

Health Risks of Smoking Compared to Swedish Snus

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Interest in tobacco harm reduction strategies has raised the question of the comparative health risks of cigarette smoking and use of other tobacco products. Although there appears to be a general belief that a unique smokeless tobacco product called Swedish snus has fewer health risks than cigarettes, no one has systematically reviewed the literature and compared the data on health risks in a quantitative manner. We reviewed the literature to identify all analytic epidemiologic studies that provided quantitative risk estimates associated with Swedish snus and cigarette smoking in a single population, using a common reference group. Seven studies were identified that addressed eight health outcomes. Although few in number, these seven studies do provide quantitative evidence that, for certain health outcomes, the health risks associated with snus are lower than those associated with smoking. Specifically, this is true for lung cancer (based on one study), for oral cancer (based on one study), for gastric cancer (based on one study), for cardiovascular disease (based on three of four studies), and for all-cause mortality (based on one study). This review has likely omitted many of the adverse effects of cigarettes, but probably few of the potential health effects of snus. Continued investigation of the reduced health risks of Swedish snus compared to cigarette smoking is warranted.

The public health community has recently been engaged in a debate about the merits of tobacco harm reduction strategies. In essence, these strategies consider the use of pharmaceutical or alternate tobacco products by cigarette smokers who are unwilling or unable to quit nicotine completely (Hatsukami et al., 2004). Of particular interest to the harm reduction community is a unique smokeless tobacco product called Swedish snuff, or snus. Snus is an air-cured, nonfermented, moist tobacco product that is marketed in Sweden either as loose snuff or in portion-bag packets (Andersson et al., 1995). The product is typically placed behind the upper lip and held in the mouth for about 30 min before being discarded (Foulds et al., 2003). Snus delivers levels of nicotine that are comparable to those absorbed from smoking cigarettes; however, snus has much lower levels of tobacco-specific nitrosamines (TSNAs) and polynuclear aromatic hydrocarbons than products sold in the United States, Africa, or India (Hatsukami et al., 2004). Furthermore, the level of TSNAs in moist Swedish snuff has declined greatly over the past 20 years (Österdahl et al., 2004).

Snus is very popular in Sweden, especially among Swedish men. In 2002, 15% of adult Swedish men smoked and 23% of

adult Swedish men used snus (Foulds et al., 2003). Snus use is less common among women: In 2002, 20% of adult Swedish women smoked and 4% of adult Swedish women used snus. During the past 25 yrs, snus use increased significantly among men (from 10% in 1976 to 23% in 2002) while smoking declined significantly (from about 40% to about 15%) (Foulds et al., 2003). Numerous authors have suggested that the low prevalence of smoking among Swedish men is directly related to the availability of snus (e.g., Foulds et al., 2003; Henningfield & Fagerström, 2001; Rodu et al., 2003). The transition of the Swedish population from smoking to snus use has been associated with a clear reduction in the incidence of major smoking-related diseases (Foulds et al., 2003).

A number of reviews of the health effects of snus have concluded that, at most, snus may be associated with a slight increase in cardiovascular risk and may pose some risks to unborn fetuses (Foulds et al., 2003). In contrast, the health effects associated with cigarettes are numerous and serious, and include cancer at many sites in the body, cardiovascular diseases, respiratory diseases, and reproductive effects (U.S. DHHS, 2004). Despite the widespread belief that snus is associated with fewer health risks than cigarettes, no one has systematically reviewed the literature and compared the data on health risks in a quantitative manner.

The goal of this paper is to help fill this gap, to the degree allowed by the available data, by comparing the health risks of snus directly to those of smoking cigarettes. The health endpoints of interest include head and neck cancers, cardiovascular disease, lung cancer, gastrointestinal cancer, and total mortality.

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METHODS

We sought to identify all analytic epidemiology studies that provided quantitative risk estimates associated with Swedish snus and cigarette smoking *within a single population*, so that direct comparisons could be made of the health risks related to the two exposures. Thus, within a single study, important design and methodologic elements are comparable and the effect of confounding factors is minimized.

Relevant studies were identified through a Dialog search of 32 scientific databases relevant to health topics, medicine, chemistry, toxicology, food, and agriculture. The search string included variations of the terms snus, Swedish snuff, and oral snuff. Full records were retrieved of all relevant articles and then reviewed for content. Once actual articles were obtained, their reference lists were "tree-searched" to identify other relevant studies that might have been missed in the online search.

The papers were reviewed in detail to understand the important issues in this literature that affect how quantitative comparisons could be made. The following factors were identified as ones that would affect the comparisons that could be made and the conclusions that could be drawn: specific health endpoint; outcome (morbidity vs. mortality); study design (case-control vs. cohort); type of reference group; and categories of exposure (exclusive use vs. mixed use). Studies must be similar in these important aspects if they are to be combined quantitatively, as in meta-analysis.

Data on risk estimates were then extracted from each paper. Some of the studies reported both univariate as well as multivariate findings (usually based on the multiple logistic model) in which the risk estimates were adjusted for factors such as age, gender, alcohol usage, occupation, and diet. We selected the multivariate results whenever available. Efforts were made to compare *exclusive* snus use to *exclusive* smoking, if the data permitted. Although dual use of these two products is not common in Sweden, we wanted to avoid comparing risk estimates that might have been contaminated by former smoking or former snus use.

Our initial efforts were devoted to determining whether risk estimates could be aggregated *across* studies (i.e., through meta-analysis). After careful review of the studies that met the inclusion criteria, we concluded that this was not possible, due to differences in the important factors already noted (e.g., health endpoints, study designs, target populations, etc.). For a few health endpoints, there were two comparable studies, but the published papers did not contain necessary information, such as adjustment for confounders.

In comparing the health risks of snus and cigarettes, it was necessary to consider the type of reference group used. In some cases, it was not possible to compare the risks of snus to the risks of cigarette smoking because the risk estimates for the two exposures were based on different reference groups. For example, in some studies, snus users were compared to nonusers of snus (who may or may not have been smokers), whereas cigarette smokers were compared to nonsmokers (who may or

may not have used snus). Because the baseline level of risk in these two reference groups is likely to be different, it would not be meaningful to compare the risk associated with the two exposures directly.

In total, 11 studies were identified that contained quantitative estimates for health risks related to both snus and cigarette smoking in a single population.

Four of these studies (addressing four health endpoints) appear to have separate reference groups. These studies are: Hansson et al. (1994) (gastric cancer); Huhtasaari et al. (1999) (myocardial infarction); Lagergren et al. (2000) (esophageal cancer); and Lewin et al. (1998) (head and neck cancer). In each of these four studies, the authors reported that smoking was associated with statistically significant increases in risk of the disease studied, while use of snus was not. However, it is not meaningful to make direct statistical comparisons between the two exposures when different reference groups are used. The remainder of this article focuses on the seven studies (addressing eight health endpoints) that appear to have common reference groups.

Important features of the seven studies with common reference groups are abstracted in Table 1. These summaries include basic information on the characteristics of the study subjects, the study design, the sample size, data necessary to make quantitative risk comparisons, and our analyses of the study conclusions. In the majority of these studies, risk associated with Swedish snus was significantly lower than that associated with cigarette smoking. Details are provided below by health outcome.

All calculations were performed using SAS statistical programs, Computer Programs for Epidemiologists (PEPI version 3.00), and our own proprietary software. To test the homogeneity of odds ratios we relied on Cochran's method (Fleiss, 1973).

RESULTS

Cardiovascular Disease

Four studies used a common reference group to derive quantitative estimates of the risk of various cardiovascular diseases associated with snus and cigarette smoking in the same population. Three of the four studies indicate that smoking poses greater risks of cardiovascular disease than snus among Swedish men.

Asplund et al. (2003) examined fatal and nonfatal stroke in a case-control study of 25- to 74-yr-old Swedish men. Univariate analyses showed that exclusive use of snus was not associated with any excess risk of stroke (OR = 1.05; 95% CI: 0.37–2.04), whereas exclusive cigarette smoking was associated with significantly elevated risk (OR = 2.21; 95% CI: 1.29–3.79). Direct comparisons of these risk estimates showed that the risk of cardiovascular disease associated with regular smoking was not significantly greater than that associated with regular use of snus. Conditional logistic regression showed that neither exposure was associated with significantly elevated risk of stroke (OR for snus = 0.87; 95% CI: 0.41–1.83) or cigarettes (OR for cigarettes = 1.74, 95% CI: 0.85–3.54), but the point estimate was twice as high for cigarettes as for snus. The authors

TABLE 1
Quantitative comparison of health risks of snus and smoking cigarettes

Citation	Outcome study type	Subjects	Exposure	Measure of effect	Conclusions
Asplund et al. (2003)	First-ever fatal or nonfatal stroke Nested case-control study (population-based)	Subjects were derived from the Northern Sweden MONICA Project and the Vasterbotten Intervention Project. Cases were 276 male patients with a first-ever confirmed stroke (fatal or nonfatal), occurring in 1985–2000. Two controls (with no history of cardiovascular disease) were matched to each case, by sex, age, geographical region, year of baseline examination, and cohort.	Cardiovascular disease ($n = 4$) Tobacco use Never users of tobacco Exclusive snus users Exclusive cigarette smokers Conditional logistic regression Regular use of snus Regular smokers	Univariate odds ratios (95% CI) 1.00 (reference) 1.05 (0.37–2.04) NS 2.21 (1.29–3.79) NS Odds ratios from logistic regression model (95% CI) 0.87 (0.41–1.83) 1.74 (0.85–3.54) Odds ratios from the logistic regression were adjusted for elevated blood pressure, diabetes, serum cholesterol levels, education, and marital status.	Snuff was not associated with any excess risk of stroke, but based on a univariate analysis cigarette smoking was associated with an increased risk of stroke. Based on a conditional logistic regression of the data neither snus use nor cigarette smoking was associated with elevated risks of stroke. Additionally, there was no statistically significant difference between the risks associated with cigarette smoking and snus. Both snus users and smokers faced a higher risk of dying from cardiovascular disease than nonusers of tobacco. However, the risk was significantly higher among smokers than among snus ($p = .007$ for <15 cigarettes/day, $p = .002$ for >15 cigarettes/day).
Bolinder et al. (1994)	Death due to all cardiovascular disease Cohort study	The cohort consisted of 84,781 male Swedish construction workers who received medical checkups from the Swedish Construction Industry's Organization for Working Environment Safety and Health from 1971 to 1974. Subjects were followed for cause-specific mortality from 1974 to 1985.	Tobacco use Nonusers Snus users Smokers, <15 cigarettes/day Smokers, ≥ 15 cigarettes/day	Relative risks (95% CI) 1.0 (reference) 1.4 (1.2–1.6) $p = .007$, .002 1.8 (1.6–2.0) $p = .007$ 1.9 (1.7–2.2) $p = .002$ These relative risks were adjusted for age and region of origin.	Both snus users and smokers faced a higher risk of dying from cardiovascular disease than nonusers of tobacco. However, the risk was significantly higher among smokers than among snus ($p = .007$ for <15 cigarettes/day, $p = .002$ for >15 cigarettes/day).
Hergens et al. (2005)	Myocardial infarction (MI) Case-control study (hospital-based cases, population-based controls)	Cases were 1432 men, age 45–70, from 2 counties in Sweden, who had an MI in 1992–1994. Controls were 1810 men who were randomly selected from the study base after stratification for age and hospital catchment area.	All cases of MI Never smoking, never snuff Current snuff, never smoking Current smoking, never snuff Nonfatal cases of MI Never smoking, never snuff Current snuff, never smoking Current smoking, never snuff Fatal cases of MI Never smoking, never snuff Current snuff, never smoking Current smoking, never snuff	Odds ratios (95% CI) 1.00 (reference) 0.73 (0.35–1.50) $p = .000$ 2.8 (2.3–3.4) $p = .000$ 1.00 (reference) 0.59 (0.25–1.4) $p = .001$ 2.7 (2.2–3.3) $p = .001$ 1.00 (reference) 1.7 (0.48–5.5) $p = \text{NS}$ 3.6 (2.4–5.2) $p = \text{NS}$ Odds ratios were adjusted for age, hospital catchment area, and smoking.	Compared to nonusers of tobacco, cigarette smokers had statistically elevated risks of myocardial infarctions, but snus users had no such elevated risks. When compared directly to snus users, cigarette smokers had statistically significantly higher risk of all cases of myocardial infarction ($p = .000$), and of nonfatal cases of myocardial infarction ($p = .001$), but not of fatal cases of myocardial infarction ($p = \text{NS}$).

(Continued on next page)

TABLE 1
Quantitative comparison of health risks of snus and smoking cigarettes (*Continued*)

Citation	Outcome study type	Subjects	Exposure	Measure of effect	Conclusions
Huhtasaari et al. (1992)	Myocardial infarction (MI) Case-control study (population-based)	Cases were 585 men aged 35–64 yr in the Northern Sweden MONICA Study with a first acute MI occurring between April 1989 and April 1991. Controls included 589 men without MI selected from a population survey of cardiovascular risk factors, who were matched by age and location to cases.	Tobacco use No tobacco Snuff dippers (all subjects) Smokers (all subjects) Cigarette smoking vs. snuff dipping 35–54 yr old 55–64 yr old All subjects	Odds ratios (95% CI) 1.00 (reference) 0.89 (0.62–1.29) $p = .002$ 1.87 (1.40–20.48) $p = .002$ OR > 1.00 indicates smoking is more harmful than snuff 3.22 (1.82–5.70) 1.09 (0.55–2.16) 2.09 (1.39–3.15) Odds ratios were adjusted for age only.	Compared to nonusers of tobacco, cigarette smokers had statistically elevated risks of myocardial infarctions, but snus users had no such elevated risks. Cigarette smokers also had statistically significantly higher risk of myocardial infarction than snus users ($p = .002$).
Schildt et al. (1998)	Oral cancer Case-control study (population-based)	Cases were 354 patients (117 females, 237 males) with histopathologically verified squamous cell oral cancer diagnosed in the 4 most northern counties in Sweden from 1980–1989 and reported to the Cancer Registry. Controls were 354 subjects (117 females, 237 males) drawn from the National Population Registry matched for age, sex, county of residence, and vital status.	Oral cancer ($n = 1$) Tobacco use Never snuff user/never smoker Active snuff user/never smoker Never snuff user/active smoker	Odds ratios (95% CI) 1.0 (reference) 0.7 (0.4–1.2) $p = .006$ 1.7 (1.1–2.6) $p = .006$ Odds ratios were not adjusted, other than for the matching characteristics of gender, age, and county.	Univariate analyses showed that there was no increased risk of oral cancer among active snus users. However, there was an increased risk of oral cancer among active smokers. Active smokers had a higher risk of oral cancer than snus users ($p = .006$).
Persson et al. (1993)	Inflammatory bowel disease Case-control study (hospital-based cases, population-based controls)	Subjects were male residents of Stockholm County (aged 15–79) between 1980 and 1984. There were 145 cases with confirmed diagnoses of Crohn's disease ($n = 63$) or ulcerative colitis ($n = 82$), selected from a central register of all hospital admissions in that county. Controls were 147 subjects obtained by random sample of a register of the inhabitants of Stockholm county. Controls were stratified by age and gender.	Gastrointestinal diseases ($n = 2$) Tobacco Use Crohn's disease Never-smoker, never-snus user Never-smoker, ever-snus user Current smoker, never-snus user Ulcerative colitis Never-smoker, never-snus user Never-smoker, ever-snus user Current smoker, never-snus user	Relative Risks (95% CI) 1.0 (reference) 0.9 (0.3–3.1) NS 1.1 (0.5–2.3) NS 1.0 (reference) 1.1 (0.4–3.1) NS 0.7 (0.3–1.5) NS Relative risks were adjusted for age.	Use of moist oral snuff alone or cigarettes alone was not associated with any increased risk of either Crohn's disease or ulcerative colitis. There was no significant difference in risk of either Crohn's disease or ulcerative colitis between snus users who had never smoked and current smokers who had never used snus.

Ye et al. (1999)	Gastric and cardia cancer Case-control study (population-based)	Subjects were males and females aged 40–79, born in Sweden, and living in one of 5 counties in northern and central Sweden from 1989 to 1995. There were 561 cases with new histologically confirmed cancer of the gastric cardia or stomach. Controls were 1,164 subjects randomly selected from population registries and frequency-matched to cases by age and gender.	Tobacco use Never smoker/never snus user Never smoker/ever snus user Current smoker/never snus user	Odds ratios (95% CI) 1.0 (reference) 0.5 (0.2–1.2) $p = .003$ 2.0 (1.3–2.0) $p = .003$ Odds ratios were adjusted for age, residence area, BMI, socioeconomic status, and use of beer, wine, and hard liquor.	Snus use was not associated with increased risk of gastric or cardia cancer. A statistically significant excess risk was noted for current smokers who had never used snus. The risk of gastric and cardia cancer was significantly higher among smokers who had never used snus than among snus users who had never smoked.
Bolinder et al. (1994)	Lung cancer mortality Cohort study	The cohort consisted of 135,036 male Swedish construction workers who received medical checkups from the Swedish Construction Industry's Organization for Working Environment Safety and Health from 1971 to 1974. Subjects were followed for cause-specific mortality from 1974 to 1985.	Lung cancer ($n = 1$) Tobacco use Men age 35–54 Nonusers Snus users Smokers, <15 cigarettes/day Smokers, ≥15 cigarettes/day Men age 55–65 Nonusers Snus users Smokers, <15 cigarettes/day Smokers, ≥15 cigarettes/day	Relative risks (95% CI) 1.0 (reference) 1.2 (0.2–9.1) NS, $p = .008$ 8.1 (3.2–20.4) NS 21.4 (8.5–54.1) $p = .008$ 1.0 (reference) 0.8 (0.1–3.9) NS, $p = .001$ 11.9 (5.5–25.6) NS 30.6 (14.6–64.1) $p = .001$ These relative risks were adjusted for age and region of origin. Adjustment for other factors (BMI, blood pressure, diabetes, history of heart symptoms, blood pressure medication) did not affect these relative risks.	For both age groups, risk of death due to lung cancer was significantly elevated among smokers (even those who smoked fewer than 15 cigarettes/day), but not among snus users. Men who smoked ≥15 cigarettes/day also had significantly higher risk of lung cancer than snus users ($p = .008$ for ages 35–54, $p = .001$ for ages 55–65). However, there was no significant difference in risk of lung cancer death among men of either age who smoked <15 cigarettes/day and men who used snus.
Bolinder et al. (1994)	All-cause mortality Cohort study	The cohort consisted of 84,781 male Swedish construction workers who received medical checkups from the Swedish Construction Industry's Organization for Working Environment Safety and Health from 1971 to 1974. Subjects were followed for cause-specific mortality from 1974 to 1985.	All-cause mortality ($n = 1$) Tobacco use Nonusers Snus users Smokers, <15 cigarettes/day Smokers, ≥15 cigarettes/day	Relative risks (95% CI) 1.0 (reference) 1.4 (1.3–1.8) $p = .039$, .001 1.7 (1.6–1.9) $p = .039$ 2.2 (2.0–2.4) $p = .001$ These relative risks were adjusted for age and region of origin.	Risk estimates associated with both smokeless tobacco and cigarette smoking were significantly elevated; however, the risk was greater among smokers and a dose-dependent relationship was seen. Men who smoked cigarettes had significantly greater risk of all-cause mortality than snus users ($p = .039$ for <15 cigarettes/day; $p < .001$ for ≥15 cigarettes/day).

Note. NS, not significant; BMI, body mass index.

concluded that, from a cardiovascular perspective, the deleterious effects of snus use are considerably less than those of cigarette smoking.

Bolinder et al. (1994) examined death due to all cardiovascular diseases among a cohort of 84,871 Swedish male construction workers. Both snus use and cigarette smoking were associated with statistically significant elevations in risk of dying from cardiovascular diseases. However, when the risk estimates for the two exposures were compared directly, the risk was significantly higher among smokers than among snus users ($p = .007$ for <15 cigarettes/day; $p = .002$ for ≥ 15 cigarettes/day).

Hergens et al. (2005) evaluated risk of myocardial infarction (all cases, nonfatal cases, and fatal cases) in a case-control study of 45- to 70-yr-old men living in 2 counties in Sweden. Compared to nonusers of tobacco, current smokers who had never used snus had statistically elevated risk of each of the three types of myocardial infarction, but current snus users who had never smoked had no such elevated risk. When the risk of cigarette smoking was compared directly to that of snus use, cigarette smokers had significantly higher risk of all cases of myocardial infarction ($p = .000$), and of nonfatal cases of myocardial infarction ($p = .001$), but not of fatal cases of myocardial infarction ($p = \text{NS}$).

Finally, Huhtasaari et al. (1992) evaluated risk of myocardial infarction in a case-control study of 35- to 64-yr-old men who participated in the Northern Sweden MONICA study. Compared to nonusers of tobacco, cigarette smokers had statistically elevated risk of myocardial infarction, but snus users had no such elevated risk. When the risk estimates were compared directly, cigarette smokers also had significantly higher risk of myocardial infarction than snus users ($p = .002$). Smoking was more harmful than snus in subjects of all ages (OR = 2.09; 95% CI: 1.39–3.15), as well as those 35 to 54 yr old (OR = 3.22; 95% CI: 1.82–5.70), but not those 55 to 64 yr old (OR = 1.09; 95% CI: 0.55–2.16).

Oral Cancer

Only one study used a common reference group to derive quantitative estimates of the risk of oral cancer associated with snus and cigarette smoking in the same population. This study, by Schildt et al. (1998), was a case-control study that included all cases of oral cancer diagnosed in the four northernmost counties in Sweden. An analysis with a common reference group showed that there was no increased risk of oral cancer among active snus users (OR = 0.7; 95% CI: 0.4–1.2). However, there was an increased risk of oral cancer among active smokers (OR = 1.7; 95% CI: 1.1–2.6). When these risk estimates were compared directly, active smokers had a higher risk of oral cancer than snus users ($p = .006$).

Gastrointestinal Diseases

Two studies used a common reference group to derive quantitative estimates of the risk of various gastrointestinal diseases associated with snus and cigarette smoking in the same popula-

tion. One study found that neither exposure was associated with increased risk of inflammatory bowel disease, whereas the second concluded that smoking poses greater risks of gastric cancer than snus.

Persson et al. (1993) evaluated risk of Crohn's disease and ulcerative colitis in a case-control study of male residents of Stockholm between the ages of 15 and 79. Use of moist oral snuff alone or cigarettes alone was not associated with significantly increased risk of either of these types of inflammatory bowel disease. When risk estimates for the two exposures were compared directly, there was no significant difference in risk of either Crohn's disease or ulcerative colitis between snus users who had smoked and current smokers who had never used snus.

Ye et al. (1999) conducted a case-control study of gastric and cardia cancer among men and women aged 40 to 79 who were born in Sweden and living in one of five counties in northern and central Sweden from 1989 to 1995. When compared to a common reference group of never tobacco users, snus users who had never smoked had no increased risk of gastric or cardia cancer (OR = 0.5; 95% CI: 0.2–1.2), whereas smokers who had never used snus had significantly increased risk (OR = 2.0; 95% CI: 1.3–2.0). When risk estimates for the two exposures were compared directly, the risk of gastric and cardia cancer was significantly higher among smokers who had never used snus than among snus users who had never smoked ($p = .003$).

Lung Cancer

One study examined the relationship between snus use and cigarette smoking and death due to lung cancer. Bolinder et al. (1994) examined lung cancer mortality among men aged 35 to 54 and 55 to 65 in a cohort of 84,871 Swedish male construction workers. The results were as expected: For both age groups, risk of death due to lung cancer was significantly elevated among smokers (even those who smoked fewer than 15 cigarettes/day), but not among snus users. When the risk estimates were compared directly, the risk was significantly higher among smokers of 15 or more cigarettes per day than among snus users ($p = .008$ for ages 35 to 54; $p = .001$ for ages 55 to 65). However, there was no significant difference in risk of lung cancer death among men of either age who smoked fewer than 15 cigarettes/day and men who used snus.

All-Cause Mortality

Comparative data on all-cause mortality are also available in the cohort study of Swedish male construction workers reported by Bolinder et al. (1994). Risk of death due to all causes was significantly elevated among snus users (OR = 1.4; 95% CI: 1.3–1.8), men who smoked fewer than 15 cigarettes/day (OR = 1.7; 95% CI: 1.6–1.9), and men who smoked 15 or more cigarettes/day (OR = 2.2; 95% CI: 2.0–2.4). The risk was greater among smokers and a dose-dependent relationship was seen. When the risk estimates for the two exposures were compared directly, men who smoked cigarettes had a significantly greater

risk of all-cause mortality than snus users ($p = .039$ for <15 cigarettes/day; $p < .001$ for ≥ 15 cigarettes/day).

DISCUSSION

Our review of the literature indicates that, for certain health outcomes, the health risks associated with snus are lower than those associated with smoking. Specifically, this is true for lung cancer (based on one study, Bolinder et al., 1994), for oral cancer (based on one study, Schildt et al., 1998), and for gastric cancer (based on one study, Ye et al., 1999). Three of four studies showed this for cardiovascular disease (Bolinder et al., 1994; Hergens et al., 2005; Huhtasaari et al., 1992). Although both snus and cigarette smoking were associated with increased risk of all-cause mortality, the risk was significantly greater with cigarette smoking (Bolinder et al., 1994; $p < .05$). Neither snus nor cigarettes were linked to increased risk of two forms of inflammatory bowel disease (Persson et al., 1993).

Of all the studies examined, the only study that showed snus users to be at elevated risk to any type of disease was Bolinder et al. (1994), which reported significant elevations for both cardiovascular disease and total mortality. (The total mortality results were mainly due to the cardiovascular findings.) But the results from Bolinder et al. (1994) must be placed into perspective by considering the findings from other studies in the field. None of the three other studies of cardiovascular disease (Asplund et al., 2003; Hergens et al., 2005; Huhtasaari et al., 1992) reported elevated levels of cardiovascular disease among snus users compared to the levels in non-tobacco users. (Moreover, Huhtasaari et al. [1999] reported statistically significantly lower levels of cardiovascular disease among snus users compared to non-tobacco users [OR = 0.58, 95% CI: 0.35–0.94].) Considering all these findings, the Bolinder et al. (1994) cardiovascular disease findings appear to be an anomaly.

All the studies in our summary were of reasonable quality. Except for Bolinder et al. (1994) (which was a cohort study), all

the studies in our review were case-control in design, in which controls were matched to cases by one or more of variables such as gender, age, and place of residence. All the case-control studies were based on population-based controls. In addition, odds ratios in all the studies adjusted for one or more of the following factors: health indicators (blood pressure, diabetes, serum cholesterol level, medication usage, history of heart symptoms, body mass index); socioeconomic factors (education, marital status, region of origin); and social habits (smoking, consumption of hard liquor). Finally, as indicated by the many statistically significant findings reported in our analyses, the studies were of adequate statistical power to compare the health risks of smoking with those of snus usage.

It must be remembered that the studies described in this review provide only part of the picture regarding the comparative health risks of snus and cigarettes. As indicated in Figure 1, only studies that presented risk information on both exposures were considered. Many important diseases known to be associated with cigarette smoking were not included (e.g., emphysema); this is because there has been little impetus to study the relationship between snus and many of the diseases associated with cigarettes. Thus, this review has omitted many of the adverse effects of cigarettes, but probably few of the potential health effects of snus.

This review has limitations: There are only seven studies that permit a direct comparison of the risk estimates associated with cigarettes and snus, and these papers cover several different health outcomes. Nevertheless, the results of this investigation are consistent with the general belief that snus is safer than cigarette smoking. Rodu and Cole (2004) have estimated that 200,000 of the 500,000 annual deaths among men in the European Union (EU) that are attributable to smoking would be avoided if the rate of smoking across the EU was the same as that of Sweden. In addition, a 9-member panel of experts who recently assessed the mortality risks of low-nitrosamine

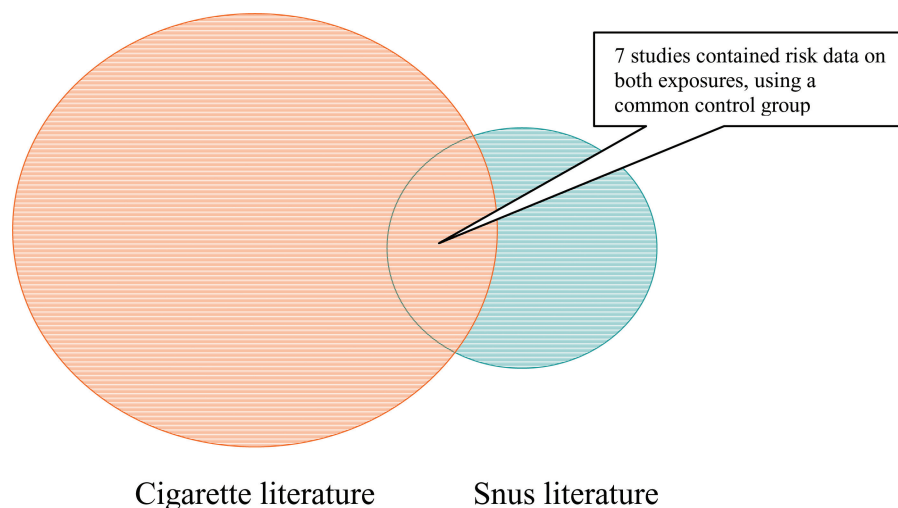


FIG. 1. Studies of smoking and snus: Health endpoints studied.

smokeless tobacco (such as snus) concluded that such products are associated with at least a 90% reduction in the risk associated with smoking cigarettes (Levy et al., 2004). Given the evidence suggesting that the widespread use of snus may at least be partly related to the low smoking-related mortality of Swedish men, further investigation into the reduced health risks of Swedish snus compared to cigarette smoking is warranted.

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