Break-Even Efficacy of the New Brunswick Heart Health Promotion Campaign

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Abstract:
While it may never be possible to accurately determine the effectiveness of a health promotion campaign, it seems clear that given adequate levels of funding, a healthy lifestyle promotion program should be capable of at least achieving a break-even level of effectiveness.

Article:
CORONARY HEART DISEASE (CHD) POSES A MAJOR burden, both in personal and economic terms, on health care management in North America. For example, CHD is the main cause of premature death and sickness among Canadians aged 35 to 64 years. Even when it does not result in mortality, heart disease still places a substantial burden on health care resources. For example, in 1990, 20 percent of hospital care days, or approximately 8 million days, were due to heart disease alone. The cost of treating heart disease topped C$16 billion in 1986 and has been on the rise ever since.[1] Figures for the United States (U.S.) portray a similar picture.[2]

Perhaps as a result of this, over the past two decades there has been widespread implementation of what have been termed “community-” or “population-” based CHD prevention programs, in the U.S., Canada and elsewhere. These primary prevention programs typically employ some combination of public education, social marketing, community mobilization, health-oriented public policy and environmental modification strategies in an effort to encourage target groups to adopt healthy lifestyle changes such as smoking cessation, dietary modifications and increased physical activity. The adoption of healthier lifestyles is, in turn, expected to prevent or forestall the onset of physiological risk factors which may subsequently lead to heart disease. The rationale for the population-based approach to heart disease prevention is based on the fact that when large segments of the general population are involved, even modest treatment effects (i.e., lifestyle changes) are likely to yield significant reductions in heart disease rates. Furthermore, from an economic perspective, the average or per capita cost of this approach is relatively low because there are neither case-finding nor individualized-treatment expenses. However, such programs have to be adopted and implemented with long-term prospects in mind. Although initial beneficial effects of such programs may start occurring soon after their initiation, studies have shown that it takes several years, anywhere upwards of five, for such behaviour modifications to reduce public health risk substantially.[3] Nonetheless, such programs have received wide attention in the public health literature in the recent past,[4] including criticism.[5]

The New Brunswick (N.B.) government's *Heart Health Promotion Program* (NBHHP)[6] is an example of one such heart health promotion campaign that adopts a primarily population-based approach, involving the mass media and several professional and community groups. The mass media are involved through the provision of advertising which encourages a lifestyle of nutritious food, exercise, moderate alcohol intake and abstention from tobacco use. Professionals and community organizations, such as physicians, teachers and the YMCA, are also involved in the program, by encouraging heart health promotion activities and offering programs that focus on heart health.

Assuming that the Program has already been in place long enough for its behaviour modification effects to have started and to continue well into the future from the period of study, we analyzed the economic break- even efficacy of this model over a 12-year period. In other words, our economic analysis is based on a 12-year snapshot of an ongoing program that is in its "steady state." Such a long time horizon of analysis was purposely chosen to improve the accuracy of our results, particularly in view of the gradual nature of the accrued benefits of a population-based prevention program.

Notwithstanding the rationale for our time horizon, our approach focuses on first estimating the net savings to the Province of N.B. from this health promotion campaign in terms of treatment costs that are forgone and the savings that are made in productivity by workers taking fewer days off due to ill health. This estimation is done by our proposed model that utilizes various socio-economic data from the Province as an input. Having predicted the net savings, we then compute the level of efficacy that this heart health promotion program would have to achieve for the future cost savings expected from the Program to break even with the costs of implementing the program. This estimated "break-even efficacy level" then serves as a basis for a qualitative assessment of the economic feasibility of the Program.

In addition, we also propose a new model which uses the estimated break-even efficacy level to determine the optimal budget allocation for this heart health promotion program. Our primary conclusions from the study indicate that (a) heart health promotion campaigns are an extremely cost-effective way of controlling health care costs; and (b) given the assumptions of our optimization model, these campaigns are significantly underfunded in N.B. at this time.

METHODOLOGY

We began the study, modelled along the lines of the NBHHP, by estimating the maximum health and economic benefits possible from implementation of a 100 percent effective heart health promotion program in a target segment of the N.B. population. The period of study for this break-even analysis was assumed to be 12 years. Maximum health benefits, defined as the number of CHD cases which could be avoided over a 12-year period, were calculated using the Framingham CHD risk prediction model.[7] Maximum economic benefits were calculated by multiplying the estimated number of avoidable cases by the treatment and lost productivity costs associated with an average CHD case in N.B. Having determined the maximum economic benefits possible from a 100 percent effective CHD promotion program, we next developed a mathematical function which expresses potential cost savings from CHD prevention as a function of the heart health program's effectiveness. Since a 100 percent effectiveness rate is almost always unachievable, this cost-effectiveness relationship was then used to determine the level of effectiveness that the heart health promotion program would have to achieve for potential cost savings from the Program to break even with its implementation costs. In keeping with standard economic practices, whenever future costs or savings were needed to be reduced to their present values, a discounting rate of five percent was used.

Target population

New Brunswick is a small province on Canada's east coast, with a total population of approximately 760 000. The target population for CHD prevention programs typically consists of individuals between 30 and 74 years of age because CHD is rare in younger age groups and primary prevention efforts are less effective in the very elderly. In N.B., this 30- to 74-year-old target population includes approximately 360 000 individuals. A sample of 967 individuals (480 males and 487 females) from this target population was derived from the 1989 *New Brunswick Heart Health Survey* (NBHHS) *Report*.[8] This report is based on the NBHHS conducted in 1988 which consisted of a stratified random sample of approximately 2000 N.B. residents between the ages of 18 and 74. It included a wide variety of heart health related knowledge, behaviour and physiological measurements as well as demographic information for each subject. The sample for the study consisted of all NBHHS participants who: (a) were between 30 and 74 years of age; (b) had no history of coronary heart disease; and (c) had records which included all of the physiological measures required by the Framingham risk equations.

Calculation of maximum health benefits

As a first step in estimating the maximum potential health benefit from a 100 percent effective heart health promotion program, the Framingham risk prediction model, as described by Anderson et al.,[9] was used to calculate the expected incidence of CHD (i.e., number of new cases) in the target population over a 12-year period, assuming that the prevalence of major CHD risk factors remained at their 1988 levels. The Framingham model begins by calculating an individual risk score which is a function of each subject's diastolic blood pressure (DBP), cigarette smoking (defined as smoking one or more cigarettes per day),10 ratio of total serum cholesterol to high density lipoprotein (HDL cholesterol), and history of left ventricular hypertrophy (LVH). In subsequent steps, the individual's sex, age and history of diabetes are factored into the model. Finally, the desired time period (in this case 12 years) is entered into the equation and an estimate of that individual's probability of developing CHD within the specified time period is calculated. After calculating a 12-year CHD morbidity estimate for each of the 967 subjects, the sample results were extrapolated to the entire target population by multiplying each subject's 12- year CHD morbidity estimate by the number of persons they represent in the target population, as obtained from the NBHHS. Summation of these weighted 12-year CHD morbidity probabilities provided an estimate of the number of persons in the target population who were likely to develop CHD over the 12-year observation period.

The second step in estimating the maximum health benefit possible from a heart health promotion program involved modelling the effects that 100 percent adoption of recommended healthy lifestyle changes would likely have on the prevalence of major CHD risk factors in the target population. To calculate the impact of 100 percent adoption of heart healthy lifestyle changes, we began by identifying the healthy lifestyle changes that subjects in the target group could benefit from. Subjects were defined as being candidates for smoking cessation if they were regular smokers; candidates for dietary modification if they had a Body Mass Index (BMI) greater than 26; and candidates for increased physical activity if they did not engage in regular physical activity. Approximately 80 percent of the target population was identified as being candidates for one or more types of lifestyle change. Table 1 gives the percentages of the sample defined as being candidates for the various combinations of healthy lifestyle changes.

Smoking cessation was defined as complete abstinence from cigarette smoking. Dietary modification was defined as adherence to a diet similar to that recommended by the American Heart Association in 1988[11] – i.e., approximately 55 percent of total energy from carbohydrates and 30 percent from fat, with saturated fat reduced to 10 percent or lower, dietary cholesterol below 300 mg per day and sodium intake less than 3 g per day. Increased physical activity was defined as regularly

table 1: breakdown of sample by type of lifestyle change recommended

Recommended modification	Percentage of sample
No Changes Required	20.2
Smoking Cessation (SC)	11.5
Dietary Modification (DM)	21.3
Increased Activity (IA)	16.6
SC + DM	9.1
SC + IA	4.7
DM+ IA	13.3
SC + DM + IA	3.3

engaging in activity of moderate intensity – i.e., enough to expend approximately 200 calories per day. We consulted the scientific literature to determine the probable effects that adoption of these healthy lifestyle changes would likely have on the modifiable CHD risk factors (i.e., smoking, diastolic blood pressure (DBP), diabetes, total and HDL cholesterol) in individual subjects. Since our model is intended to reflect the "probable" impact of voluntarily adopted healthy lifestyle changes in a target population, we generally utilized the more conservative estimates of the effects of the various lifestyle changes found in the clinical literature.

In the third step of the post-behaviour-change morbidity calculation, subjects' risk-factor levels were adjusted to reflect the estimated impact of 100 percent adoption of all recommended lifestyle changes. For example, all subjects who were regular smokers had their smoking status changed to that of a non-smoker; diastolic blood pressure was reduced in subjects who were identified as being candidates for dietary modification and/or increased physical activity; TCH (Total Cholesterol) was reduced in subjects who were identified as candidates for dietary modification and/or increased physical activity, and so on. The results of this modelling exercise yielded a "post-behaviour-change" risk-factor profile for the target population sample. Each individual's new risk-factor profile was then entered into the Framingham equations and a second or postbehaviour-change estimate of CHD incidence in the target population was calculated using the weighting given in table 1. The maximum number of CHD cases which could be avoided through healthy lifestyle changes was determined by finding the difference between the first or prebehaviour-change CHD incidence estimate and the postbehaviour-change CHD incidence estimate.

Calculation of maximum economic benefits

The maximum economic benefits possible from implementation of a 100 percent effective heart health promotion program were calculated by estimating the annual treatment and lost productivity costs for an average CHD case in N.B. and then multiplying those cost figures by the number of years of symptoms which could be avoided if 100 percent of the target population were to adopt and maintain all recommended lifestyle changes. We calculated the treatment and lost productivity costs associated with CHD by following the approach that Wigle et al. developed to calculate the economic burden of cardiovascular disease in Canada. [12] First, we estimated the total annual direct treatment costs due to CHD in N.B. Second, we estimated the prevalence of CHD in the 18- to 74-year-old population. This prevalence estimate was then used to calculate the average annual cost of treating an individual CHD case in N.B. Third, we estimated the total annual lost productivity costs associated with CHD. Lastly, we used the CHD prevalence estimate for the 30- to 64-year-old population to calculate the average annual lost productivity costs associated with an individual CHD case in N.B.

RESULTS

To apply the methodology discussed in the previous section to our model, we calculated the various input data for the target population in N.B. Then, we applied this data to a model that we developed for that population to predict the total savings to the Province as a function of the success rate of our health promotion campaign. As is typical of most pilot studies, the specific data for the province of N.B. was unavailable in one case; consequently, we extrapolated similar data available from a nationwide study.

Maximum health benefits – As per the steps described above, the Framingham model was used to predict the number of CHD cases avoidable through the adoption of healthy lifestyle changes. We validated our results by comparing them against similar data available for the neighbouring province of Nova Scotia, whose socioeconomic profile is similar to that of N.B. Doing so, we found that the maximum number of CHD cases that could be avoided over the 12-year prediction period – if 100 percent of the target population adopted and maintained all recommended lifestyle changes – is:

7166 cases over 12 years (1)

We used the number defined in (1) for future calculations. However, before proceeding further, we noted a subtle, nonetheless important, assumption. Exactly how long it takes for individuals to realize the benefits of reduced heart health risk behaviour is largely dependent on the individuals themselves; this fact poses an analytical problem for any break-even study. To circumvent this problem, we performed a "steady-state analysis" of an ongoing heart health management program. In other words, we assumed that the intervention program has been in existence long enough to have actually started generating benefits at the beginning of the period of analysis and, further, that it will stay in existence well beyond the period of study. Hence, an individual case counted in the period of study may actually have been caused by behaviour modification adopted prior to the period of study. By the same token, there may be individuals whose behaviour modification during the period of study may actually accrue benefits only after the period of analysis. However, our assumption of performing a steady-state analysis of an ongoing program is used to "average out" such effects.

Maximum economic benefits – Average annual treatment costs – We estimated the total annual cost of treating CHD in N.B. by calculating direct provincial government expenditures in four main cost categories identified by Wigle et al. [13] As shown in table 2, the Province spends an estimated total of approximately C$44 million annually on CHD treatment.

table 2: annual direct treatment costs for CHD in New Brunswick
(in millions of dollars)

Hospital costs	$27.75
Drug costs	$11.41
Medical care costs	$4.74
Total	**$43.90**

To arrive at an estimate of the average annual cost of treating one CHD case in the target population, the $43.9 million total cost figure was first adjusted to reflect only those costs which are likely to be associated with individuals under the age of 75. Information on hospital separations indicates that individuals over 75 account for approximately 30 percent of all hospital separations due to myocardial infarction in N.B.[14] Therefore, we assumed that individuals over 75 account for 30 percent of the Province's total annual CHD treatment costs and that individuals under that age account for the remaining 70 percent. This adjustment yields a total annual treatment cost of approximately $30.73 million for the under-75 population. Based on results from the NBHHS, we estimated that 8.9 percent (10.9 percent males and

7.1 percent females) of the 30- to 74-year-old population (32 761 individuals) had some form of CHD which requires ongoing treatment. Dividing the adjusted total annual treatment cost figure $30.73 million by the estimated number of CHD cases in this age segment yields an:

$$\text{Annual average treatment cost estimate} = \$938 \text{ per case} \qquad (2)$$

Since the treatment cost savings associated with avoiding the onset of CHD symptoms are expected to be realized over a 12-year period, it would typically be necessary to discount the future cost savings to reflect the fact that they will not accrue until some time in the future. However, on the basis of its past performance (for the past decade, the Consumer Price Index for health care has outpaced the average inflation rate by more than one percent per annum), the inflation rate for treatment costs is expected to be at least equal to the overall inflation rate. Hence, we did not discount the anticipated future cost savings in treatment of $938 per case.

Average annual lost productivity costs – In addition to treatment costs, CHD also generates costs in terms of time lost from work as a result of short-term and chronic disability. Wigle et al. have calculated chronic and short-term disability costs for cardiovascular disease (CVD) in Canada.[15] However, similar figures for CHD (a sub-component of CVD) are not available. To approximate short- and long-term disability costs associated with CHD, it was necessary to estimate what proportion of CVD disability costs are due to CHD. Approximately 38 percent of hospital separations due to CVD in N.B. are attributable to CHD.[16] Therefore, the CHD disability costs were assumed to be approximately 38 percent of the corresponding CVD disability costs. To extrapolate the national cost estimate to N.B., the average annual lost productivity per Canadian worker due to CVD ($104.40) was multiplied by the size of the N.B. labour force (315 000 workers)[17] to yield an estimate of the total annual lost productivity costs due to CVD of $32.57 million per year. To estimate the average lost productivity cost per CHD case in N.B., we then divided the lost productivity total for N.B. by the estimated number of CHD cases in the 30- to 64-year-old population[18] as given by the census to obtain the:

$$\text{Average annual lost productivity per CHD case in N.B.} = \$2219 \qquad (3)$$

Model to predict net savings

In the previous discussion, it is predicted that if our hypothetical heart health promotion campaign is 100 percent successful, then the total number of new CHD cases that would be avoided is 7166 over the 12-year intervention period (from (1)). Further, we also computed the average savings in treatment costs (in (2)) and lost productivity (in (3)) for each case of CHD avoided in N.B. We then used these socio-economic data as input to calculate the total savings that would accrue to the Province over the entire 12-year intervention period. The details of the computation will be described fIrst. Then, the entire series of computations is summarized in the form of a generalized model.

We began by calculating the total savings in treatment costs accrued to the Province over the 12-year intervention period. Note from (1) that 7166 CHD cases[19] could be avoided over a 12-year period if 100 percent of the target group adopted and maintained all the recommended healthy lifestyle changes. Assuming, as in Grover et al. ¸20 that the occurrence of avoided cases is uniformly distributed over the 12-year prediction period, the predicted savings in treatment costs can be conceptualized as follows. We know that each case avoided saves $938. In addition, a 100 percent effectiveness will guarantee 7166 fewer cases over the 12-year intervention period, which translates to approximately 597 fewer cases annually for each of these 12 years. The 597 people who do not get sick in the first year of this 12-year period will save the Province $938/case for each of the 12 years of observation. The 597 cases avoided in the second year will similarly save $938 for the last 11 years of observation, and so on. Thus the total savings in treatment costs is:

$$938 \times [\,(597 \times 12) + (597 \times 11) + (597 \times 10) + \ldots + 597\,] = \$43.65 \text{ million} \qquad (4)$$

Next, we computed the total savings in productivity incurred by the Province over the entire intervention period. For this purpose, note that it has already been estimated in (3) that the loss in productivity/worker/ year is $2219. Further, in an effort to keep the estimate conservative, we only considered the 30 to 54 age group as being the ones that will contribute to the savings in productivity. The data from the application of the Framingham model described above showed that 2854 cases can be prevented over a 12-year period in the 30 to 54 age group. Assuming a provincial unemployment level of 15 percent[21] (we deliberately chose a high figure to estimate the savings conservatively), 2426 cases of these represent employed people in whom the incidence of CHD is avoided. Thus, it is these 2426 cases that are assumed to generate the productivity savings over the 12-year period. As before, assuming a uniform distribution, about 202 cases will be avoided for each of the 12 years that will contribute to the productivity savings.

By using the same argument as before, the 202 cases avoided in the first year will each generate a productivity savings of $2219 for each of the 12 years. Unlike treatment costs however, wages have not kept pace with inflation in Canada over the past decade. Thus, there is a need to use a discounting factor for the future savings obtained from the regained productivity. Assuming a discount rate of five percent, and that the productivity savings of any year are accrued at the end of the respective year, the total savings in productivity to the Province that these people generate is:

$$202 \times [\,2219/1.05 + 2219/(1.05)^2 + 2219/(1.05)^3 + \ldots + 2219/(1.05)^{12}\,] \qquad (5)$$

Repeating computations such as (5) for each of the 12 years, it can be seen that if 100 percent of the targeted population switches to a healthier lifestyle, then the total savings in productivity that will be accrued to the Province over the entire 12-year period is:

$$202 \times 2219 \times [\, 1/1.05 + 2/(1.05)^2 + 3/(1.05)^3 + \ldots + 12/(1.05)^{12} \,] = \$23.53 \text{ million} \qquad (6)$$

Hence, the total savings that might accrue over the 12-year prediction period can be easily estimated by adding together the two estimates (4) and (6) obtained above. Doing so, it can be seen that if 100 percent of the target population made all recommended healthy lifestyle changes, then:

$$\text{total cost savings} = \text{treatment cost savings} + \text{productivity cost savings}$$

$$\$67.18 \text{ million} = \$43.65 \text{ million} + \$23.53 \text{ million} \qquad (7)$$

The estimated total cost savings of approximately $67.18 million is a purely hypothetical figure since in the real world we would never expect to see 100 percent adoption of healthy lifestyle changes in a target population. For example, an intervention program which is 50 percent effective would be expected to generate half the cost savings; one that is 25 percent effective, only a quarter of that amount. Therefore, if the effectiveness (denoted as Δ) of a heart health promotion program is defined as the proportion of the target population which adopts and maintains recommended lifestyle changes, then the cost savings likely to be generated by such a program can be defined as below:

$$(\$67.18 \text{ million})\Delta \qquad (8)$$

The above procedure employed to produce (8) can also be generalized in the form of a simple mathematical model that can be used to do similar economic analysis for other heart health promotion campaigns in other populations.[22]

Break-even analysis

Unfortunately, it is extremely difficult, if not impossible, to estimate the effectiveness of population-based heart health promotion programs. However, by using the relationship between program effectiveness and potential cost savings described above, it is possible to estimate how effective our hypothetical intervention program would have to be to recoup the costs incurred to implement it (i.e., to break even). Like its counterparts in the other provinces, the NBHHP was jointly funded by Health Canada and the provincial Department of Health and Community Services over a period of five years. During its mandate, the NBHHP received an average of $400 000 per year in funding.[23] Consequently, we conducted a break-even analysis with the assumption that our hypothetical 12-year intervention program also had an annual funding of \$400 000. Assuming a time value of money of five percent, the present value of this stream of funding can be calculated as an annuity of \$400 000 at five percent over 12 years, and the program implementation cost can be calculated as being equal to \$6.37 million. If Δ_{BE} denotes the break-even efficacy level of the health promotion campaign, then by setting this implementation cost equal to the expression for calculating potential cost savings in (8), we found that:

$$\$6.37 \text{ million} = (\$67.18 \text{ million})\Delta_{BE}, \text{ implying that,}$$
$$\Delta_{BE} = 9.48 \text{ percent} \qquad (9)$$

So the break-even efficacy level of our hypothetical campaign is 9.48 percent over 12 years of operation or an annual effectiveness level of approximately 0.78 percent. In other words, on an annual basis, a program of this magnitude needs to motivate about 0.78 percent of its target audience to adopt and maintain all healthy lifestyle changes in order to break even. In our opinion, whereas the exactness of this number may be subject to debate, particularly in light of our assumptions and approximations, such a low value strongly conveys one conclusion. It underscores the fact that heart health promotion programs only need to effect relatively modest changes in their target populations to generate significant long-term cost savings. For example, to examine the feasibility of achieving this break-even level of success, we observed that the prevalence of regular smoking in N.B. declined by approximately five percentage points between 1988 and 1995.[24] It would appear that population behaviour changes of the magnitude necessary for heart health promotion programs to achieve break-even effectiveness are clearly feasible.

Our conclusion is further corroborated by noting that in the present analysis we have only considered the impact of heart health promotion programs on treatment and lost productivity costs attributable to coronary heart disease. However, the healthy lifestyle behaviours targeted by heart health promotion programs also have a direct impact on the prevalence of numerous other diseases and conditions including many forms of cancer, cerebrovascular disease, hypertension and kidney disease, to name but a few. It is not at all unreasonable to suggest that for every dollar of cardiovascular disease treatment and lost productivity savings generated by a heart health promotion program, there will be additional savings in treatment and lost productivity savings associated with other lifestyle-related diseases and conditions. Therefore, when the broad impact of heart health promotion programs on lifestyle-related diseases and conditions is considered, it is not unreasonable to contend that the break-even effectiveness level may be even less than what is required for CVD alone.

This suggests that heart health promotion programs offer an extremely economical means of combating both CVD and a host of other lifestyle-related conditions. Even if the impact of this type of population intervention program is very modest and difficult to distinguish from ongoing secular trends, our research suggests that it will still generate significant long-term cost savings.

Optimal budget allocation

Using the results of the preceding economic analysis, we developed a model for calculating the optimal level of funding for a heart health promotion program in N.B. We began with the most fundamental assumption of our model, namely, the relationship between the success rate of the campaigns and the budgets allocated to them. It is intuitively clear that as we allocate increasing sums of money to health promotion strategies, they can have a greater impact (i.e., their effectiveness may increase). These programs reach their audience through a variety of advertising media such as pamphlets, television and radio spots, advertisements in newspapers and popular magazines, and even through community activities.

However, it is reasonable to expect that although increased exposure to the general public will initially increase the effectiveness of such campaigns, this increase will gradually taper off as the exposure level increases beyond a certain point. One reason for this possibility might be "advertising wear-out" of the targeted population – a phenomenon that is well-recognized in the marketing literature.[25] Yet another reason for such diminishing returns could be that eventually these programs may reach their saturation level of effectiveness (i.e., that group of the targeted population that has the motivation and the discipline to change their lifestyles would have done so, leaving the others unchanged).

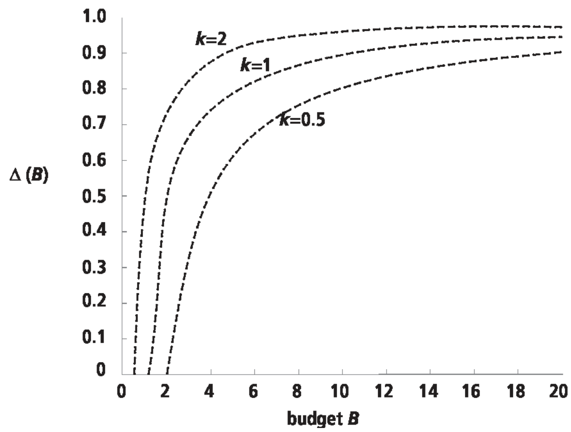
Nonetheless, as the first step, we needed a precise mathematical expression that related the budget allocated to these programs to their final level of effectiveness. Further, this relationship should accurately mirror this behaviour of diminishing returns. We therefore assumed for our analysis that over the entire 12-year intervention period, if the total budget allocated to these health promotion campaigns were \$$B$ million, then the resulting level of effectiveness that could be achieved over the entire intervention period, that we denote $\Delta(B)$, is given as:

$$\Delta(B) = 1 / kB \quad \text{where} \quad B \geq 1 / k \qquad (10)$$

The factor k refers to the *Responsiveness Index* of the targeted audience and measures how responsive this audience is to such campaigns. The higher the value of k, the lower will be the budget required to achieve a desired level of effectiveness. In other words, a high value of k will represent an audience that is highly receptive to health promotion campaigns, thereby making it easier for the Province to mold the behaviour of the targeted population through these campaigns. In practice, we would expect this responsiveness index to be determined primarily by the socio-economic characteristics of the targeted population such as education levels, income levels, etc., and to be outside the control of the agency responsible for implementing the health promotion campaigns. Based on these arguments, it was assumed to be a constant in our model.

As an illustration, see figure 1 where the function $\Delta(B)$ has been shown for three values of k, namely, k = 0.5, 1 and 2. This demonstrates that for the same budget, a higher value of the responsiveness index guarantees a higher level of success. As a final point, note that for the results of (10) to be meaningful, the annual budget B must be at least ($1/k$) – hence, we assumed that this is always the case.

figure 1: relationship between effectiveness level and allocated budget



One of the key problems with using (10), however, is that the exact value of the responsiveness index (*k*) for the N.B. population is not known and may be difficult to measure. But, it can be estimated in the following simple way. As mentioned above, the assumed present level of funding for our program is $400 000 per year. At a discounting rate of five percent, this amounts to a total implementation cost of $6.37 million over the entire 12 year period; hence $B = 6.37$. If we let $\Delta present$ denote the present level of effectiveness of our hypothetical campaign over the entire 12-year horizon of study, then by substituting the present value of *B* back into (10), we can see that for the N.B. population, the value of the responsiveness index is equal to:

$$k = 0.157 / (1 - \Delta_{present}) \qquad (11)$$

Thus, if a pilot study shows that the health promotion campaign in N.B. is only breaking even, i.e., its present level of effectiveness is 9.48 percent over the 12-year period, then, by (11), the responsiveness index for the targeted population in N.B. is equal to 0.1734. We then obtained a relationship between the optimal 12-year budget in millions of dollars, denoted by B_{opt}, and $\Delta present$. Note that the 12-year level of effectiveness, namely, $\Delta(B)$, is given by equation (10). Given that, some elementary mathematical operations[26] allowed us to deduce that the optimal 12-year budget was related to $\Delta present$ in the following way :

$$B_{opt} = 20.68 \left(\sqrt{1 - \Delta_{present}}\right)$$

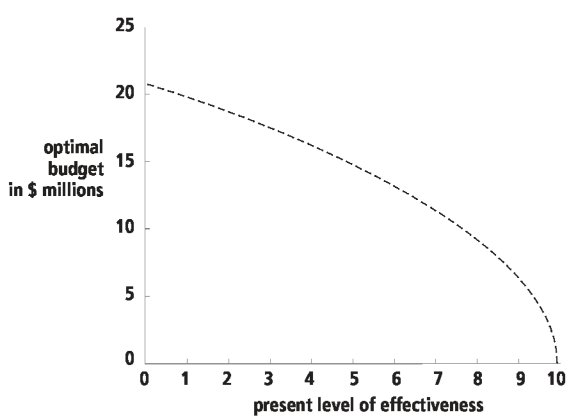
where B_{opt} is the optimal 12-year budget in $ millions
and $\Delta_{present}$ is the present level of effectiveness of the program (12)

Based on this, we concluded that:

- If the assumptions of our mathematical model were correct, then the optimal budget for a population- based heart health promotion program would be a decreasing function of its expected level of effectiveness. This stands to reason, since the more responsive the target population is, the less resources will be required to achieve a given level of program effectiveness.

- The optimal budget for a heart health program such as NBHHP would be no higher than $20.68 million over a 12-year period. Discounted at a five percent rate, this amounts to a funding level of $1.3 million annually, or approximately $3.60 annually for each individual in the target population. By the definition of optimality, this is the budget amount that will maximize the program's cost-effectiveness, i.e., generate the greatest cost savings per implementation dollar spent, when the responsiveness index of the population is very close to zero (i.e., the targeted audience is highly unresponsive).
- Perhaps the most interesting observation from figure 2 is that the current annual budget of $400 000 of N.B.'s heart health promotion program is optimal only if the expected level of program effectiveness is very high, approximately 90 percent over the entire 12-year period. While the effectiveness level of population-based healthy lifestyle promotion programs in N.B. is unknown, it is virtually certain that such a high effectiveness rate is impossible. According to our model, this implies that NBHHP, with its funding of $400 000 per annum or approximately $1.10 annually for each individual in the target population, was *significantly underfunded*. For example, if the program is assumed to be only breaking even for the 12-year program scenario, i.e., $\Delta present$ = 9.48 percent, then, by equation (12), the optimal budget for the Program should be about $1.23 million annually, or $3.40 per year for each individual in the target population. It can be verified that given a 12-year effectiveness rate of 9.48 percent and funding of $3.40 per person per year, the program would break even and still generate a net treatment and lost productivity savings of about $28.19 million over the 12-year intervention period.

figure 2: optimal budget (in $millions) and present effectiveness level



There is very little information in the scientific literature concerning the cost of implementing effective population-based CVD prevention programs or their optimal levels of funding. Pearson et al.[27] have suggested that a CVD prevention program could be mounted for about $0.75 per capita per year in developing countries where implementation costs are assumed to be much lower than in the industrialized world. Kottke et al.,[28] drawing on information from the North Karelia Project[29] have estimated that the cost of an effective population-based CVD prevention program in the U.S. is likely to be approximately $20 per person per year. Recent

Canadian estimates[30] suggest that population-based heart health promotion programs can achieve modest reductions in CHD risk factors at a cost per person of between $3 and $30 per year, depending on the level of intervention. Based on these estimates of probable implementation costs, the $3.40 per person per year funding level predicted by our optimization model appears to be close to the cost that we would expect to incur in order to implement a relatively low intensity population-based heart health promotion program designed to yield modest (i.e., break-even level) population lifestyle changes.

Conclusions and recommendations

In these days of increasing fiscal restraint, spending scarce health care dollars efficiently is one of the prime concerns of all levels of government and the health care industry. Since heart disease accounts for a substantial portion of the health care costs in Canada and the U.S., any savings resulting from a decreased CHD incidence would be of significant benefit. One way to reduce the incidence of heart disease is by primary prevention through population-based heart health promotion programs. However, the effectiveness of these programs has been difficult to evaluate, and although relatively inexpensive on a per capita basis, these programs still require a substantial investment which should be based on sound cost-effectiveness considerations.

We have demonstrated a method of examining the potential cost effectiveness of a typical population-based heart health promotion program in N.B. and have attempted to quantify the level of effectiveness that such a program would have to achieve to make it a cost- effective health promotion strategy. Our analysis suggests two important conclusions:

- It is clear from our study that population-based heart health promotion programs are a very cost-effective strategy for improving population health and reducing treatment and lost-productivity costs. Even at very modest levels of effectiveness, this type of program is capable of generating significant longterm cost savings. For example, our estimates show that in N.B., for every one percent of the 30- to 74- year-old target population which adopts and maintains a heart healthy lifestyle, the Province will save approximately $0.67 million in forgone treatment and lost-productivity costs over a 12-year period. While it may never be possible to accurately determine the effectiveness of this type of health promotion program, it seems clear that given adequate levels of funding, a healthy lifestyle promotion program such as our 12-year program should be capable of at least achieving a break-even level of effectiveness (e.g., as little as 0.8 percent annually) which will generate long-term cost savings sufficient to offset program implementation expenses.
- If the assumptions of our mathematical budget optimization model were accurate, then the current level of funding for heart health promotion in N.B. (i.e., approximately $1 per individual in the target population) would be optimal only if the expected level of effectiveness of these programs is extremely high (approximately 90 percent). Since this is almost certainly not the case, it would appear that in all probability, heart health promotion is probably significantly underfunded in N.B., and that the Province could substantially increase its long-term treatment and lost-productivity cost savings by devoting more resources to heart health and healthy lifestyle promotion initiatives. Our

theoretical model suggests that the optimal budget for an ongoing heart health promotion program in N.B. would be approximately $1.23 million annually or $3.40 per individual in the target population.

As this is a first pass at this highly challenging and complex problem, there are numerous avenues for further research. Among the most immediate would be to fine-tune the optimization model and supplement it with more empirical work. Another interesting strand of future research could be to use the economic evaluation approach that we used to look at cost-effectiveness issues in other areas of health promotion and disease prevention. Although the results of this study apply specifically to the N.B. population, we believe that the same economic-evaluation strategy can be used, with minor modifications, to conduct similar studies on a wide range of health care-related issues where costs and savings can be estimated but treatment effects are difficult to quantify.

notes

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18. The number of cases in the 30- to 64-year-old population was estimated from NBHHS and used in this calculation because less than two percent of CHD cases occur in individuals under 30 years of age; and it was assumed that since the majority of individuals over the age of 65 are likely to be retired, there are no lost productivity costs associated with CHD cases in this age segment.

19. For the sake of conceptual simplicity, the impact of population behaviour change on the onset of CHD symptoms is described in terms of avoided cases. However, it may be more accurate to describe the predicted changes in CHD incidence in terms of “case equivalents” where a case equivalent is defined as 365 days of avoided symptoms. Although the results are presented as if each case equivalent represents one individual, in reality each case equivalent may consist of multiple individuals. For example, 365 days of avoided symptoms could consist of two months of symptom avoidance in six individuals, one day of symptom avoidance in 365 individuals or any similar combination.

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