

Evaluating the Public Health Impact of Health Promotion Interventions:

The RE-AIM Framework

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Abstract

Objectives and Rationale: Progress in the area of community-based and public health interventions has been hampered by the lack of a consistent, comprehensive framework appropriate to these kinds of programs. Multi-level interventions that incorporate policy and environmental interventions as well as those with an individual focus often are not amenable to classic randomized double blind, dose-response evaluations. They must be evaluated using measurements suited to their goals and purpose.

Methods and Results: This paper proposes dimensions for such measures: The RE-AIM framework focuses on Reach, Efficacy, Adoption, Implementation, and Maintenance dimensions for evaluating a public health intervention. The central thesis is that these dimensions, which occur at different levels (e.g., individual, clinic or organization, community), some of which are rarely evaluated, interact to determine the overall public health or population based impact of an intervention.

Discussion and Conclusions: We describe issues involved in using each of these dimensions, as well as methods for displaying results and combining the dimensions to determine the public health impact. Failure to adequately evaluate public health programs on all of these dimensions leads to a waste of resources, discontinuities between stages of research, and failure to improve public health to the limits of our capacity. It may also lead to harm because the potential reach of population-based programs means that negative, as well as positive, effects of programs are magnified. The discussion addresses strengths and limitations of the proposed model and areas of recommended future research and application of the RE-AIM framework.

Evaluating the Public Health Impact of Health Promotion Interventions:

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The field of health promotion has made substantial progress over the past two decades. Important advances have been made in conceptual models and theories of human¹⁻⁴ and in cost-effective interventions.⁵⁻⁷ Social and structural changes such as the implementation of clinical information systems and the emergence of prevention standards offer great potential to increase accountability and quality of care.^{8,9} Information technology has enormous promise for improving the delivery of personalized behavior change interventions to an unprecedented number of persons.¹⁰⁻¹³

However, our ability to recognize and respond to these advances, and to fully explore the potential of conceptual, intervention and technological innovations is limited by the methods we use to evaluate our programs. We now have the potential to evaluate comprehensively the public health and population-based (intent to treat) impact of our programs. However, with a few exceptions, most evaluations to date have restricted their focus to one or two of five “dimensions of quality” we believe to be important.

Rationale

In their comprehensive synthesis of the literature on worksite and community-based public health interventions, Sorensen, Emmons, and Dobson¹⁴ called for the development of new methods to evaluate the public health significance of intervention programs. They presented a persuasive argument that the efficacy-based research paradigm that dominates our current research journals is limiting, and not the only, or even always the appropriate, standard to apply.

One of the consequences of our present reductionistic scientific¹⁵⁻¹⁷ is its tendency to oversimplify intervention issues in the quest to isolate and identify efficacious treatments. In particular, the emphasis in most clinical trials on eliminating potential confounding variables results in samples of very homogeneous, highly motivated, healthy individuals without any health conditions other than the one being studied, and free of possible contraindications. There is nothing inherently wrong with this approach, but from an external validity perspective it often results in samples of predominantly highly educated, relatively affluent, and nonrepresentative white males.^{18,19}

Similarly, the emphasis on developing clinically significant, powerful, efficacious treatments often produces interventions which are intensive, expensive, and demanding of both patients and health care providers.²⁰ These interventions tend to be studied in the rarified “controlled” atmosphere of tertiary specialty treatment centers using highly standardized protocols. This “efficacy” paradigm²¹ is not, however, the optimal way to develop and test interventions that are feasible or practical to apply in busy, underfunded and understaffed public health clinics, hospitals, or community-based programs.

Our cultural emphasis on producing immediate results focuses attention on interventions such as pharmaceutical agents that produce outcomes within a short period of time, and whose onset, offset and dosage can be easily defined and controlled. In contrast, there is little research focus on identifying interventions that are long lasting, that can remain in place or become ‘institutionalized’.²²⁻²⁵ It is ironic, although understandable, that many of the most convincing demonstrations of treatment efficacy find that the interventions which prove so efficacious -- and occasionally even cost-effective -- are abandoned or not maintained by the very settings in which their efficacy is demonstrated.²⁶ For example, we conducted a formal cost-effectiveness evaluation

of both outpatient²⁷ and inpatient⁶ smoking intervention programs in a large HMO. Both programs were highly cost-effective, well received, and welcomed by the participants. Yet, implementation has been delayed for years after this demonstration for reasons that relate to structural and political issues more than to scientific or economic ones.²⁷

Evaluation Issues and Models

There have been discussions of several of these issues^{12,28} and some attempts to focus research efforts on representativeness of participants^{19,29} of samples. Seldom, however, is there any discussion of the representativeness of the settings -- the clinics, work sites, or communities -- in which public health interventions are evaluated. Many evaluations, such as the otherwise well-designed COMMIT trial³⁰ explicitly restricted selection of participating communities to those that were the most motivated, organized and prepared for change.³⁰ Most collaborative trials restrict participation to research centers that are most experienced and qualified, and have the best resources available. This selection results in expert, highly motivated research teams and settings, which are, by definition, unrepresentative of the settings in which their results will be applied. Most disease occurs among underserved and noncompliant populations. We found, for example, that 62% of invasive cervical cancers occur among women who have not had a pap smear in more than five years.^{27,31}

Both the NCI and the NHLBI have recognized some of the distinctions above and proposed their own 'stages' of research.^{14,21,32} These schemes portray a sequence moving from hypothesis generation to testing under controlled conditions, to evaluations in 'defined populations,' and finally, dissemination research. These models propose an orderly progression of scientific inquiry, with those interventions found to be efficacious (e.g., NCI Phase 3 research)

then being selected to undergo Phase 4 ‘effectiveness’ evaluations, and programs which prove to be effective -- and especially cost-effective³³ selected for dissemination research (Phase 5).

In practice, however, there is often difficulty in making the transition across phases. We argue that this may be due to flawed reasoning in the basic sequence, and that many of the characteristics of interventions that make them efficacious (e.g., they are intensive, demanding, designed for homogeneous highly motivated populations) work against their being effective in more complex, less advantageous settings and with less motivated and more challenged populations. Such interventions tend to demand expertise, time, resources, and ongoing commitment to a particular problem or program: quantities that are difficult to find in the midst of the chaos that characterizes much of present day health care.^{8,34,35} In contrast, low intensity interventions that have small individual impacts but which can be delivered to large numbers of people may have a profound and highly cost-effective impact on public health.^{27,36,37}

Abrams and colleagues³⁸ introduced an important point when they defined the impact of an intervention as being the product of a program’s reach (or percent of the population receiving the intervention) times its efficacy ($I = R \times E$). This paper expands upon this RE (Reach X Efficacy) concept by adding three dimensions that apply especially to the settings in which research is conducted (Adoption, Implementation and Maintenance-AIM) in an attempt to more completely characterize the public health impact of an intervention program.

The purpose of this paper is to present and explain the RE-AIM model, and to discuss its implications for health education and public health research.

RE-AIM Model

We propose an evaluation framework that is compatible with systems-based or social-ecological thinking and interventions^{15,39,40} as well as comprehensive community-based and public

health interventions.^{41,42} Central to this framework is the concept that the “bottom line” or public health impact of an intervention is due to an interaction of the performance of a program on five separate evaluative dimensions. The RE-AIM evaluation model derives from epidemiologic thinking. This framework expands upon earlier work by Glasgow and Anderson,⁴³ Glasgow, McCaul, & Fisher,⁴⁴ and especially Abrams and colleagues.³⁸

The RE-AIM evaluation framework is summarized in Table 1, which enumerates the various factors contributing to the Public Health Impact of an intervention (which could be a policy, a community program or a person to person or small group intervention). We conceptualize the public health impact of an intervention as a function of five factors: Reach, Efficacy, Adoption, Implementation quality, and Maintenance (see Table 2).

 Insert Table 1 about here

Readers familiar with the epidemiologic concepts of population attributable risk,⁴⁵ number needed to treat,⁴⁶ positive predictive value,^{47,48} and with Bayes theorem⁴⁹ will recognize similarities and the importance of base rates and prevalence of an intervention (or a disease, etc.) in the population. The RE-AIM model also explicitly considers multiple levels of effects (individual citizens, providers of care, and institutions such as worksites and health plans/clinics).

 Insert Table 2 about here

Following a brief discussion about the lack of research on some of these factors (see also Table 2), we will describe each component or dimension of the Public Health Impact or RE-AIM model.

Complexities and relations to other criteria. Like any framework, the RE-AIM model somewhat oversimplifies reality to present an understandable equation. It also emphasizes certain factors at the expense of others. This section discusses some of these issues as well as the relationship of Public Health Impact to currently debated topics such as quality of health care and cost-effectiveness/benefit.³³

How does the RE-AIM framework address quality, accountability, medical care effectiveness, and issues involving cost-containment, cost-effectiveness/benefit/utility?^{28,33} The Public Health Impact summary score, represented as a multiplicative combination of the component dimensions (see Table 2), is probably the best overall representation of quality. To some extent, ‘quality is in the eye of the beholder’ and ‘we all see a different part of the elephant’ --or focus on a different RE-AIM dimension. Thus, to a health care provider, quality may refer primarily to efficacy--that is, when a patient takes a medication or follows a recommendation (e.g., low saturated fat dietary plan) as prescribed, what result does it have on a physiologic outcome of interest (e.g., LDL cholesterol). To administrators, quality may refer primarily to implementation or delivery skill and consistency. From a patient perspective, quality may refer to effects of Implementation (day in and day out results when dealing with life’s multiple responsibilities and hassles). To a health services researcher, quality may be best considered as extent of a population reached, or long term maintenance of a service.

The RE-AIM model is silent on the choice of outcome or efficacy measure--except that we recommend that the outcome be quantifiable, be important to the general research and practitioner community (e.g., be accepted as relevant and generally seen as practical to collect, reliable and valid--such as HEDIS measures - NCQA), and to patients and the public at large.

Examples are serum cholesterol, dietary fat intake, levels of physical activity, smoking status, and blood pressure.

The RE-AIM model is also silent concerning the time frame of evaluation. Implicit in the constructs of Implementation, and even more so, Maintenance, is that measurement be collected for a minimum of 1 year (for Implementation) and 3-5 years (for Maintenance). Frequency of assessment should of course be based on the particular issue, goals, setting, and resources. In general, we recommend that the RE-AIM dimensions, as well as the overall score be collected repeatedly over time, such as 3-6 month intervals. If this is done, then a RE-AIM profile such as that depicted in Figure 1 can be plotted. Such repeated measurement--as well as visual displays^{50,51}--can enhance our understanding of intervention effects, or be used to contrast different interventions (Figure 3).

 Insert Figure 1 about here

Cost-effectiveness and economic outcomes. The RE-AIM framework does not explicitly address economic analyses. However, these issues are involved in the model in two ways. First, cost is often a major factor determining the extent to which a program or intervention will be Adopted, Implemented consistently, and/or Maintained after a formal demonstration or evaluation is completed.⁵²⁻⁵⁴ Second, cost-effectiveness and cost-benefit are certainly appropriate evaluation outcomes. They determine how well resources are being used, and whether or not more good could be accomplished by using them in alternative ways.

RE-AIM Dimensions

As illustrated in Table 1, each of the five RE-AIM dimensions is represented on a 0 to 1 scale, or 0 to 100% Reach, Efficacy, etc. A complication arises from the fact that, in addition to

the absolute percent of the population, settings, or patients involved, the Public Health Impact also depends on the characteristics of these persons or settings. For example, two worksite health promotion interventions might both reach 50% of employees, but a program that reached an equal proportion of higher risk blue collar employees would likely have more impact than one that reached primarily low risk participants with healthy behavior patterns. Therefore, it is important to analyze risk state of participants and their representativeness in addition to overall outcomes for each of the five RE-AIM dimensions.

Participation and Representativeness

Two RE-AIM dimensions, Reach and Adoption, refer to how broad and representative a sample is that participates in a program. However, Adoption and Reach operate at different levels.⁴⁴

Reach. Reach is an individual level measure (e.g., patient or employee) of participation. Reach refers to the percent and characteristics of members of a defined population (e.g., members of an HMO, community residents) who receive or are affected by a policy or program. For complex programs having multiple or optional components, we recommend keeping it simple when evaluating reach and reporting the percent of individuals who receive any contact with a program, possibly supplemented by the percent of persons who receive the complete or entire program.

Reach is measured by comparing records of program participation to complete sample or ‘census’ information on an entire defined population. Examples of census information include lists of all patients in a given clinic or HMO, employees of a worksite, or residents of a community. Assuming that accurate records are kept of both the numerator (participants) and the denominator, calculation of reach is straightforward.

Assessing the representativeness of participants is more challenging.^{19,44,55} It requires at least demographic, and preferably also psychosocial, medical history, or case-mix information on nonparticipants as well as participants. Detailed information on nonparticipants is often complicated and difficult to collect and also raises ethical issues since nonparticipants have typically not given their consent to be studied.^{13,56} Solutions to this dilemma are urgently required, and may entail a health plan or worksite providing anonymous data on all employees which can then be contrasted with participant characteristics. Cooperative arrangements that permit investigation of the precise ways in which participants are and are not representative of the larger ‘denominator’ population should be a priority for future research.

This issue is important because studies that have investigated reach have often reported that those who participate in health promotion activities tend to be those who need it the least-- e.g., the worried well,^{57,58} healthier or more affluent or physically fit, nonsmoking employees.⁵⁹ With the increasing gap between have and have nots in our country,⁶⁰ and the compelling data on the impact of SES on health status,⁶¹ understanding the degree to which a program reaches those in need is increasingly important. Collection of information on factors such as race, ethnicity, SES, medical history, occupation, age, degree of social isolation, self-reported health status, and level of self-efficacy⁶² for health behavior change is recommended. Because they are addressed to very large numbers of people, even small differences in risk levels of participants vs. nonparticipants can have great effects on the efficiency and cost-effectiveness of public health interventions.²⁷ Data that relate to risk allow programs to be targeted to groups where maximal benefit will occur.

Adoption. Adoption is a larger social unit or organization-level variable that refers to the percent and representativeness of settings (such as worksites, clinics, health departments, or

communities) that will adopt a given policy or program. The diffusion of innovation literature suggests common temporal patterns in the type and percentage of settings that will adopt an innovative change.^{63,64} Knowing where in the cycle of innovation adoption a social innovation or health program is, can provide important information about expected rapidity of further adoption and types of concerns that ‘early adopter’ vs. ‘late adopter’ settings will be likely to have. RE-AIM may also be considered an index of coverage for some set of potentially adoptive settings (hospitals, clinics), participants (researchers, patients, providers, payers, purchasers), and practices (treatment protocols, self-management activities, allocation rules).

Adoption is usually assessed either by direct observation, or by structured interviews or surveys. When assessing characteristics of settings that do not participate in an innovation, it is also important to collect information on barriers to adoption for future program planning.

Efficacy and Effectiveness

Entire textbooks and graduate and post-graduate institutes have addressed issues related to determining the efficacy and effectiveness of interventions^{55,65-67} and detailed discussion is beyond the scope of this paper. We discuss two specific issues below: the importance of assessing both positive and negative or iatrogenic consequences of programs; and the need to include behavioral, quality of life, and consumer satisfaction outcomes as well as physiologic endpoints and risk factors.

Positive and negative impacts. Most evaluations of population-based health programs are oriented to their efficacy in achieving improvement in some targeted health or risk indicator. Thus, we assessed the efficacy of treating isolated systolic hypertension by determining its impact on the incidence of stroke and mortality,⁶⁸ and the efficacy of an outpatient based tobacco intervention program by its effect on long-term smoking cessation.⁶⁹ Public health interventions

are, in fact, responsible for the great majority of gains in life expectancy. These improvements have come, not from medical technology, but from public health programs and changes in individual behaviors.⁷⁰ But there is often a great difference between efficacy in an ideal setting, and the effectiveness of a program under more representative conditions and in more representative settings. Effectiveness may vary widely depending on the nature of the target group and the skill and resources available to the program.

Interventions delivered to large numbers of people can also have unanticipated negative effects. Simply labeling someone with a potential illness may have profound social and psychological consequences.^{71,72} The avalanche of tests for genetic susceptibility to various cancers that is about to descend on us will raise serious issues about the negative effects of interventions delivered to the general public. These negative effects may be subtle. For example, if a patient who smokes responds to a public health campaign to increase breast and cervical cancer screening by deciding to get screened instead of quitting smoking, the campaign may cause more harm than good for that woman, since quitting smoking is more likely to reduce her risk of dying from cancer than is being screened regularly.

Such distinctions may seem trivial until the pattern of prevention services as they are actually delivered in our communities is examined.^{27,73} Many very effective services remain under-delivered, while others are delivered which are not necessary or effective in the groups to which they are given. Even services that cost only a few dollars can have substantial negative (as well as positive) impact when delivered to millions of people who have little need for them. Routine, repeated cholesterol screening of young, low-risk adults, for example, has little benefit.⁷⁴ The appropriate evaluation of population-based programs is critical, not only to determine benefit, but also to be certain that harm (including misplaced resources) does not outweigh that benefit.

What outcomes should we measure? Traditional clinical research has emphasized biologic measures of outcomes, in particular, risk factors such as cholesterol, glycosylated hemoglobin, or hypertension levels.^{55,75} More recently, our national health care crisis and concerns about how best to use limited resources have led to an increasing emphasis on health care utilization measures.^{8,28,76} These outcomes are certainly important to collect, but a public health evaluation should include more than just biologic and utilization measures. At least three other types of outcomes merit inclusion in public health evaluations:

1) Behavioral outcomes should be assessed for participants (e.g., smoking cessation, nutritional behavior changes, physical activity levels), for staff who deliver an intervention (approaching patients, delivering prompts and counseling, making follow-up phone calls), as well as for the payers and purchasers who support the intervention (adopting interventions, evaluating interventions). 2) A patient-centered or quality of life perspective^{8,77} should be adopted to evaluate the ‘bottom line’ impact of interventions on patient functioning and mental health. This includes collecting measures of patient satisfaction since these provide a critical check on real world service delivery practices. 3) Evaluations should assess community and systems level changes in implementation, and enforcement of guidelines and policies.^{28,78}

Implementation

The term effectiveness has been used to describe the impact of a program when conducted in real world settings (see Table 4).^{32,79} Implementation refers to the extent to which a program is delivered as intended. It can be thought of as interacting with efficacy to determine effectiveness (Efficacy X Implementation = Effectiveness). Once again, there are both individual and program level implementation measures to collect. At the individual level, measures of participant follow-

through, completion of homework assignments, or “adherence” to recommended medical regimens is important for interpreting study outcomes.^{80,81}

At the provider or office/setting level, the extent to which interventionists who are not research staff, but regular employees who have many other responsibilities in addition to implementing a research protocol, deliver intervention as intended is a critically important implementation outcome. For example, Stevens et al.⁸² demonstrated that part (but not all) of the reason that a brief hospital based stop-smoking program was more successful when implemented by experienced, dedicated smoking cessation counselors than when delivered by regular hospital respiratory therapy staff was due to differential levels of protocol implementation. Implementation research is crucial to determining which of a set of equally efficacious interventions may be practical enough to be effective when used in more representative, non-academic settings.

Maintenance

A major challenge at both individual and organization/community levels is long-term maintenance of behavior change.^{23,83,84} At the individual level, relapse following successful initial behavior change is a ubiquitous finding.^{85,86} Long-term behavior change--levels of targeted behaviors two or more years after a formal intervention program has ended--is important. Because of the large socio-environmental-economic-cultural influences on maintenance,^{15,87-90} it is essential that public health investigations collect long-term follow-up data.

It is equally important that program or setting-level measures are collected of the institutionalization²⁴ of a health promotion program or policy. Institutionalization refers to the extent to which a health promotion practice becomes routinely conducted and part of the everyday culture and norms of an organization. There has been a recent wave of interest in the measurement of factors related to the extent to which a program is institutionalized.²⁴ At the

worksite or medical clinic level, such research is needed to address the extent to which innovative or experimental policies and practices become integrated into the organizational culture (see Table 4).²² At a community level, maintenance or institutional research is needed to document the extent to which policies are actually enforced over time (e.g., laws concerning alcohol and tobacco sales to minors, no smoking policies).

Maintenance or institutionalization can be considered as a temporal extension of the Implementation dimension discussed above. In other words, as illustrated in Figure 1, Maintenance (institutionalization at the setting level) is the level and consistency of Implementation over time. Thus, maintenance is a measure of the extent that innovations become a relatively stable, long-term part of the behavioral repertoire of an individual (or staff or organization or community).

Factors Influencing Each RE-AIM Dimension

Many factors influence the degree of program reach, efficacy, adoption, implementation, and maintenance. These are summarized in Table 3. Resource requirements are related to all five dimensions. The more something costs, the more difficult it is to implement. On the other hand, this relationship is probably not simple and linear. Costly programs, once implemented, develop a cadre of employees and consumers. Thus, changing or eliminating costly programs in light of new evidence or the discovery of better approaches may be more difficult than for those which are less costly.

Simple programs are easy to implement, require less expertise and training and lower initial budgetary outlays. But brief interventions are also usually less efficacious, although this disadvantage may be mitigated by greater reach.^{91,92} Lack of skill and knowledge impairs implementation and efficacy in particular. For example, a brief, inpatient smoking cessation

program that worked very well with skilled cessation counselors, had little impact when it was delivered by regular hospital staff.^{6,93} It would have been a costly mistake to assume that the efficacy study was directly transferrable to a normal hospital setting.

Simple programs usually require less training and skill than do complex ones. They also typically require less change in existing routine and structure. Complexity will impair adoption and also effectiveness since it is more difficult to have a complex program delivered optimally. Support from professional organizations is useful in encouraging adoption, implementation, and maintenance, but is probably less critical than professional standards and consumer demand. Financial incentives are probably more important for organizations than for individuals since they are likely to be more substantial at that level. Effectiveness data are useful for overcoming skeptical views and for arguing how to re-direct resources. Marketing is probably most effective when directed at consumers who generate a demand. Accountability is a key issue in determining the degree to which an adopted program is successfully implemented and maintained.⁹⁴ If no one has a clear responsibility on which their job performance depends, then an organization is unlikely to be effective in implementing a program. Finally, other issues that may affect RE-AIM dimensions include peer models and timely feedback.

Insert Table 3 about here

Discussion

The last several years have seen a variety of provocative and stimulating articles on changing paradigms of health and health care--for example, moving from a focus on acute disease focus on a given patient to a population-based public health model.^{8,12,35,95-99} Unfortunately, there have been far fewer discussions of evaluation models that are appropriate for this population-

based, effectiveness research. Even economic analyses and outcomes research³³ do not address several of the core evaluation issues and dimensions along which these new or evolving paradigm approaches differ from the traditional medical model.

Evaluation methods and procedures must match the conceptual issues and intervention methods being studied. We are currently in the midst of a historical shift from a focus on a solely biological, reductionistic, mechanistic approach to medicine and health.^{12,27,99} The approach toward which we are evolving--albeit painfully, and at times haphazardly--is one of multiple causation, holistic or systems thinking,^{16,100} with recognition of complexity and various levels of disease determinants from micro to macro-societal.^{38,89,101,102}

A significant determinant of the problem results from unit of analysis issues.¹⁰³⁻¹⁰⁵ That is, often--the unit of assignment and analysis in more methodologically sophisticated studies is not the individual patient--but rather a 'larger social unit'¹⁰⁶ such as a clinic, a worksite, a hospital or a community.^{30,107,108} Many of the same issues of selection and representativeness, individual differences, follow-through, behavior change, and maintenance with which we have struggled for years at the individual level also apply to these larger social units (see Table 4).⁴⁴ Although there are scattered references that address some of these issues (see Table 2),^{18,42} there is to our knowledge no overall evaluation methodology that addresses these issues in a comprehensive manner.

 Insert Table 4 about here

There is increasing recognition that while the classic randomized controlled trial (RCT) methodology has significantly advanced our knowledge about pharmacotherapy and medico-surgical interventions,^{55,109} it has limitations when applied rigidly to behavioral issues, and

especially to community intervention trials.^{66,67,99,110-113} We feel that is because the classic RCT emphasizes efficacy to the defacto exclusion of other factors such as adoption, reach, or institutionalization.^{66,67,110} Expansion of the concept of health interventions beyond immediate treatment for acute conditions to encompass patient managed illness prevention and illness management activities^{12,27} requires the adoption of evaluation methods compatible with the conditions and settings in which such activities occur.

How RE-AIM Can Help to Use Health Care Resources Most Wisely

The United States has an inefficient medical care system. Despite the highest expenditure per capita on medical care of any nation, we exclude about 15% of the population from medical coverage, and provide inadequate coverage to another 15-20%.¹¹⁴⁻¹¹⁶ The U.S. is the only industrialized nation lacking universal health care coverage. In the United States, expenditures for prevention services, particularly those directed at entire populations, are small.¹¹⁷ Even more problematic, rarely, if ever are these expenditures ranked according to their relative probability of reducing morbidity and mortality. Vilnius and Dandoy¹¹⁸ proposed a basic priority rating model that consolidates multiple values into a systematic objective method for combining scientific data with political, ethical, economic, and public opinion values in assessing priorities. Because only about 3% of the health care dollar goes to public health issues,²⁷ appropriately ranked use of those resources is essential in achieving maximal impacts of public health programs. Better use of prevention resources gives countries such as the United Kingdom and Japan their better health statistics when compared to the United States. And, it is our penchant for attempting to solve our health problems with expensive, technological based solutions instead of effective, well-evaluated public health programs that makes our medical care system so expensive.

The RE-AIM dimensions provide a framework for determining what programs are worth sustained investment, and for identifying those that are and are not working effectively in their real-world environments. To the extent that these dimensions become incorporated into organizational data collection and analysis, decision makers will have better and more complete information on which to adopt and discontinue programs.

The precise nature of the relationships among the five RE-AIM dimensions or factors, and how they combine to determine the overall public health impact of a health promotion program or policy is unknown. We have represented these factors as interacting multiplicatively since we feel that this is closer to reality than an additive model. For example, a highly efficacious program that is not adopted by many clinics or only reaches a very small proportion of eligible citizens will have little population-based impact. Future research is needed to determine if other mathematical functions may better represent the interplay of these dimensions than does multiplication.

Within the multiplicative approach, data collected using the RE-AIM dimensions can serve at least three evaluative purposes:

- 1) Assessing the Public Health Impact (PHI) of an intervention within an adopting organization across time. Figure 1 shows hypothetical data for an ongoing intervention that is evaluated every two months. The pattern of scores on the dimensions reflects an organization that has been able to adopt a relatively efficacious intervention in most of its service settings, but has encountered difficulties in implementing and maintaining the intervention consistently with those who might benefit from exposure. Using a multiplicative approach to combining the dimensions, the PHI ranges from 0 to .09 across the various assessment points (if any one of the dimensions is 0, using the multiplicative approach, the product is also 0).

2) Comparing the PHI of an efficacious intervention across several organizational units.

Figure 2 shows the hypothetical scores on each of the five dimensions for six locations that have committed to a high efficacy ($E=.9$) intervention. The lowest PHI is .04 for Location, 6 which has reached only 14% of those who might benefit despite having successfully implemented the intervention in 74% of the 67% of the possible delivery settings adopting the intervention. Location 4, with a PHI of .76, has adopted, implemented, and maintained the intervention in virtually all of its settings ($A=.99$, $I=.93$, $M=.96$) and has reached some 95% of those targeted for the intervention.

 Insert Figure 2 about here

3) Comparison of one or more interventions in a setting. Figure 3 compares two interventions in a single set of service settings. One of the interventions is highly efficacious ($E=.9$) but costly to adopt, implement, and maintain (reflected in scores of $A=.2$, $I=.45$, and $M=.3$). The other has lower efficacy ($E=.35$) but is lower in cost making it easier to adopt, implement, and maintain ($A=.6$, $I=.7$, $M=.5$). The lower cost intervention has a reach 3 times that of the higher cost intervention (.8 vs. .25) and a PHI 10 times as great (.06 vs. .006).

 Insert Figure 3 about here

Limitations of the Current Model

The extent to which these dimensions are independent or orthogonal also is an open question. Future research should investigate these relationships, which should prove quite provocative in their policy implications. For example, if it is true that programs which have a larger reach tend to be less efficacious,⁹¹ what are the public health actions that should follow?

What if it turns out, as we expect, that programs which are most efficacious (under highly controlled, optimal conditions) tend to be those that have the worst Implementation results? Such an inverse relationship between program Efficacy and Implementation, especially if robust, could have significant implications for the types of interventions on which NIH and other funding organizations should be placing high priority. An inverse relationship would also suggest different criteria for selecting programs for efficacy testing if the goal is to produce practical programs that have population-based impact.

The RE-AIM model as presented here does not directly address issues of cost-effectiveness, an increasingly important outcome and major determinant of program adoption and institutionalization (see Table 3).³³ A population-based or “bottom-line” cost-effectiveness index could, however, be calculated by dividing the resulting Public Health Impact of an experimental program or policy by the total societal costs³³ of the program. In addition, dividing each component dimensional index of the RE-AIM model (e.g., Reach or Implementation) by the costs relevant to that dimension could help elucidate where these costs were coming from, and to identify areas of efficiency and waste.

Future Research and Application Issues

1) We recommend systematic reviews to determine the extent to which different research fields have emphasized—or neglected—each dimension of the RE-AIM framework. We expect that Adoption and Maintenance/Institutionalization, and secondarily, Reach, will be the most understudied dimensions, but this needs to be documented for different research topics.

2) The RE-AIM model should be especially applicable to innovative technologies; electronic, interactive and distance learning interventions; and other interventions such as Web-TV¹³ capable of reaching millions of persons. Comparisons of these innovations to more

traditional public health outreach and low tech programs on each of the RE-AIM dimensions would increase understanding of the advantages and limitations of both types of interventions.

Summary and Conclusions

We suggest that public health interventions and policies should be evaluated more broadly and comprehensively than has traditionally been the case.^{28,42,97} In particular, we argue that frequently omitted dimensions, such as Reach, Adoption and Implementation are crucial to the evaluation of programs intended for wide scale dissemination. We hope that the RE-AIM framework, or some similar model that focuses on the overall population-based impact of programs, can be used to more fully evaluate future public health innovations. Such a conceptual model and related evaluation framework is helpful to remind us of the differences between public health, organizational change, or community interventions^{91,97,113,119} and the much more common randomized clinical/pharmacological trials that typically maximize efficacy results while failing to attend to the other RE-AIM dimensions. It is high time to RE-AIM, or refocus our evaluation efforts.

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Table 1

Characteristics of RE-AIM Dimensions

Evaluation Dimension	Units and Level of Measurement	Prevalence of Research (Example References)
Reach	Percent and representativeness of members of an organization that participate (0 to 1.0)	Modest ^{38,43,64}
Efficacy	Magnitude or percent of improvement on outcome(s) of concern (0 to 1.0)	Substantial ^{55,79}
Adoption	Percent of organizations or settings that try an intervention (0 to 1.0)	Minimal ¹²⁰
Implementation	Consistency and quality of intervention delivery under real world conditions (0 to 1.0)	Moderate ^{32,79}
Maintenance	Extent to which individuals or implementation agents continue to deliver a program over time (0 to 1.0)	Little ^{2,84}
Public Health Impact	End result of interaction of factors above (0 to 1.0)	None to our knowledge ¹²

Table 2

Component Dimensions of the RE-AIM Evaluation Framework

	% REACH (what proportion of the panel of patients in each setting will receive or be willing and able to participate in this intervention?)
X	% EFFICACY (success rates if implemented as in guidelines: Defined as positive outcomes minus negative outcomes)
X	% ADOPTION (how many settings, practices and plans will adopt this intervention?)
X	% IMPLEMENTATION (how often is the intervention implemented as intended in the real world?)
X	% MAINTENANCE (extent to which program is sustained over time)

=	PUBLIC HEALTH IMPACT (population-based effects) of an Intervention.
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Table 3

Extent of Influence of Various Factors on RE-AIM Dimensions

Influence Factors*	RE-AIM Dimensions				
	Reach	Efficacy	Adoption	Implement.	Maintenance
Cost: Money or Time (-)	High	High (direct)	High	High	High
Simplicity/Ease (-)	High	Medium	High	High	Medium
Lack of Knowledge or Skill (-)	Medium	High	Medium	High	Medium
Amount of Training or Change Required (-)	Low	High (direct)	High	Medium	Medium
Endorsement of Professional Orgs. (+)	Medium	Low	Medium	High	Medium
Financial Incentives to Use (+)	High	Low	High	High	High
Data on Effectiveness (+)	Medium	Low	Medium	High	Medium
Packaging/Promo/Marketing Claims (+)	High	Low	Med-High	High	High
Peer Examples and Models (+)	High	Medium	High	Medium	Low
Pt. Satisfaction and PR Concerns (+)	Med-High	High	Medium	Medium	High
Timely - Useful Feedback (+)	Low	High	Low	High	Med-High
Accountability (+)	Low	Medium	Low	High	High

*Positive or negative sign in parentheses indicates direction of relationship.

Table 4

Relationship of RE-AIM Dimensions to Levels of Analysis

	Level of Analysis or Change Unit	
	Individual or Participant Level	Larger Unit or Setting Level
Research Evaluation Issue		
Representativeness of participants	Reach - Recruitment from defined population	Adoption - recruitment from list of all possible clinics, worksites, providers
Outcome under optimal conditions	Efficacy in RCT	Efficacy (same as individual level)
Outcome under real world conditions	Effectiveness in defined population-based, Phase 4 or Dissemination Trials	Implementation studies
Long-term maintenance of behavior or practices	Maintenance or relapse	Institutionalization of organizational practices

Figure Caption

Figure 1. Display of Scores on Different RE-AIM Dimensions over Time

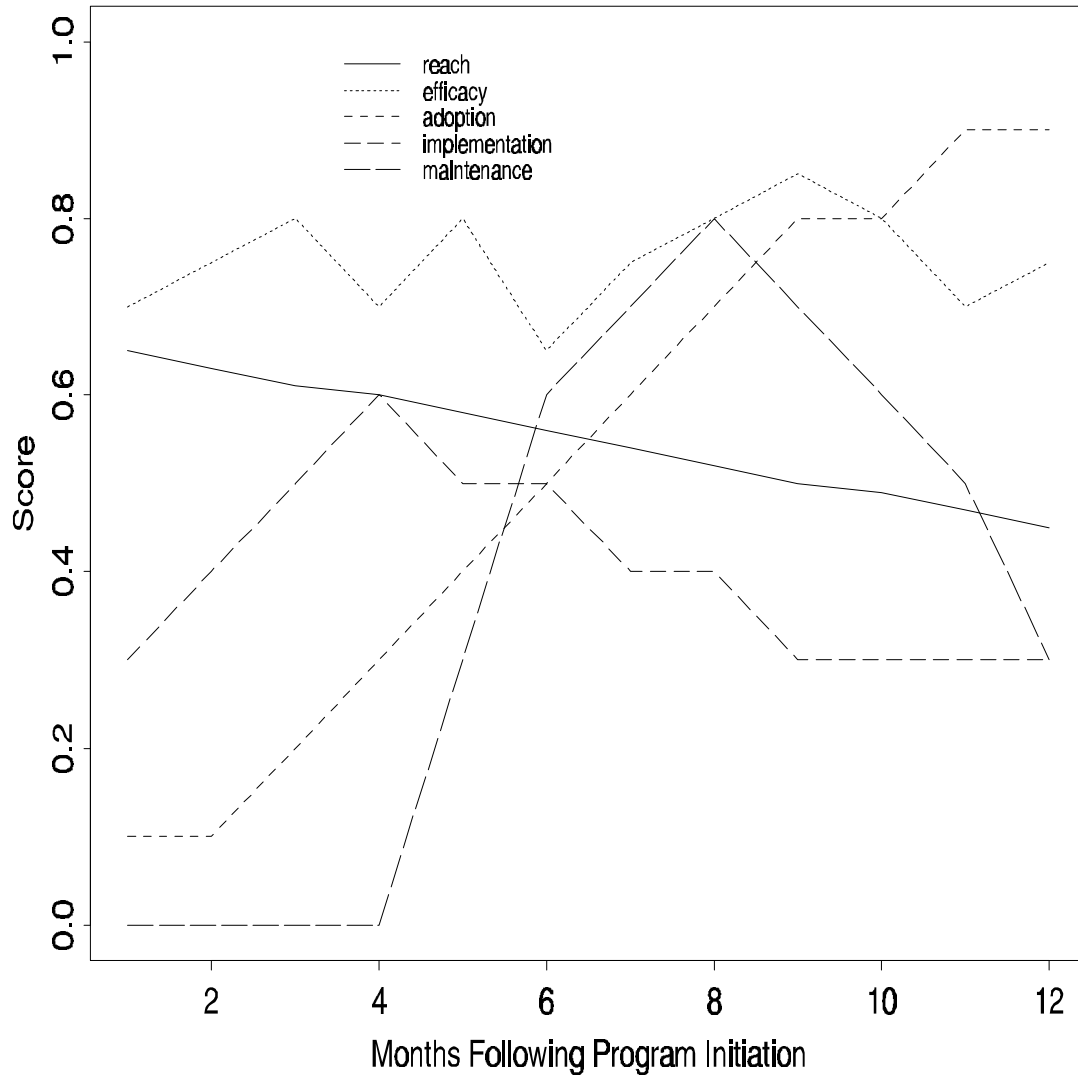


Figure Caption

Figure 2. “Star Display” of Performance Across Different Performance Locations on Each RE-
AIM Dimension (R=Reach, E=Efficacy, A=Adoption, I=Implementation, M=Maintenance)

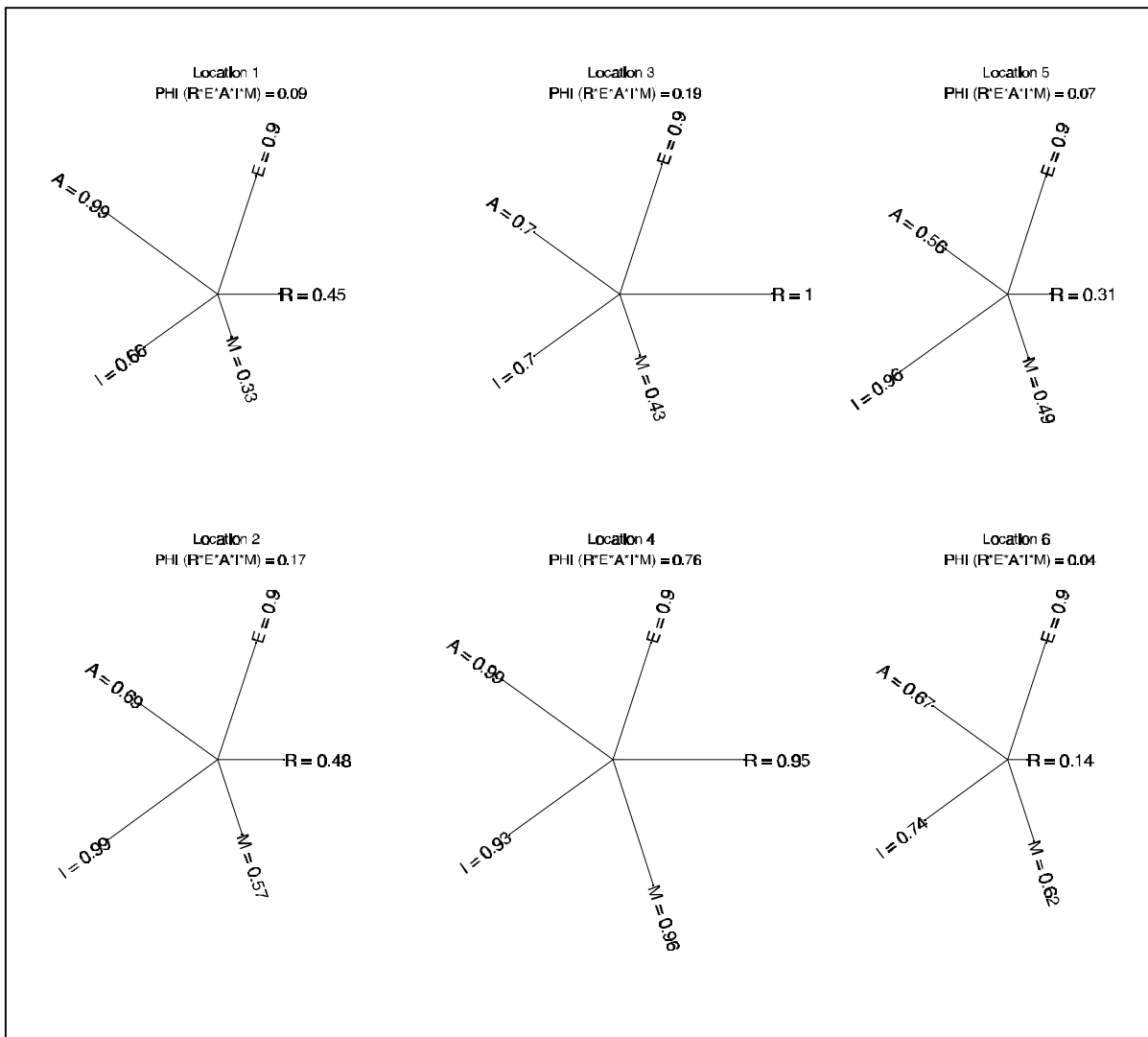
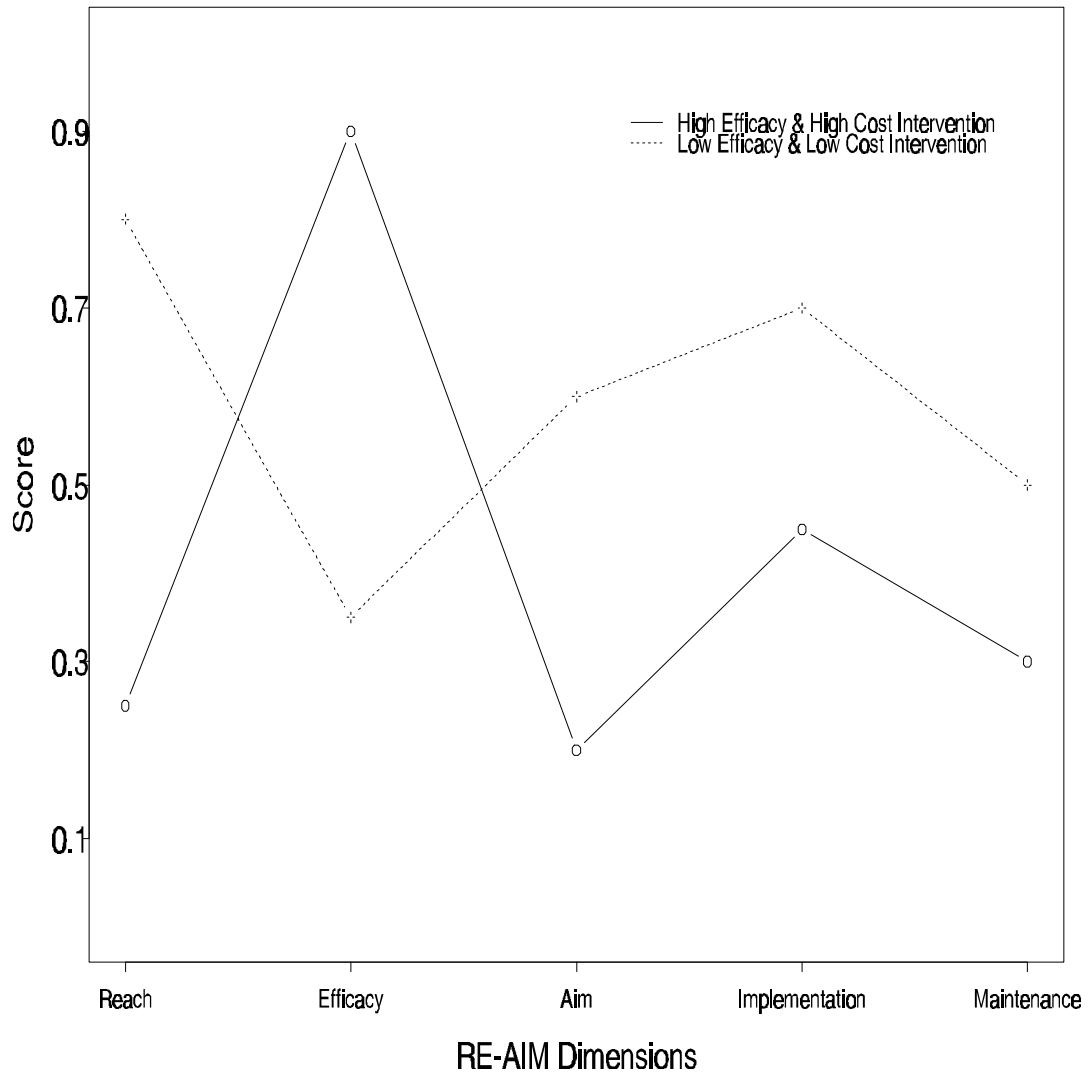


Figure Caption

Figure 3. Display of Two Different Intervention Programs on Various RE-AIM Dimensions



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