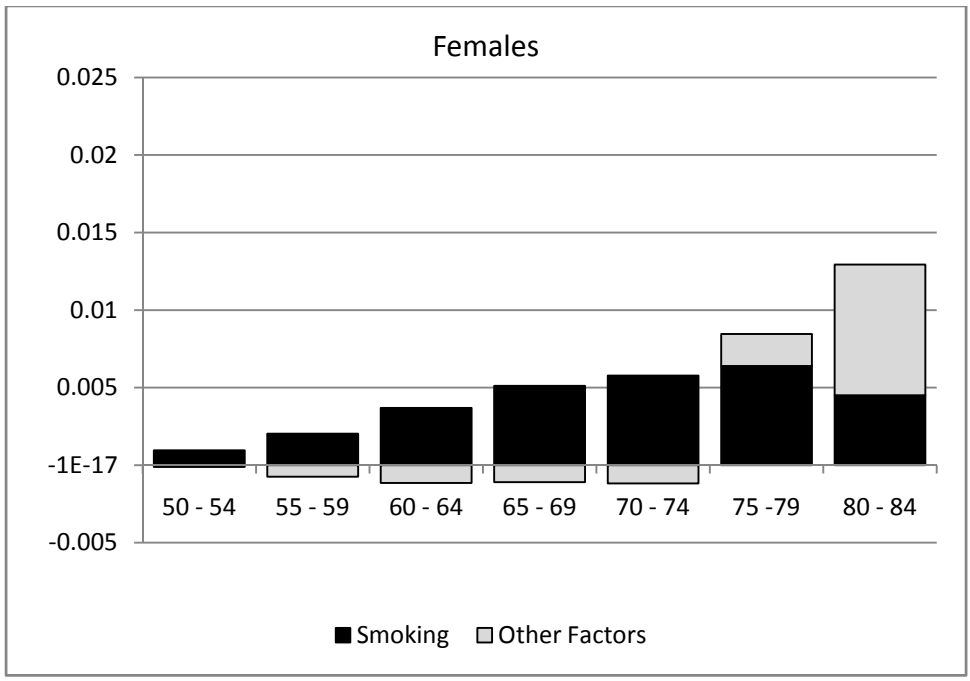


Figure 4: Difference in death rates (non-Hispanic white minus Hispanic) attributable to smoking and attributable to other causes, U.S. in 2000



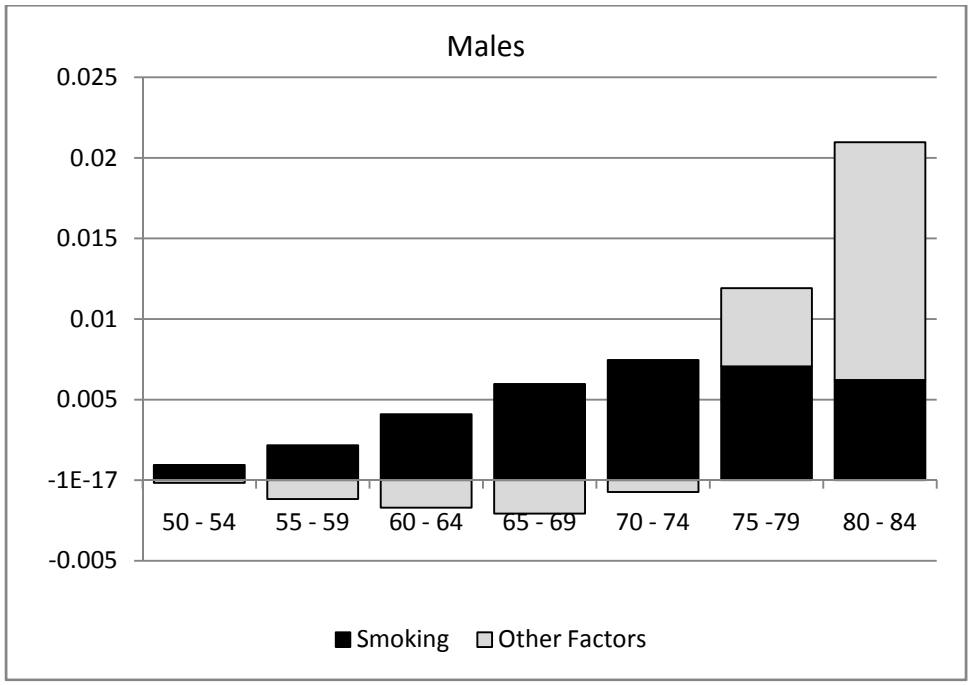


Table 1. Differences in Life Expectancy at Age 50 (e_{50}), U.S. in 2000: Total Difference and the Proportion Due to Smoking

Populations compared	Total difference in e_{50} (in years)	Difference in e_{50} that is attributable to smoking (in years)	Remaining difference in e_{50} in the absence of smoking (in years)	Difference in e_{50} that is attributable to smoking (proportion)
Native- v. foreign-born, female	2.09	1.48	0.60	71.01%
Native- v. foreign-born, male	2.74	1.60	1.14	58.27%
Non-Hispanic white v. Hispanic, female	2.82	2.13	0.70	75.33%
Non-Hispanic white v. Hispanic, male	2.11	1.86	0.25	88.17%

APPENDIX A: VALUES OF *P*, THE PROPORTION OF LUNG CANCER DUE TO SMOKING (U.S., 2000)

NATIVE-BORN POPULATION

	MALE			FEMALE		
AGE	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P
50-54	0.00058	0.000066	**0.885**	0.00038	0.000055	**0.855**
55-59	0.00123	0.00009	**0.927**	0.00077	0.00007	**0.909**
60-64	0.00217	0.000146	**0.933**	0.00133	0.000128	**0.904**
65-69	0.00336	0.000206	**0.939**	0.00208	0.000173	**0.917**
70-74	0.00474	0.000301	**0.936**	0.00237	0.000248	**0.895**
75-79	0.00557	0.000464	**0.917**	0.00278	0.000353	**0.873**
80-84	0.00554	0.000786	**0.858**	0.00263	0.000516	**0.804**
85+	0.00491	0.001258	**0.744**	0.00212	0.000694	**0.673**

FOREIGN-BORN POPULATION

	MALE			FEMALE		
AGE	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P
50-54	0.00028	0.000066	**0.760**	0.00015	0.000055	**0.635**
55-59	0.00062	0.00009	**0.855**	0.00028	0.00007	**0.746**
60-64	0.00091	0.000146	**0.840**	0.00044	0.000128	**0.707**
65-69	0.00161	0.000206	**0.872**	0.00083	0.000173	**0.790**
70-74	0.00254	0.000301	**0.881**	0.00116	0.000248	**0.786**
75-79	0.00356	0.000464	**0.870**	0.00152	0.000353	**0.768**
80-84	0.00363	0.000786	**0.784**	0.00178	0.000516	**0.710**
85+	0.00456	0.001258	**0.724**	0.00190	0.000694	**0.634**

NON-HISPANIC WHITES

	MALE			FEMALE		
AGE	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P
50-54	0.000527	0.000066	**0.875**	0.000378	0.000055	**0.854**
55-59	0.001172	0.00009	**0.923**	0.000779	0.00007	**0.910**
60-64	0.002101	0.000146	**0.931**	0.001338	0.000128	**0.904**
65-69	0.003264	0.000206	**0.937**	0.002108	0.000173	**0.918**
70-74	0.004642	0.000301	**0.935**	0.002403	0.000248	**0.897**
75-79	0.005463	0.000464	**0.915**	0.002821	0.000353	**0.875**
80-84	0.00547	0.000786	**0.856**	0.002692	0.000516	**0.808**
85+	0.004925	0.001258	**0.745**	0.002151	0.000694	**0.677**

HISPANICS

	MALE			FEMALE		
AGE	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P	OBSERVED LUNG-CANCER DEATH RATE*	EXPECTED NEVER-SMOKER LUNG-CANCER DEATH RATE**	P
50-54	0.000223	0.000066	**0.704**	0.0001	0.000055	**0.450**
55-59	0.000479	0.00009	**0.812**	0.000192	0.00007	**0.635**
60-64	0.000792	0.000146	**0.816**	0.000268	0.000128	**0.523**
65-69	0.001354	0.000206	**0.848**	0.000626	0.000173	**0.723**
70-74	0.002254	0.000301	**0.866**	0.000728	0.000248	**0.659**
75-79	0.003205	0.000464	**0.855**	0.000968	0.000353	**0.635**
80-84	0.003479	0.000786	**0.774**	0.001386	0.000516	**0.628**
85+	0.003858	0.001258	**0.674**	0.001438	0.000694	**0.517**

* Calculated from NCHS Multiple Cause-of-Death Public-Use Microdata Files and Census 5-Percent Public Use Microdata Sample Files

** From Thun, Michael J. et al. "Lung Cancer Occurrence in Never-Smokers: An Analysis of 13 Cohorts and 22 Cancer Registry Studies." *PLoS Medicine*, Vol. 5, No.9, 2008.

APPENDIX B: MORTALITY DISPARITIES AND THE PROPORTION EXPLAINED BY SMOKING (U.S., 2000)

FOREIGN-BORN V. NATIVE-BORN

	MALE			FEMALE		
AGE	DIFFERENCE IN OBSERVED DEATH RATE (NATIVE MINUS FOREIGN)	DIFFERENCE IN ESTIMATED SMOKING-RELATED DEATH RATE	PROPORTION OF TOTAL DEATH-RATE DIFFERENCE DUE TO SMOKING	DIFFERENCE IN DEATH RATE (NATIVE MINUS FOREIGN)	DIFFERENCE IN ESTIMATED SMOKING-RELATED DEATH RATE	PROPORTION OF TOTAL DEATH-RATE DIFFERENCE DUE TO SMOKING
50-54	0.00257	0.000937	**0.365**	0.00158	0.000785	**0.497**
55-59	0.00339	0.001898	**0.560**	0.00249	0.001707	**0.685**
60-64	0.00557	0.003922	**0.705**	0.00401	0.003085	**0.769**
65-69	0.00755	0.005464	**0.724**	0.00650	0.004314	**0.663**
70-74	0.01213	0.006871	**0.567**	0.00721	0.004178	**0.579**
75-79	0.01322	0.006276	**0.475**	0.00921	0.004321	**0.469**
80-84	0.02236	0.005957	**0.266**	0.01183	0.002951	**0.249**
85+	-0.01440	0.000937	--	-0.02150	0.000777	--

NON-HISPANIC WHITES V. HISPANICS

	MALE			FEMALE		
AGE	DIFFERENCE IN DEATH RATE (NHW MINUS HISPANIC)	DIFFERENCE IN ESTIMATED SMOKING-RELATED DEATH RATE	PROPORTION OF TOTAL DEATH-RATE DIFFERENCE DUE TO SMOKING	DIFFERENCE IN DEATH RATE (NHW MINUS HISPANIC)	DIFFERENCE IN ESTIMATED SMOKING-RELATED DEATH RATE	PROPORTION OF TOTAL DEATH-RATE DIFFERENCE DUE TO SMOKING
50-54	0.00078	0.000950	**1.216**	0.00085	0.000959	**1.134**
55-59	0.00100	0.002167	**2.171**	0.00128	0.002025	**1.588**
60-64	0.00238	0.004092	**1.717**	0.00254	0.003690	**1.453**
65-69	0.00389	0.005970	**1.534**	0.00401	0.005111	**1.274**
70-74	0.00673	0.007462	**1.109**	0.00459	0.005778	**1.258**
75-79	0.01191	0.007057	**0.592**	0.00846	0.006391	**0.755**
80-84	0.02097	0.006220	**0.297**	0.01294	0.004505	**0.348**
85+	0.02991	0.003334	**0.112**	0.03218	0.002460	**0.076**

APPENDIX C: SENSITIVITY OF RESULTS TO CHANGES IN THE VALUES OF *P* AND *Q*

PERCENTAGE OF THE DIFFERENCE IN LIFE EXPECTANCY AT 50 EXPLAINED BY SMOKING-RELATED MORTALITY

	FOREIGN-NATIVE		HISPANIC-NHW	
SCENARIO	FEMALES	MALES	FEMALES	MALES
Best estimate[1]	71.02%	58.27%	75.33%	88.17%
High estimate[2]	84.90%	79.02%	84.58%	116.56%
Low estimate[3]	61.75%	47.77%	70.75%	75.71%
Low estimate with strong salmon-bias correction[4]	45.01%	37.84%	62.46%	63.92%
Low estimate with ½ salmon-bias correction[5]	54.51%	43.15%	67.16%	70.22%
Peto-Lopez method[6]	77.51%	65.62%	74.66%	86.94%

[1] Values for *P* are calculated from never-smoker lung-cancer death rates among whites only, as tabulated by Thun et al. (2009); *Q* = 0.29 for females and *Q* = 0.32 for males

[2] Values for *P* for native-born Americans and for non-Hispanic whites are calculated from the never-smoker lung-cancer death rates among whites, as tabulated by Thun et al. (2009); values for immigrants and Hispanics are calculated from the never-smoker lung-cancer death rates among Asians; among native-born Americans and non-Hispanic whites *Q* = 0.29 for females and *Q* = 0.32 for males; among immigrants and Hispanics *Q* = 0.34 for females and *Q* = 0.37 for males

[3] Values for *P* are calculated from never-smoker lung-cancer death rates among whites, tabulated by Thun et al. (2009); among native-born Americans and non-Hispanic whites *Q* = 0.29 for females and *Q* = 0.32 for males; among immigrants and Hispanics *Q* = 0.24 for females and *Q* = 0.27 for males

[4] Values of *P* and *Q* are the same as those from "Low estimate," but lung-cancer death rates among immigrants and Hispanics are inflated by the full difference in mortality-to-incidence ratio observed between Hispanics and non-Hispanic whites (SEER, 2009). For foreign-born and Hispanic women, lung-cancer death rates are multiplied by 0.7646/0.583 = 1.3115; for men, by 0.9008/0.7847 = 1.1480. This assumes all differences in mortality-to-incidence ratio are due to salmon bias, and not to case severity differences

[5] Values of *P* and *Q* are those from "Low estimate," but lung-cancer death rates among immigrants and Hispanics are inflated by one half of the difference in mortality-to-incidence ratio observed between Hispanics and non-Hispanic whites (SEER, 2009). For foreign-born and Hispanic women, lung-cancer death rates are multiplied by 0.5*(0.7646/0.583 - 1) + 1 = 1.1557; for men, by 0.5*(0.9008/0.7847 - 1) +1 = 1.1074

[6] Calculated using method from Peto, Lopez et al. (1992, 1994)