Social Marketing, Stages of Change, and Public Health Smoking Interventions

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Abstract

As a "thought experiment," the authors used a modified stages of change model for smoking to define homogeneous segments within various hypothetical populations. The authors then estimated the population effect of public health interventions that targeted the different segments. Under most assumptions, interventions that emphasized primary and secondary prevention, by targeting the Never Smoker, Maintenance, or Action segments, resulted in the highest nonsmoking life expectancy. This result is consistent with both social marketing and public health principles. Although the best thing for an individual smoker is to stop smoking, the greatest public health benefit is achieved by interventions that target nonsmokers.

Keywords

stages of change, social marketing, health marketing, substance use, tobacco control, intervention

One role of public health agencies is to encourage healthful behaviors in the population. Because of budget limitations, agencies must choose effective interventions. Insights from the theories of individual behavioral change and social/health marketing may help agencies choose the interventions that best improve the health of the public. Diehr, Derleth, Cai, and Newman (2007) have suggested a thought experiment to compare the effectiveness of different generic public health interventions. This involved conceptualizing the public as being in one of three states: healthy, sick, or (eventually) dead. Potential interventions (the set of all possible interventions) were classified as to whether they primarily increased the probability that a sick person would become healthy or decreased the probability of becoming sick or dying. That study examined the effect of improving each of the transition probabilities by 10% and identified the intervention that maximized the healthy life expectancy of the population. Under most assumptions, decreasing the probability of becoming sick was the most effective. In this study we conduct a similar thought experiment to compare potential smoking interventions, segmenting the population by stages of change rather than by healthy/sick/dead. Potential interventions were classified as to which transition among stages they affected. We then identified the intervention that maximized nonsmoking life expectancy (NSLE) rather than healthy life expectancy.

Stages of Change for Individuals

Individual behavior change theories abound to help us understand how to help an individual smoker quit. One of these theories is the stages of change, or transtheoretical, model (DiClemente et al., 1991; Prochaska, Norcross, & DiClemente, 1994; Prochaska & Velicer, 1997). This model proposes that smokers become nonsmokers by moving through five stages of readiness to quit smoking: Precontemplation (not even thinking about quitting), Contemplation, Preparation, Action (short-term abstinence), and Maintenance (long-term abstinence). Persons are thought to progress through these stages at different rates, often moving back and forth several times before attaining the goal of Maintenance. Intervention approaches can be tailored to smokers in different stages of readiness to quit smoking. Strategies that emphasize increasing motivation to quit may be most appropriate for smokers in the Precontemplation or Contemplation stages,

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whereas behavioral skill training interventions that empha-size specific quit strategies are more appropriate for smokers in the Preparation and Action stages (Curry, Wetter, Grothaus, & Taplin, 2009; Treating Tobacco Use and Dependence, 2008). In terms of this model, the objective of a public health inter-vention can be considered as improving the distribution of persons among the stages; for example, a population goal could be to have fewer person-years spent in Precontempla-tion and more spent in Maintenance.

Individual and Public Health Interventions

Existing interventions for individual smokers may be described in terms of the stage of change they target. Programs that cover the cost of nicotine replacement drugs help smokers in the Action phase abstain long enough to reach Maintenance, thus increasing the probability of moving from Action to Maintenance. Prevention messages, such as the American Legacy Foundation "Truth" ads, attempt to lower the proba-bility of transitioning from never smoker to smoker (Farrelly, Davis, Haviland, Mossen, & Healton, 2005). Smoking bans may increase the probability that current smokers transition from Preparation to Action (Pizacani et al., 2004) and may also decrease the probability that quitters relapse. Smoking cessation quitlines may also affect more than one stage; set-ting a quit date with a counselor increases the probability of moving from Preparation to Action, whereas counseling after quitting increases the probability of transitioning from Action to Maintenance. The success of individual interventions might be judged by the number of program participants who are not smoking a year later or, less ambitiously, the number who have moved to a higher stage.

Public health agencies are concerned with the health of the entire population, including nonsmokers, and have longer term objectives such as increasing the NSLE (nonsmoking life expectancy). Public health interventions naturally attempt to influence smoking in the population, rather than in individual smokers. Interventions could include ecological approaches such as media campaigns, new laws, and taxation, as well as the funding of interventions for individuals. A pop-ulation may be described by its distribution of stages of change, such as the proportion in Precontemplation. A public health agency might tailor the interventions to the population, such as funding informational public service announcements if the population were primarily in Precontemplation but sub-sidizing the purchase of nicotine gum for populations that were primarily in Action.

Social Marketing

Social (or health) marketing theory suggests that populations should be segmented into relatively homogenous subgroups and that interventions should be tailored to match each segment's needs (Grier & Bryant, 2004; Kotler & Lee, 2008; Siegel & Lotenberg, 2007). The literature suggests that one cannot address all of the stage transitions in a single inter-vention and so should focus on one segment at a time (Kerin, Berkowitz, Hartley, & Rudelius, 2003; Kotler & Keller, 2006; Lavidge & Steiner, 1961). One recommended strategy is to target the segment most ready to change (the persons most ready to quit smoking, in our example). Alternatively, the tenet of "customer relationship management," which stresses the importance of retaining current customers (Kotler, 2001), suggests interventions that aim to encourage and support persons who already have good behaviors, such as persons who have never smoked, or former smokers who have since quit. Although populations are often segmented by available demographic characteristics such as age or sex, social marketing theory suggests segmenting by the attitudes or behaviors that are most relevant to the behavior of inter-est. With respect to smoking, social marketing suggests identifying segments of the population who have similar smoking-related beliefs and behaviors and then tailoring interventions for those segments.

Stages of Change in Populations

A population segment that meets these criteria could be defined as all the persons in the same stage of change. The population, however, also includes persons who have never smoked, and calculation of the NSLE requires keeping track of the deaths. To adapt the stages of change model to repre-sent the population over time, we added two stages, Never Smoker and Dead. We do not adopt any assumptions from the individual-level model but rather estimate the probabili-ties of transitions among stages from existing data.

Consider the modified stages of change model in Figure 1, where each circle represents one of the stages. Each arrow represents a transition from one stage to another; for example, Transition 1 represents a move from Precontemplation to Contemplation. For simplicity, Figure 1 shows only the tran-sitions from each stage to its adjacent stages. Actually, transitions among all stages are allowed, except that a person cannot return to Never Smoker or return from Dead. Note that Figure 1 does not represent instantaneous transitions, but rather tran-sitions in a defined amount of time (2 years in our primary example). Thus, although a person cannot transition instanta-neously from Never Smoker to Maintenance (Transition 9), there is ample time in 2 years for a never smoker to start to smoke, then to quit and achieve maintenance, which is how that arrow should be interpreted.

Available survey data were used to estimate the proba-bility that a particular transition occurs. For example, in the data set described later on, about 16% of the persons in Precontemplation had moved to Contemplation 2 years later. The numbers on the arrows will be used in several ways: to index a particular transition (e.g., Transition 1), the probability
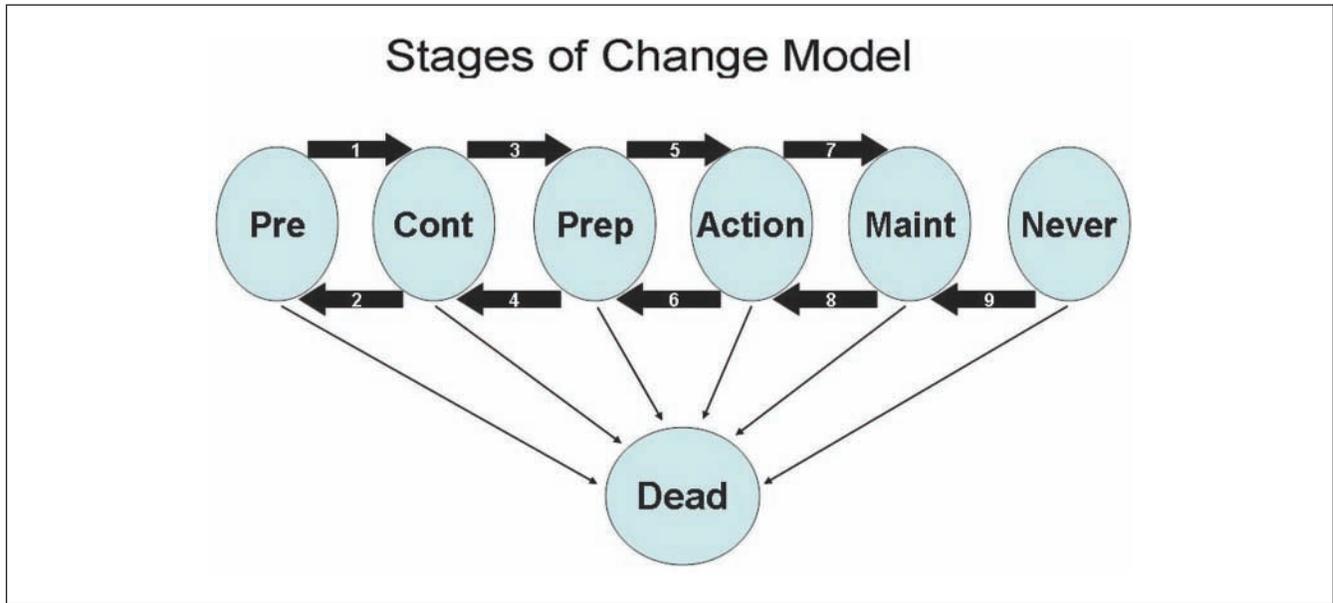
Stages of Change Model

Figure 1. Population stages of change model for smoking in the population.
Note: A simplified diagram of 2-year (not instantaneous) transitions among the five stages of change (Precontemplation, Contemplation, Preparation, Action, and Maintenance). Stages for Never Smoker and Dead were added. Arrows represent the transitions between adjacent stages. Transitions between other stages are also allowed, but are not shown here to simplify the figure. The number inside each arrow is used variously to refer to the indicated transition, to the probability of making that transition, and to the intervention that "improves" that probability. Arrow 9 may be thought of as the probability of starting to smoke, because most persons who started to smoke had quit and achieved maintenance by the following survey wave (see Table 1).

Table 1. Two-Year Transition Probabilities of Stage Change From Time 1 to Time 2

Stage at Time 1	Stage at Time 2						No. of Persons
	Precontemplation	Contemplation	Preparation	Action	Maintenance	Never	
Precontemplation	0.632	0.159	0.049	0.097	0.062	0.000	993
Contemplation	0.369	0.291	0.120	0.110	0.110	0.000	426
Preparation	0.240	0.244	0.260	0.120	0.136	0.000	242
Action	0.080	0.124	0.060	0.143	0.594	0.000	251
Maintenance	0.008	0.010	0.012	0.022	0.949	0.000	2,597
Never Smoker	0.001	0.001	0.002	0.004	0.038	0.954	5,113
Total							9,622

Note: The tabled values represent the probability, estimated from Data Set 1, of moving from the row state at Time 1 to the column state at Time 2. Rows of probabilities add to 1.000. For example, of the 993 persons in Precontemplaton at Time 1, 6.2% had achieved Maintenance 2 years later. The multistate life table calculations required age-specific versions of this table and had an additional row and column for death.

of making that transition (Transition Probability 1), or later on, to denote an intervention that can improve (increase) that transition probability (Potential Intervention 1).

Potential Public Health Interventions

What intervention would yield the most public health benefit? As a thought experiment, let us suppose that a public health agency has the resources to improve exactly one of the nine transition probabilities by 10%. For example, it might target persons in the Precontemplation stage and attempt to improve (increase) the probability of making

Transition 1. Potential Intervention 1 is a generic name for an intervention with behavioral goals appropriate to this stage transition. That is, it would be an evidence-based intervention that was known to be effective in moving people from Precontemplation to Contemplation. As mentioned above, about 16% of the persons in Precontemplation will be in Contemplation 2 years later. A 10% improvement in that probability would change that probability to about 18%. By targeting only a portion of the precontemplaters, or by selecting a mix of available approaches at the individual or population level, or a particular frequency or intensity of a message, the potential intervention could be calibrated to

achieve a 10% improvement in the number who move from Precontemplation to Contemplation in the following period.

Similar potential interventions could be imagined for the other arrows in the model. The interventions considered here either increase the probability of making transitions numbered 1, 3, 5, or 7 (the probability of advancing to the next higher stage) by 10%, or decrease probabilities numbered 2, 4, 6, 8, or 9 by 10%. Interventions 1 to 5 all target current smokers and so may be thought of generally as smoking cessation interventions. Interventions 6 to 8 deal with former smokers, and so are variants of relapse prevention. Intervention 9 is primary smoking prevention. We next ask which of the nine potential interventions would have the most effect on NSLE, and whether the choice depends on the population's stage of change.

Selecting the Best Public Health Intervention

Suppose the agency can afford only one intervention. If it can improve just one of the probabilities by 10%, which one should it choose? The perspective of reducing health disparities might suggest Intervention 1, which would target the persons with the most need, those in Precontemplation. Traditionally, public health emphasizes prevention (Institute of Medicine Committee, 1988), suggesting that the agency would prefer Intervention 9, which decreases the probability that a never smoker starts to smoke. The health marketing perspective of targeting the markets most ready for action suggests increasing Probability 7 by 10%. Alternatively, the tenet of customer relationship management, which stresses the importance of retaining current customers, suggests that interventions should aim to decrease Transition Probability 8 or 9. We used a modification of the Diehr approach (Diehr et al., 2007) to identify the potential intervention that would result in the greatest NSLE.

Methods

We used available data to estimate the NSLE, using both the original and the "improved by 10%" transition probabilities, and identified the potential intervention that produced the highest NSLE. Additional detail about the data, methods, and analysis is available in a technical report (Diehr et al., 2010).

Data

Longitudinal data on smoking, taken from three studies, were used to estimate transition probabilities. Data Set 1, the largest, included data on 5,553 adults from 11 western U.S. communities interviewed by telephone in up to three waves 2 years apart, for a total of 9,622 assessments of stage of change (Diehr et al., 1995). The first survey wave was in

1988. Ages ranged from 16 to 100, with a mean of 52, but data were sparse below age 40. The data came from a randomized trial of community interventions to improve health behaviors, but smoking was not one of the behaviors addressed. Because no differences were found between the treatment and control groups on any measure, the two groups were combined. Stages of change were operationalized as follows: Precontemplation: no quit attempts in the past year; Contemplation: one to two quit attempts; Preparation: three or more attempts; Action: abstained <1 year; Maintenance: abstained >1 year; Never Smoker: smoked <100 cigarettes in lifetime. Because the data set had no information about intention to quit, we had to operationalize the Precontemplation and Contemplation stages according to the number of quit attempts rather than by the stated intention to change. For this reason we used two additional observational data sets.

Data Set 2 followed 545 ever smokers, assessing their stages of change at 6-month intervals, and the transition probabilities have been published (Martin, Velicer, & Fava, 1996). Data Set 3 included information on 544 current smokers who were reinterviewed after a median of 21 months (Pizacani et al., 2004). Both data sets were small and were missing some stages. However, both had satisfactory definitions of Precontemplation ("no plans to quit in the next 6 months" or "not thinking of quitting," respectively) and Contemplation ("serious plans to quit in the next 6 months" or "thinking of quitting in the next 6 months") and so were used as a comparison for Data Set 1. Additional information about all three data sets is available in the technical report (Diehr et al., 2010).

Analysis

The data were used to estimate transition probabilities, multistate life tables were constructed, and potential interventions were evaluated.

Transition probabilities. The probabilities of moving from one stage to another in the following wave were estimated separately from Data Sets 1 and 3. We used the average of the published transition probabilities from Data Set 2 (Martin et al., 1996). Because no data set had information about death, we assumed that mortality rates differed by stage, as follows: The age-specific probability of death for persons in Maintenance was set to the national age-specific estimate for men (e.g., the probability of dying in the next 2 years is .00533 at age 40; National Center for Health Statistics, 2004), the probability for the Action stage was 1.5 times as high (.00800), the probability for current smokers was twice as high (.01067), and the probability for never smokers was half as high (.00267 at age 40). The importance of these mortality assumptions was checked in a sensitivity analysis reported later on.

Multistate life tables. The transition probabilities were used to calculate a multistate life table starting at age 40 (data

were sparse below age 40). Briefly, for each hypothetical population (specified by the number of persons in each stage at age 40) the probabilities were used to project the number who would be in each stage 2 years later, 4 years later, and so on. In the same way that a standard life table calculates life expectancy, the multistate life table calculates the expected number of years that a hypothetical population will spend in each stage in the future. More detail is given in a later section.

Potential interventions. We evaluated nine potential interventions, one for each arrow in Figure 1. Each intervention would improve one of the transition probabilities by 10% (an arbitrary amount). The improved transition probabilities were used to calculate new multistate life tables, and the expected number of years spent in each stage was compared with results from the other potential interventions. Note that some of the transitions and thus the potential interventions are more complicated than they appear. For example, Potential Intervention 9 lowers the probability that Never Smokers will be in Maintenance 2 years later. This transition actually requires that the Never Smokers start to smoke (perhaps moving first to Precontemplation) and later quit smoking, eventually ending up in Maintenance. This sequence can easily occur in the 2 years between survey waves. Similarly, persons cannot move from Maintenance directly back to Action, because they must first start to smoke again and then stop. Remaining in Action (as a short-term quitter) requires relapsing and then quitting again.

Comparison of the potential interventions. For each data set, we estimated the effect of each intervention in hypothetical populations where everybody was in the same stage at age 40 (e.g., an initial population of 100,000 Precontemplaters), and also in a hypothetical population distributed proportional to the actual distribution of the data. The primary outcome was the NSLE; that is, the number of years expected to be spent in the Maintenance and the Never Smoker stages. There were two secondary outcomes. One was life expectancy after age 40, which is straightforward. The third outcome, called the "partial credit sum," gave some credit for the number of years spent in every stage but gave more credit for the more desirable stages. This type of outcome is often used in evaluations with short follow-up, where the most that can be expected is that persons move to a higher stage, not necessarily that they achieve Maintenance. Three different time horizons were considered: lifetime (from age 40 to 100), 10-year (ages 40 to 50), and 4-year (ages 40 to 44).

We expected all three data samples to be positively selected because healthy volunteer bias was likely, and because attrition was higher for smokers (Diehr et al., 1995). In addition, the probability of a never smoker starting to smoke was higher than we had expected (about 5%). To determine how sensitive the findings were to biases in the transition probabilities, we studied sensitivity of the findings to large changes in the probabilities of remaining

in Precontemplation, in Maintenance, or as a Never Smoker, and also in the probability of dying. This is explained further below.

Results

Transition probabilities were estimated and used to calculate multistate life tables, which estimated the NSLE for each potential intervention. The outcomes of the different potential interventions were compared.

Transition Probabilities

Table 1 shows the raw transition probabilities for the 9,622 observations in Data Set 1. For example, row 1 shows that the 993 persons in Precontemplation at Time 1 had about a 63% chance of still being in Precontemplation 2 years later but a 16% chance of moving to Contemplation and a 6% chance of moving to Maintenance. Note that because of the 2-year interval between survey waves, every transition was logically possible except for being in the Never Smoker stage.

Persons in the Precontemplation, Maintenance, or Never Smoker stages at Time 1 were most likely to be in that same stage at Time 2, but those in Contemplation, Preparation, or Action were more likely to have changed stages. More than half (5,113) were never smokers, and 95.4% of them were never smokers 2 years later. The 2-year smoking initiation rate was thus nearly 5%, and was similar at all ages (not shown). Of the 1,661 current smokers, 993 (60%) were initially in Precontemplation. Transition probabilities for the other data sets are shown elsewhere (Diehr et al., 2010).

Multistate Life Tables

All three sets of transition probabilities were used to estimate the trajectory of hypothetical populations consisting of 100,000 persons who were all in a single stage at age 40. For example, Figure 2 shows the projected distribution of stages over time (age) of a hypothetical population of 100,000 persons who started out in Precontemplation (bars with vertical stripes) at age 40. Based on the probabilities in Table 1, a total of 63,200 would still be in Precontemplation 2 years later, 15,900 would have moved to Contemplation, and so on. (Because Figure 2 was actually calculated using age-specific transition probabilities and included the probability of death, the plotted results are slightly different.) Those in each stage at age 42 were then redistributed, according to the relevant probabilities for that stage, to obtain the expected numbers who would be in each stage at age 44, and so on.

The number in Maintenance (the clear bars) increases until about age 62, after which it declines as more persons die. Life expectancy (the area under the highest curve) is 35.6 years. The area under the lowest curve (the clear bars) is the
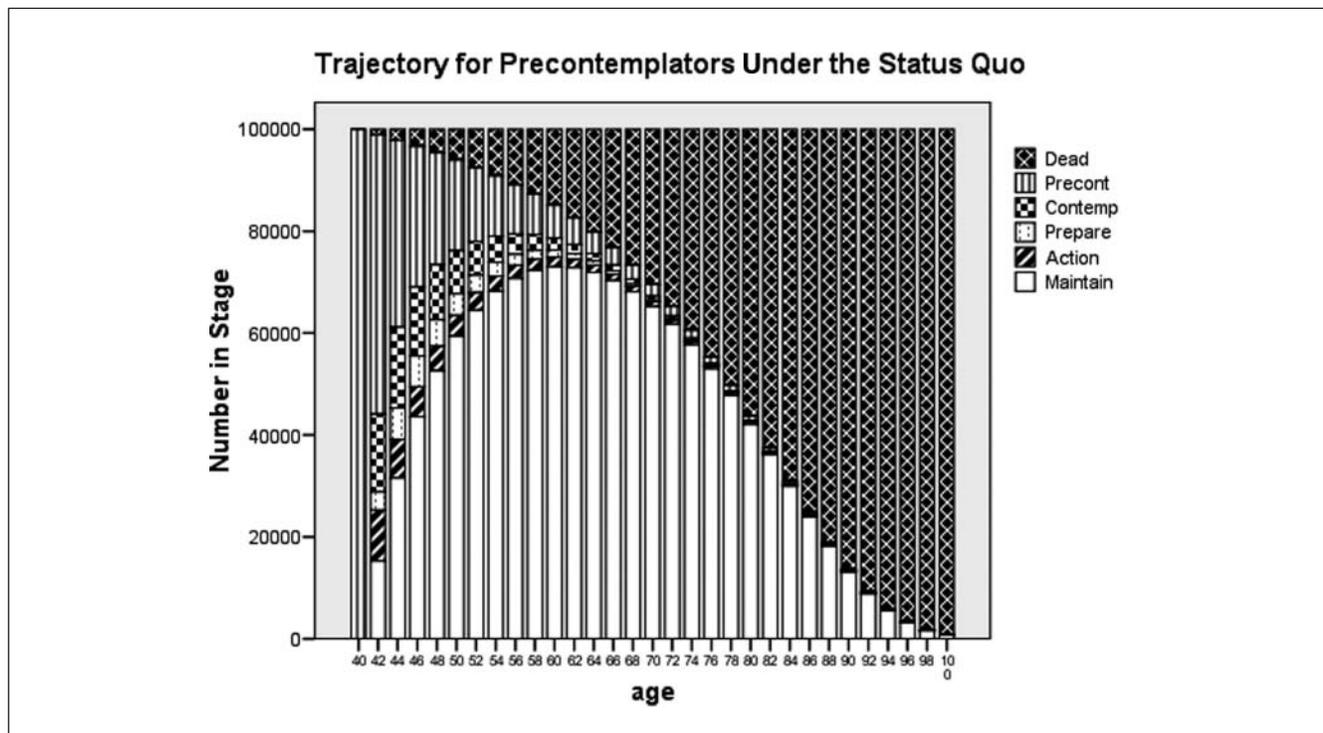
Figure 2. Trajectory of a hypothetical population all in the Precontemplation stage at age 40.

expected number of years spent in Maintenance, 26.0 years (the NSLE for this initial population). Thus, even with this unfavorable distribution of stages at age 40, the great majority of person-years are expected to be spent in the Maintenance stage. For a general population that also included never smokers, life expectancy was 38.1 years, of which 23.2 years were spent in Maintenance and 11.8 years in Never Smoker; thus, NSLE = 23.2 + 11.8 = 35.0 years (not shown).

Comparison of Potential Interventions

The interventions that maximized NSLE in various situations are shown in Table 2. Each row represents a different initial population at age 40; the columns represent the three data sets. Lines 1 through 6 show results for hypothetical populations that include only current and former smokers, and lines 7 and 8 include Never Smokers. For example, for an initial population in which everyone started in Precontemplation (Line 1), Intervention 7 (which increases the probability of moving from Action to Maintenance by 10%) had the highest NSLE for all three data sets.

The primary results are in column 1. Potential Intervention 7 was best for all the hypothetical populations that were restricted to current and former smokers (Lines 1 to 6), and 9 was best when never smokers were included (Lines 7 and 8). The consistency of the results is remarkable. The intervention

Table 2. Potential Intervention Yielding the Highest Nonsmoking Life Expectancy

Line No.	Initial Distribution of Stages at Age 40	Data Set		
		1	2	3
1	All in precontemplation	7[c]	7	7
2	All in contemplation	7[d]	7	7
3	All in preparation	7[d]		7[a]
4	All in action	7	7	7
5	All in maintenance	7[e]	8	8
6	Proportional to baseline	7	7[b]	7
	Includes never smokers			
7	All in never smoker	9		
8	Proportional to baseline	9[f]		

Note: The tabled number is the intervention number that maximized the NSLE. *Lines 6 and 8:* The distribution among stages is proportional to the baseline distribution (Table 1). Only Data Set 1 included Never Smokers. Superscript letters denote situations where the best potential intervention was different from the tabled result for different outcome measures or sensitivity analyses: *Other outcomes:* partial credit sum outcome, a = Intervention 5 was best; survival outcome (60 years horizon only), b = Intervention 8 was best. *Sensitivity analyses* (evaluated for Data set 1 only): 5 times as many persons remain in Precontemplation at next wave, c = Intervention 1, d = Intervention 2, e = Intervention 8 was best; mortality is the same in all stages, f = Intervention 7 was best.

effects were usually small. For example, the best intervention for the population in Line 8 increased the NSLE by only 2 months (data not shown).

Data Sets 2 and 3 were too small to permit estimation of age-specific transition probabilities and were missing important stages. They did, however, have better definitions of precontemplation and contemplation than Data Set 1, and Data Set 2 had 6 months between survey waves as compared to the 2-year spacing in the other data sets. The close agreement of the three columns in Table 2 suggests that the findings are not sensitive to the exact definitions of the stages nor to the length of time between the survey waves.

Using different outcome criteria occasionally found a different intervention to be best (superscript letters a and b in Table 2). Results using the shorter time horizons usually supported those for the 60-year horizon. The few discrepancies denote situations in which a short-term evaluation using the partial credit sum outcome could result in selecting a less effective intervention, one that does not maximize the NSLE.

We conducted sensitivity analyses to examine the effect of a large change in three of the key probabilities. When the probability of remaining in Precontemplation was increased from .63 to about .85 (it varied by age), there were a few differences in the preferred intervention, indicated by superscript letters c, d, and e in Table 2. Potential Intervention 1 would be chosen if the population all started in Precontemplation, 2 if all were in Contemplation or Preparation, and 8 if all were in Maintenance at age 40. Thus, if the probability of remaining in Precontemplation is much higher than the data show, *and* if the population is all in Precontemplation or Contemplation at age 40, interventions targeting those stages would be more effective. Further sensitivity analyses that decreased the probability of remaining in Maintenance or of smoking initiation did not change any of the comparative results in Table 2. To determine whether the strong assumptions about mortality affected the results, we repeated the primary analyses letting all stages have the same age-specific mortality rate. The only discrepancy was on Line 8 (superscript f), where Intervention 7 would be chosen instead of 9.

Discussion

Summary

As a thought experiment, we used the stages of change model, modified to include segments for never smokers and for death, to define homogeneous segments of a hypothetical population. If public health efforts were restricted to improving just one of the transition probabilities among the stages, which intervention would yield the highest NSLE? Based on the analysis of three data sets, we found that if the population of interest includes never smokers, Potential Intervention 9 would have the highest NSLE. That is, some form of primary smoking prevention would be best (Line 8 of Table 2). If concern is primarily for the subset who have ever smoked (Lines 1 to 6), then Intervention 7, which increases the probability of moving from Action to Maintenance, would be best *even if the population started out with no one in the Action stage.*

Discussion of Findings

The effectiveness of intervening on nonsmokers, even where there are none, can be better understood by considering Figure 2. Intervention 7 cannot have any effect at age 40, because there is no one in the Action stage. This means that short-term evaluations might not find Intervention 7 to be best. However, there are some persons in Action every year after that, and 59% of them next move to Maintenance, from which they have only a 5% chance of relapsing in the next 2 years (see Table 1). Increasing Probability 7 by 10%, from 59% to about 65%, was the best intervention, even though the number in Action is always small. This nonintuitive finding demonstrates the importance of examining the transition probabilities.

The relatively poor performance of the interventions that target current smokers (1 to 5) may seem surprising, because a person in Precontemplation clearly needs to move from that stage. The 2005 National Health Interview Survey data show that at least half of all smokers made one or more serious quit attempts in a given year (Curry, Sporer, Pugach, Campbell, & Emery, 2007). Unfortunately, 37% of those in Contemplation were back in Precontemplation 2 years later (Table 1). Smokers are thus already likely to try to quit, but often fail to maintain their cessation (Hughes, Keely, & Naud, 2004). Interventions that help them do so will have more population effect than interventions that solely motivate smokers to attempt to quit.

This finding illustrates the difference between the perspective of an individual smoker and the public health perspective. The best intervention for an individual smoker would target only current smokers, possibly using a different intervention for each stage of change. For the population, however, the optimal approach is to target nonsmokers (those in Never Smoker, Maintenance, and Action). That is, the best decision at the individual level does not necessarily "scale up" to be the best decision at the population level, even if the population initially consists only of current smokers. This is due in part to the long-term objective that is appropriate for a public health agency as opposed to the shorter term objective of helping an individual smoker to advance to the next stage.

The usual public health preference for prevention was validated here, because Intervention 9 represents primary smoking prevention and Interventions 7 and 8 are forms of secondary or relapse prevention. The result is also consistent with the principles of social marketing mentioned above, because interventions that targeted the Action stage (most likely to change) and the Maintenance or Never Smoker stages (current customers) were found to be the best.

Limitations

The strong consistency of the results for the three data sets suggests that results were not sensitive to the age of the data, the exact definitions of the stages, or the length of time between survey waves. The sensitivity analyses suggested that the findings are insensitive to moderate biases in the estimated transition probabilities. The findings were also consistent for greatly different initial population distributions (the various lines in Table 2), which suggests that the initial distribution of stages is not very important. Younger persons, who may be the greatest public health concern, were not formally addressed. However, it is likely that the comparative results would be much the same because the higher smoking initiation rate at younger ages would make prevention even more desirable. A public health agency would rarely be able to identify which members of the population were in each stage of change. Fortunately, the results suggest that agencies should target nonsmokers, who are the majority of the population in this country. Even untargeted prevention interventions will reach primarily that segment.

Interventions that change more than one transition probability at a time were not considered here. A successful intervention may modify social norms, which may further improve transition probabilities, and this possibility was not considered. The analysis implicitly assumed that all interventions had the same cost, but this may not be the case. For example, Intervention 7 was 7 times as effective as Intervention 1 (not shown), but Intervention 1 might still be preferred if Intervention 7 was more than 7 times as expensive. Dealing properly with cost-effectiveness will require actual rather than potential interventions. We also did not formally discount the NSLE, but our consideration of shorter time horizons is conceptually similar to discounting. Failure of the transition probabilities to meet the usual Markov assumptions may lead to biased estimates of NSLE, but this bias should be about the same for all the interventions, and should not have affected the comparative results. Although the transition probabilities from the three data sets may shed some light on whether the movements among stages fit the assumptions of the stages of change model, such an analysis was outside the scope of this study.

Implications for Practice and Research

Practitioners trying to help an individual smoker to quit should continue to do so, perhaps with greater emphasis on relapse prevention. The major implications of this research are for public health agencies. Interventions that focus on primary smoking prevention or on relapse prevention are likely to be the most effective in achieving the public health objective of increasing the NSLE, independent of the initial stage distribution of the population.

Although this analysis was framed in terms of public health interventions, the findings should be relevant for choosing interventions for other types of populations, such as health plan enrollees, schools, or workplaces. Policies that reward and encourage nonsmokers, former smokers, and recent quitters may be more effective in increasing NSLE than programs that merely motivate current smokers to consider quitting.

The results may also be relevant for other health behaviors. For example, if this pattern of results held for obesity control interventions, a public health agency's interventions would do best to target persons who already exercise, eat appropriately, and are at a healthy weight and help them maintain these behaviors rather than target persons with less healthful behaviors. It would be interesting to conduct this research.

There is a further implication for researchers who conduct randomized trials to compare existing interventions. Evaluations are necessarily of short duration, and statistical power considerations often require using something like the partial credit sum as the outcome measure. Researchers should be aware that such study designs may not identify the intervention that maximizes the NSLE and so should aim for longer follow-up where possible.

Conclusions

The relatively low rates of smoking in the U.S. population are a tribute to current public health strategies, and persons in Precontemplation are already likely to reach Maintenance. Incremental public health interventions that target nonsmokers (Never Smokers or persons in Action or Maintenance) may be more effective than interventions that target current smokers (those in Precontemplation, Contemplation, or Preparation) in increasing the nonsmoking life expectancy for the population of interest. This result would have been predicted by some principles of social marketing. The individual and the public health perspectives may suggest different intervention choices, and both perspectives need to be considered. Further research is needed in different and younger populations and for different health behaviors.

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