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Quantifying the effects of promoting smokeless tobacco as a harm reduction strategy in the USA

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Abstract

Background—Snus (a form of smokeless tobacco) is less dangerous than cigarettes. Some health professionals argue that snus should be promoted as a component of a harm reduction strategy, while others oppose this approach. Major US tobacco companies (RJ Reynolds and Philip Morris) are marketing snus products as cigarette brand line extensions. The population effects of smokeless tobacco promotion will depend on the combined effects of changes in individual risk with population changes in tobacco use patterns.

Objective—To quantitatively evaluate the health impact of smokeless tobacco promotion as part of a harm reduction strategy in the US.

Methods—A Monte Carlo simulation of a decision tree model of tobacco initiation and use was used to estimate the health effects associated with five different patterns of increased smokeless tobacco use.

Results—With cigarette smoking having a health effect of 100, the base case scenario (based on current US prevalence rates) yields a total health effect of 24.2 (5% to 95% interval 21.7 to 26.5) and the aggressive smokeless promotion (less cigarette use and increased smokeless, health-concerned smokers switching to snus, smokers in smokefree environments switching to snus) was associated with a health effect of 30.4 (5% to 95% interval 25.9 to 35.2). The anticipated health effects for additional scenarios with lower rates of smokeless uptake also overlapped with the base case.

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Contributors: SAG conceived of the study and programmed the Monte Carlo simulation. ABM refined the decision structure and collected most of the data on transition probabilities and health effects, with some help from SAG and PML. All three authors contributed to analysis and interpretation of the results, drafting the article, and revising it critically for important intellectual content. All authors approved the version to be published.

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Conclusions—Promoting smokeless tobacco as a safer alternative to cigarettes is unlikely to result in substantial health benefits at a population level.

Introduction

There are well documented effective strategies to reduce the harm caused by tobacco use, including smokefree policies, strong media campaigns, tax increases and strong graphical warning labels. There is a continuing debate over the desirability of promotion of smokeless tobacco products as an alternative to cigarettes rather than simply urging all people to quit using tobacco.[1–3] The debate over this particular harm reduction strategy has primarily centred on a Swedish form of low tobacco-specific nitrosamine moist snuff called snus that comes in small porous packets that are inserted between the user's gum and upper lip and claim to be spitless.[4] Smokeless tobacco causes less pulmonary disease than cigarettes, so if a smoker immediately and permanently switched to low nitrosamine smokeless tobacco, their risk would be reduced.[5] Many traditional smokeless tobacco users, however, are dual users of cigarettes and smokeless tobacco.[6–8] Snus promotion may encourage uptake among non-tobacco users, lead to smoking, or lead smokers who would have quit to become dual users.[9–12] Marketing and sales of snus and related oral tobacco products are banned in Australia and the European Union, except Sweden,[9] but are allowed in other markets, including the US.

After decades of study, including the use of smokeless tobacco as an alternative to cigarettes in smokefree environments,[13] between 2006 and 2007 the major US cigarette companies began promoting new smokeless tobacco products with popular cigarette brand names, such as Camel Snus and Marlboro Snus, in nationwide test markets. By 2009, the companies were encouraging dual use of cigarettes and snus products by portraying snus as a temporary way to deal with smokefree policies in public places, bars, workplaces and aeroplanes (figure 1).[14] The marketing strategies appear to be designed to attract young people and other new users to smokeless products (free samples, flavoured products, lower nicotine levels, stylish imagery, and promotions at bars and nightclub parties).[13] In January 2010 Philip Morris announced that Marlboro Snus would move out of test marketing and be available everywhere in the US in March 2010.[15]

Internationally, British American Tobacco (BAT) has sold Lucky Strike Snus in Sweden and South Africa and Peter Stuyvesant Snus in South Africa, and its Canadian subsidiary Imperial Tobacco Canada test marketed Du Maurier Snus[16] in 2008. In February 2008, BAT announced ownership of a new snus business through an acquisition of Scandinavian cigarette manufacturer Skandinavisk Tobakskompagni.[17]

In 2009, Philip Morris[18] and RJ Reynolds[19] petitioned the US Food and Drug Administration (FDA) to endorse a harm reduction strategy with the focus on smokeless tobacco. These submissions ignored the fact that the effects on population health as these new tobacco products achieve greater market penetration will depend on the changes in individual risk and population changes in tobacco use patterns, including dual use, which leads to increased exposure to toxicants and maintenance of smoking behaviour.[20] Accepting the industry's recommendations as good public health policy requires robust evidence that doing so would lead to substantial health benefits, after taking potential changes in population tobacco use patterns into account. To address this question, we developed a static lifetime decision tree model of tobacco use patterns to estimate the net effect of promoting smokeless tobacco as a harm reduction strategy on population health at a societal level.

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Methods

The model (figure 2) begins with initiation pathways, starting with non-users of tobacco. Assuming that non-users do not initiate tobacco use as dual users, non-users either become cigarette initiators, smokeless initiators, or remain never users.

Cigarette initiators (defined as ever having smoked at least 100 cigarettes in their lifetime) were divided into 4 mutually exclusive groups based on their primary motivation to quit: 'stable' smokers (who will not consider quitting), health-concerned smokers, smokers in smokefree environments and price-sensitive smokers. This division into subgroups reflects the fact that not all smokers are the same and that people quit smoking for different reasons. Despite the reality that some overlap in these primary motivations exists, the technical requirements of decision tree models dictate the four categories to be mutually exclusive. For quantitative estimates of the size of each subgroup, an analysis by Gilpin *et al*[21] of national survey data described the different primary reasons why smokers quit and how many smokers quit for the different reasons. The size of the four subgroups in our model was adjusted so that the composition of the group of quitters in the end state reflected similar frequency of quitting reasons as in the Gilpin *et al*[21] study.

Pathways from each group led to four possible end states: quitting, cigarette use, smokeless tobacco use, or dual use. The model was adjusted so that the percentage of smokers, quitters and smokeless tobacco users in the end state reflected the current smoking and smokeless use prevalence and quit ratio in the 2006 National Health Interview Survey (NHIS) survey.[22] The probabilities for each outcome were summed, then multiplied by a tobacco-related health effect associated with each outcome, then summed to obtain the total tobacco-related health effects of several scenarios.

Tobacco-related health effects

Smokeless use has been linked to oral cancer,[9] oropharyngeal cancer,[11] heart disease[592324] and pancreatic cancer.[25–28] Levy *et al*[9] report the results of an expert panel that estimated a 90% reduction in mortality risk when using low nitrosamine smokeless tobacco compared to cigarette smoking.[10] This estimate probably underestimates the actual adverse health effects because the panel did not consider pancreatic cancer and probably underestimated the cardiovascular risk. The panel estimated that the median risk of heart disease associated with the use of smokeless was 10% of the heart disease risk from cigarette use. Data from the multinational INTERHEART study, a large case-control study of acute myocardial infarction (AMI), indicate an association between chewing tobacco use and AMI (OR 2.23, 95% CI 1.41 to 3.52) that was 75% of the risk of smoking cigarettes (OR 2.95, CI 2.77 to 3.14) and that the risk of dual use was larger than smoking[21] (OR 4.09, CI 2.98 to 5.61). Another 2005 review of the health risks of smoking compared to snus found that the risk of heart disease associated with snus is about half that of smoking.[5] A meta-analysis of studies of smokeless tobacco use in the US and Sweden found that the relative risk of fatal myocardial infarction was 1.13 (95% CI 1.06 to 1.21) and the relative risk of fatal stroke was 1.40 (1.28 to 1.54).[24]

Tobacco-related health effects were assigned to each outcome on a unitless scale, with current cigarette smoking set to 100, never users set to 0, former users were log-normally distributed with mean 5 and SD 5 (5th percentile 1, 95th percentile 15). To produce estimates of the health effects of different scenarios that are purposefully biased in favour of smokeless tobacco use as a component of a harm reduction strategy, following Levy *et al*,[10] we set the health effects of smokeless tobacco to be log-normally distributed with mean 11 and SD 5 (5th percentile 5, 95th percentile 20) and dual use with mean 90 and SD 6 (5th percentile 80, 95th percentile 100).

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Transition probabilities

Each pathway was assigned a transition probability and associated standard error based on actual US tobacco use patterns using data from large national surveys, peer reviewed literature and tobacco industry marketing research documents (table 1). For a few pathways, direct estimates were not available and estimates based on available data were made. The transition probabilities in figure 2 are for one of two versions of the 'base case', which reflects current use patterns. (The alternate base case has different transition probabilities out of the smokeless initiator node with less dual use; see table 1.)

Initiation

Data from the 2006 National Health Interview Survey indicated that 40% of the population had ever smoked 100 cigarettes in their lifetime.[22] Of the 60% of the US adult population who were never cigarette smokers, we estimated 4% of the population initiated smokeless tobacco use,[22] leaving 56% as never users.

Cigarette initiators

Because we could not locate any sources that directly reported the primary motivators of changes in smoking behaviour in mutually exclusive groups as required by the model, we adjusted our probabilities to match the observed tobacco use behaviours (current prevalence of smoking and smokeless tobacco use, former smokers and quit ratio) according to 2006 National Health Interview Survey data.[2230] The current US adult smoking prevalence is 20.8% and the current quit ratio is approximately 50% (45.7 million of the 91 million ever smokers had quit smoking).[22] Given the uncertainties associated with this process, we assumed relatively large standard errors of 0.02 for each of these transition probabilities.

Our estimate of quitting rates among smokers in smokefree environments is consistent with similar estimates from a meta-analysis of the effect of smokefree workplaces on smoking behaviour.[32] This meta-analysis found that the impact of a smokefree workplace was equivalent to a very large ($2.29 per pack) cigarette price increase[32]; thus we assumed that the probability of an average price-sensitive smoker quitting was lower than the effect of smokefree environments. Further, we assumed that because smokeless tobacco use is not widely prevalent in the US population, in the base cases it was not used as a way to cope with smokefree environments or to save money from smoking cigarettes.

Smokeless initiators

The probabilities for subsequent behaviour among people who initiated tobacco use with smokeless are direct estimates from a longitudinal study of adolescent boys in Oregon between 1994 and 1999.[6] (We assume that these patterns apply to both genders because snus is being promoted to both genders.) While this dataset has the advantage of being relatively recent, it was limited to a small geographic area. Therefore, we also ran our base case and all subsequent simulations using a second, earlier, nationally representative data from a longitudinal study of adolescent boys and young adult men collected in 1989 and 1993.[8] This second, earlier study found substantially lower levels of dual use than the newer data, and higher levels of continued smokeless use and subsequent smoking among smokeless users.

Scenarios

We investigated four scenarios with differing probabilities assigned to transitions in the model in figure 2 to estimate what may happen with broader promotion of snus as part of a harm reduction strategy. These four scenarios were analysed twice, using the two base cases[68] with different smokeless initiation patterns.

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The development of the model permits a wide variety of scenarios and assumptions to be tested, and if increased knowledge from real-world changes provides improved understanding of the transition probabilities or tobacco-related health effects, the model can be easily revised and the implications of this new information tested. The four scenarios are meant to bracket a broad range of scenarios that could be evaluated with this model.

In the *aggressive smokeless promotion scenario*, snus would be heavily and successfully promoted as healthier and more socially acceptable than cigarette use, increasing smokeless tobacco initiation 10 times, half from people who would have started smoking cigarettes and half from people who would not have used tobacco. Stable smokers would remain unaffected. Health-concerned smokers would increase switching to smokeless by a factor of 10 (half from those who continued smoking, half from quitters), and 25% of those smokeless users would become dual users. We assumed that aggressive promotion of snus has a similar effect as permitting smoking lounges in otherwise smokefree environments,[32] reducing the effect of smokefree environments on quitting by 50%, with half of those smokers switching to snus, and 75% of those who switch to snus becoming dual users (because temporary use of snus is promoted in these situations). We assumed half the price-sensitive smokers would switch to snus (half from those who continued smoking and half from quitters) and that 25% of the snus users would become dual users.

The *US Smokeless Tobacco Company (USST) scenario* represents more modest success in smokeless tobacco promotion, in which smokeless uptake increased by a factor of 3.7, based on USST's estimates of their potential growth in the smokeless market.[33] In a 2007 presentation for investors, USST stated that of the 45 million US smokers, 22 million desire a socially acceptable alternative to smoking, posing an opportunity to increase the current 6.1 million adult male moist smokeless consumers market by a factor of 3.7. All the other assumptions in this model are the same as the aggressive promotion scenario.

In an aggressive promotion with most new users from smokers scenario, snus initiation was again increased by a factor of 10, but with 75% of new snus users from smokers. This scenario was based on the (questionable) claim that new smokeless tobacco marketing is strongly directed to converting smokers to less harmful smokeless products.

We modelled a *no effect on initiation scenario* where snus promotion had no effect on initiation of either cigarettes or snus by never tobacco users, but current smokers increased their snus use in the same patterns as the aggressive promotion scenario.

Monte Carlo simulations

The model in figure 2 was used in a Monte Carlo simulation to obtain the distribution of end states (never user, quitter (former tobacco user), cigarette smoker, smokeless user, or dual user) for both versions of the base case, assuming that the transition probabilities are normally distributed (table 1). Each probability was selected independently for each of 10 000 trials, then the probabilities for each node were normalised to sum to 1.00. The health effect of each of the alternative scenarios was computed using the same 10 000 sets of values as the corresponding base cases as well as the ratio of the tobacco-related heath effects for the alternative scenario to the base case (with the same set of parameter values). The simulation was run using Crystal Ball V.7.3.1 (Oracle Software, Redwood Shores, CA, USA).

Sensitivity analysis

To evaluate the sensitivity of the changes in estimated tobacco related health effects in the four scenarios to the base case, we applied the Crystal Ball sensitivity analysis procedure, which approximates a variance decomposition to the health effects ratio.

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Model availability

The full model (as an Excel spreadsheet) is available as supplementary material.

Results

Based on 10 000 Monte Carlo trials, the base case corresponds to a tobacco-related health effects of 24.2 (5% to 95% interval 21.5 to 27.1) (figure 3 and table 2). While being associated with less cigarette only use (smoking prevalence drops to 10.5%), the aggressive smokeless promotion scenario was associated with increased health effects over the current base case 30.5 (25.7 to 35.5) (table 2), although the distributions of predicted health effects overlapped. The mean health effect of the no effect on initiation scenario was 22.3 (19.8 to 25.1; table 2), only slightly lower than and having substantial overlap with the distribution of health effects for the base case. The other two scenarios yielded similar ranges of tobacco-related health effects as the base case.

In the second set of analyses in which the base case uses the older national data for smokeless use patterns[8] with lower dual use estimates, the mean health effect for the base case is almost identical to that of the recent data,[6] 23.5 (19.8 to 25.1), and decreases for the aggressive smokeless promotion with most new users from smokers scenario: 19.2 (16.6 to 22.2; table 2). The distributions of health effects for these scenarios overlap with each other and with the first base case, as do the other scenarios.

The ratios of tobacco-related health effects do not produce consistent robust evidence of substantial health benefits (table 2). Viewed from this perspective, in the first set of analyses, the aggressive smokeless promotion scenario was associated with an increase in tobacco-related health effects, the no effect on initiation scenario was associated with reduced effects, and the other two scenarios were associated with no change in effects. In the second set of analyses (based on older data[8]), three of the scenarios were associated with reduced tobacco-related health effects. The fact that these scenarios tended to have lower effects than in the first analysis is largely due to the fact that the older data had much lower dual use than the more recent data (table 1).

Sensitivity analysis

The only two parameters that consistently contributed more than 15% to the variance in the tobacco-related health effect ratio between a given scenario and the base case were the initiation rate for smokeless tobacco usage and the health effect associated with dual use. Almost all the other transition probabilities in the model were associated with less than 5% of the variance in the effect ratio.

Discussion

The fact that the distributions of tobacco-related health effects overlap, combined with the lack of a large consistent drop in the ratios of health effects among the different scenarios, leads to the conclusion that it is unlikely that promotion of snus would be associated with any substantial health benefits on a population basis. The sensitivity analysis indicated that this conclusion is not sensitive to the specific transition probabilities and other parameters we used in the model. The fact that this analysis is based on health effect estimates for smokeless and dual use that are probably low strengthens this conclusion.

Swedish snus, the product most widely proposed for harm reduction, delivers similar nicotine levels as cigarettes but has lower levels of carcinogenic tobacco-specific nitrosamines.[4] The Marlboro snus products being marketed in the US have very low nicotine delivery,[34] which may increase the probability of dual use. Moreover, in the US, a variety of

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smokeless tobacco products are used, including some that are not low nitrosamine. The varying forms of smokeless tobacco products, their different manufacturing processes, toxicant levels,[35] and methods of use,[4] have made assigning smokeless tobacco products a precise risk estimate increasingly difficult.[9] We nevertheless used an estimate of risk based on low nitrosamine products[10] and therefore probably underestimate the health impacts of smokeless and dual use. All these factors lead to the conclusion that, if anything, our model underestimates the risks associated with smokeless tobacco.

Dual Use

Dual use of smokeless tobacco and cigarettes is an important contributor to the health effect associated with increased promotion of smokeless tobacco, particularly since tobacco companies are now aggressively promoting snus and other smokeless products as a way to deal with smoking restrictions rather than quitting.

An Australian study concluding that snus is likely to produce a net health benefit to population health, if adopted in sufficient numbers by inveterate smokers, did not account for dual use.[36] They concluded that at least 19 people (averaging men and women) would have to begin using snus for each person that would otherwise have stopped all tobacco use to crossover from reducing health effects to producing net harm. Reducing the base probability of smokeless initiators becoming cigarette smokers or dual users to 0 and placing these people in the continuing smokeless group in our model (to reflect the Australian assumption of no dual use) produces a similar result, with the ‘crossover point’ at 21.5 new snus users per cigarette user avoided; well within the uncertainty of both models. (Increasing the tobacco-related health effect of smokeless in our model slightly, from 11 to 12 units, would make the estimated crossover points the same in the Australian model and our model.) The fact that our model can be modified to produce predictions similar to the Australian model increases confidence in our model and highlights the importance of dual use in determining the population-level health impact of smokeless tobacco promotion.

The prevalence of dual tobacco use has been found to be high among smokeless tobacco users in some,[6712][37] but not all,[38] US studies. Because the health effects of cigarettes and smokeless are different, the health effects of concurrent (dual) use of these two tobacco products may be additive or even synergistic, may increase the risk of tobacco-related diseases and mortality above single product use.[20] As noted above, the INTERHEART study found that dual use was associated with the highest increase in risk of acute myocardial infarction when compared to smoking and chewing tobacco alone.[23] Since we assumed that dual use had, on average, a lower health effect than smoking cigarettes alone (assuming lower levels of carcinogen exposure were associated with dual use) and, in any event, no higher risks than smoking, we are almost certainly underestimating the health effect associated with increased promotion of snus.

The importance of dual use in predicting the population-level health effects of aggressive smokeless tobacco use is also reflected in the lower tobacco-related health effects in our second set of scenarios, based on older data on smokeless use patterns that assume low levels of dual use (tables 1 and 2).

Dual use in a smokefree environment was modelled in all three alternative scenarios as having the effect of cutting quitting in half, with half the smokers adopting smokeless and three-quarters of them subsequently becoming dual users, based on the fact that the tobacco industry is explicitly promoting dual use of snus as a way to cope with smokefree environments (figure 1) while continuing to smoke at other times. This increase in dual use is one of the most important reasons that promotion of snus is unlikely to have any

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substantial benefits on a population level, despite the fact that switching from cigarettes to snus reduces individual risk.

Sweden is widely cited as the prototype for promotion of smokeless snus as a harm reduction strategy even though the effects of snus use on smoking behaviour in Sweden remains controversial.[39] The low rates of dual use reported for Sweden[40] are based on a definition that requires someone to smoke cigarettes and use snus every day to be categorised as a dual user. This definition is not relevant to the way that snus is being promoted in the US, particularly as a way to cope with smokefree environments (figure 1), which might only encourage snus use on weekdays at work or in certain situations such as travel or attending concerts. Smokeless tobacco use is not associated with cigarette cessation in the US.[38] More important, there are important differences in the way that snus is marketed in Sweden versus the US and other new markets that the multinational cigarette companies are developing. RJ Reynolds and Philip Morris are actively promoting Camel and Marlboro snus as line extensions of their cigarette brands.

Limitations

Because the paper seeks to anticipate the effects of increased promotion of smokeless tobacco as a harm reduction strategy, the available data are clearly limited compared with the situation that would exist if one were evaluating what had happened after the tobacco industry had had a decade to firmly establish this emerging market. Given the limited available data, the model includes a mix of determinants of youth initiation and changes in adult behaviour. It would be ideal to be able to provide a more detailed assessment of the transitions over time among youths and adults to assess impacts in different age groups and cohorts of tobacco users, but this is not possible with available data. We have made the model available online (see supplementary material) so that others can apply it to new data as they become available.

The initiation probabilities for smokeless initiation are assumed to be identical for both genders, which is not consistent with patterns in the US or other Western countries, where men use smokeless tobacco use at much higher rates than women. Based on the new more unisex marketing strategies for snus products that the tobacco companies are implementing and the potential market of female snus users, we assumed that women will use smokeless tobacco at rates similar to men.

Our estimates of the health effects of smokeless tobacco use were based on a consensus estimate for the effects of low nitrosamine snus[9] that were made before evidence was published showing substantial effects on cardiovascular risks.[524]

To the extent that promotion of smokeless tobacco as a ‘reduced risk’ product ‘spills over’ into other forms of smokeless tobacco (such as Skoal, which is not low-nitrosamine moist snuff), it is likely that we underestimated the health effects in assigning risk to smokeless tobacco use and dual use. As noted above, our estimates of the health effects of smokeless and dual use are probably too low, which biases the results in favour of promoting smokeless tobacco as a component of a harm reduction strategy. For example, none of the distributions for ratios of health effects are below 1 if the mean health effect of smokeless tobacco is set to 20% of smoking and dual use equal to smoking (results not shown).

We assumed that the cigarette companies would not respond to increased competition from snus and other smokeless products by increasing promotion of cigarettes (although this is unlikely). This assumption is another purposeful underestimate of the risks of promoting snus.

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Conclusions

Using the best available data we show that in the US, promoting snus as a less dangerous alternative to cigarettes is unlikely to provide substantial population health benefits. Given that there is no clear evidence of benefit and evidence that harm may result, promoting smokeless tobacco as part of a harm reduction strategy is not warranted.

There are a number of reasons why harm reduction may not occur at a population level. First, in countries (like the US) where the industry remains free to market its products, it will be free to take advantage of any endorsement of snus or other forms of smokeless tobacco as a 'harm reduction' product by public health authorities. While advocates of promoting smokeless tobacco as a component of a harm reduction strategy define it more carefully as promotion of smokeless tobacco use only for complete substitution by smokers without dual use, it is unclear the public would perceive these messages in this way, having already been (and likely continuing to be) exposed to extensive marketing messages from the tobacco industry explicitly promoting dual use and smokeless uptake by new users. The prospect of harm reduction would most likely be framed as an 'added benefit' to the 'benefits' of smokeless tobacco already aggressively marketed.

Second, there are other risks of public health advocates either promoting smokeless tobacco or taking no position. These include the fact that promotion of smokeless may undermine effective smokefree policies, confuse public messages (via messages that some tobacco products are 'good') and legitimise tobacco companies. As smokefree workplaces have spread and cigarette smoking has become increasingly socially unacceptable, smoking rates have declined. It is unsurprising therefore that the major US tobacco companies are aggressively expanding their promotion of smokeless tobacco (snus) as an alternative to quitting in response to these social pressures.[4142]

Large-scale tobacco control programs that denormalise tobacco use and the tobacco industry reduce smoking and promote cessation.[43–45] Cessation aids such as quitlines[46] and health professional interventions[47] also contribute to reducing smoking prevalence. Public health and clinical professionals should focus on these harm reduction strategies for which there is a substantial evidence base rather than turn to a strategy relying on tobacco companies to manufacture and promote 'less harmful' tobacco products.

In particular, regulatory agencies such as the US Food and Drug Administration should consider the population-level effects as well as individual risks when assessing industry requests to endorse promotion of smokeless tobacco products as part of a comprehensive harm reduction strategy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

The Camel Snus marketing web site (http://www.camelsnus.com accessed April 2008) includes interactive images. Once a user is logged onto the Camel Snus website, they can learn what snus is, how to use snus and the fact that it can be used where it is not possible to smoke cigarettes. When the user scrolls over various images, text appears that says ‘Yes!’ in response to the questions ‘Can you snus at a club?’ and ‘Can you snus on an aeroplane?’. Marlboro Snus direct mail promotion (bottom) distributed in December 2009, which promotes snus as an alternative way for smokers to use tobacco ‘whenever smoking isn't an option’. The text states, ‘You are now free to enjoy Marlboro without matches’ and ‘The foilpack fits perfectly alongside your smokes’. This mailer specifically promotes dual use; it includes coupons to receive either one or four free packs of Marlboro snus when the recipient buys Marlboro cigarettes.

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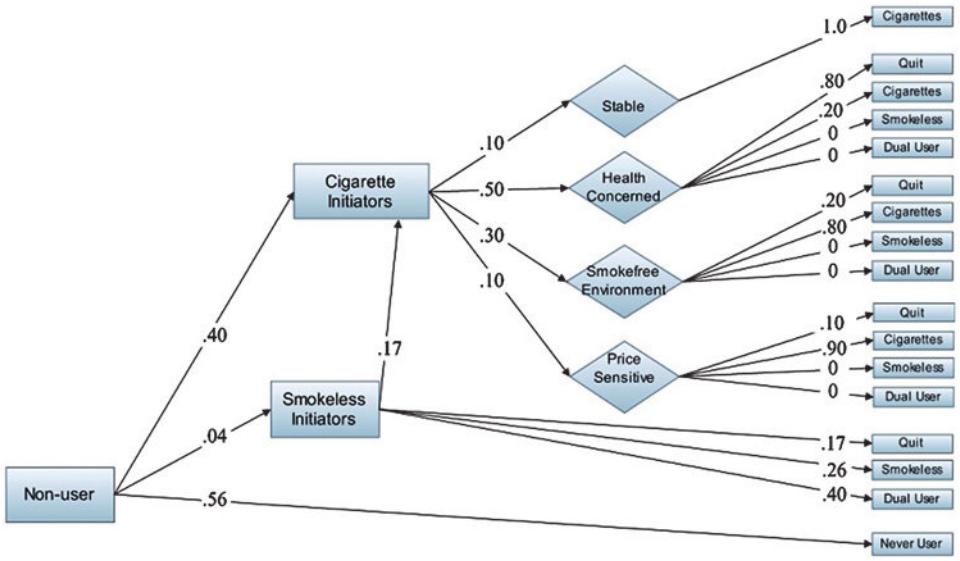

Figure 2.

Model of use patterns of cigarettes and smokeless tobacco. The numbers indicate the transition probabilities for the base case (current US). The sources for the values and their standard errors are in table 1. The smokeless node in this figure presents the transition estimates from Oregon, USA.[6] As noted in the text and table 1, we also consider an alternative set of transition probabilities for the Smokeless node with low levels of dual use.[8] The structure of the model is the same for each of the alternative scenarios, with the different transition probabilities listed in table 1. A spreadsheet containing the full model for the base case and the alternative scenarios is available as supplementary material.

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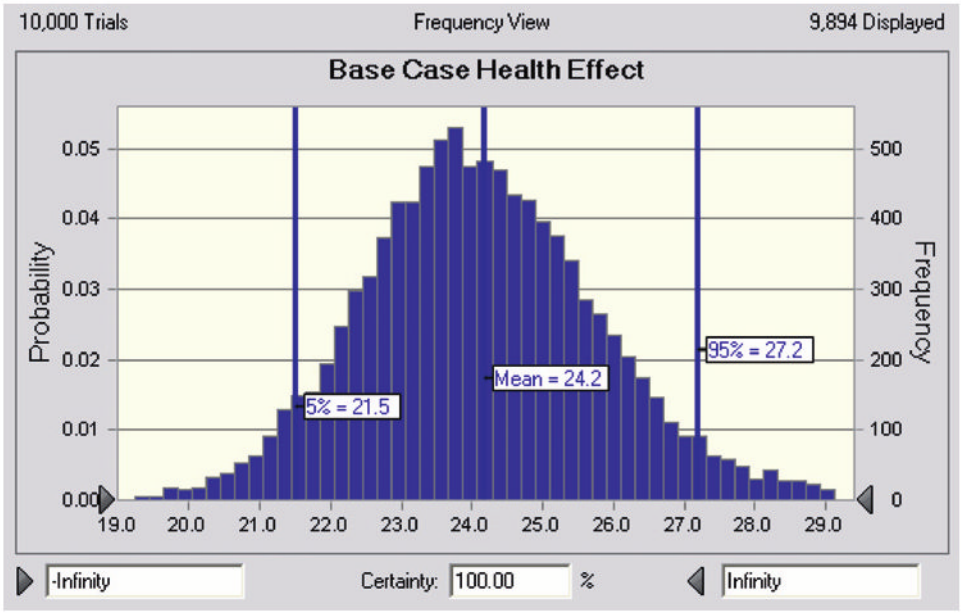

Figure 3.
Distribution of estimated health effects under the case based on current US tobacco use patterns (figure 2).

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Table 1
Transition probabilities, standard errors and data sources for figure 2

Pathway	Probability	SE	Source
Initiation			
To cigarette initiators	0.40	0.01	2006 NHIS[22]
To never user	0.56	0.01[a]	0.60 of population are never smokers minus 0.04 smokeless users; SE calculated from 95% CI of total smoking prevalence 18+[22]
To smokeless initiators	0.04	0.01	Average based on adult prevalence of smokeless NHIS 2000[29] (2.3%, 95% CI 2.1% to 2.5%) and 2003 teen current use (6.7%, 95% CI 5.2% to 8.2%) (Monitoring the Future and Youth Risk Behavior Survey, 2003[30]) 2005 Substance Abuse and Mental Health Services Administration (SAMHSA) data estimate of 3.3% among ages 18 and older, 5.1% for 18–25 year olds[31]
Smokeless			
To quit	0.17	0.01	Oregon adolescent males 1994–1999[6]
To cigarettes	0.17	0.01	
To smokeless	0.26	0.02	
To dual user	0.40	0.02	
Cigarettes			
Stable	0.10	0.02	Adjusted to obtain current overall smoking prevalence (21%) and quit ratio (50.2%)[22]
Health concerned	0.50	0.02	
Smokefree environment	0.30	0.02	
Price sensitive	0.10	0.02	
Health concerned			
To quit	0.80	0.02	Adjusted to obtain current overall smoking
To cigarettes	0.20	0.02	prevalence (21%) and quit ratio (50.2%)[22]
To smokeless	0		
To dual user	0		
Smokefree environment			
To quit	0.20	0.02	Adjusted to obtain current overall smoking
To cigarettes	0.80	0.02	prevalence (21%) and quit ratio (50.2%)[22]
To smokeless	0		
To dual user	0		
Price sensitive			
To quit	0.10	0.02	Adjusted to obtain current overall smoking
To cigarettes	0.90	0.02	prevalence (21%) and quit ratio (50.2%)[22]
To smokeless	0		
To dual user	0		
Alternative patterns of smokeless use (using older national data with low levels of dual use)[31]			
To quit	0.15	0.01	National young males in 1989 and 1993[8]
To cigarettes	0.26	0.02	
To smokeless	0.45	0.03	
To dual user	0.14	0.01	

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Table 2

Use patterns and heath effects associated with various scenarios for promotion of smokeless tobacco use as a safer alternative to cigarettes

Scenario	Condition	Never user	Quit	Cigarettes	Smokeless	Dual	Quit ratio	Tobacco-related health effect (5% to 95%)	Health effect ratio (5% to 95%)
Base case	Figure 2	56.0%	19.8%	21.6%	1.0%	1.6%	47.9%	24.2 (21.5 to 27.1)	
Aggressive smokeless promotion	***Initiation:*** Increase smokeless initiation ×10; half from cigarettes, half from never users ***Health concerned*:** Increase smokeless use ×10, half from cigarettes, half from quitters. Fraction of dual use among new smokeless users: 0.25. ***Smokefree environment:*** Cut quitting in half. Fraction of cigarette users to smokeless: 0.50. Fraction of dual use among new smokeless users: 0.75. ***Price sensitive*:** Cut quitting in half and move to smokeless. Fraction of cigarette users to smokeless: 0.50. Fraction of dual use among new smokeless users: 0.25.	38.0%	19.3%	10.5%	12.6%	19.6%	64.8%	30.5 (25.7 to 35.5)	1.26 (1.10 to 1.44)
US Smokeless Tobacco Company (USST)	Increase smokeless initiation ×3.7. Other assumptions remain the same	50.6%	18.7%	13.5%	6.6%	10.6%	57.9%	24.7 (21.8 to 27.9)	1.02 (0.96 to 1.09)
Aggressive promotion with most new users from smokers	Increase smokeless initiation ×10; 75% from smokers, 25% from never users. Other assumptions remain the same.	47.0%	15.4%	7.2%	11.9%	18.5%	68.1%	25.9 (22.7 to 29.5)	1.07 (0.96 to 1.21)
No effect on initiation	No change in initiation patterns. Other assumptions remain the same.	56.0%	18.4%	14.8%	4.1%	6.7%	55.3%	22.3 (19.8 to 25.1)	0.92 (0.89 to 0.95)
Alternative patterns of smokeless use (using older national data, with low levels of dual use)[31]									
Alternate Base	Other probabilities same as figure 2	56.0%	19.9%	21.8%	1.8%	0.6%	47.8%	23.5 (20.8 to 26.5)	
Aggressive smokeless promotion	Same as above except for different smokeless use patterns	38.0%	20.1%	11.8%	20.4%	9.7%	63.0%	23.8 (20.9 to 27.4)	1.01 (0.93 to 1.11)
USST	Same as above except for different smokeless use patterns	50.6%	18.9%	14.0%	9.5%	6.9%	57.4%	22.2 (19.7 to 25.2)	0.95 (0.91 to 0.99)
Aggressive promotion with most new users from smokers	Same as above except for different smokeless use patterns	47.0%	16.2%	8.5%	19.8%	8.5%	65.4%	19.2 (16.6 to 22.2)	0.82 (0.73 to 0.91)
No effect on initiation	Same as above except for different smokeless use patterns	56.0%	18.5%	15.0%	4.9%	5.7%	55.2%	21.6 (19.1 to 24.4)	0.92 (0.89 to 0.95)