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Using the Concept of “Population Dose” in Planning and Evaluating Community-Level Obesity Prevention Initiatives

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Abstract
When planning and evaluating community-level initiatives focused on policy and environment change, it is useful to have estimates of the impact on behavioral outcomes of particular strategies (e.g., building a new walking trail to promote physical activity). We have created a measure of estimated strategy-level impact—“population dose”—based on our work in evaluating obesity prevention initiatives that uses elements of the RE-AIM method of combining reach and effectiveness to estimate the impact of a strategy on risk behaviors within a target population. We provide a definition and examples of measuring population dose, discuss measurement options in the face of uncertainty about key parameters, review ways of increasing population dose, and illustrate how the concept of population dose has been used in the Kaiser Permanente Community Health Initiative.

Keywords
obesity prevention, community-level initiatives, evaluation, strategy-level impact

Introduction
There is an increasing focus among public health practitioners on using policy and environmental change to promote long-lasting improvements in population health (Ashe et al., 2007; Brownson, Haire-Joshu, & Luke, 2006; Jilcott, Laraia, Evenson, Lowenstein, & Ammerman, 2007;
Policy and environmental approaches are particularly well suited to obesity prevention efforts, but have been used in other areas, including tobacco and substance abuse prevention (Backinger, Fagan, Matthews, & Grana, 2003; Flay 2000). Examples of these approaches in the obesity prevention area include promoting physical activity [PA] by making changes in the built environment and increasing the availability of healthy food choices in community settings (Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; Glanz & Hoelscher, 2004; Lake & Townshend, 2006; Powell, Slater, Mirtcheva, Bao, & Chaloupka, 2007; Sallis et al., 2006; Sallis & Glanz 2006).

Implementing policy and environmental change is challenging and requires a sustained effort from a broad range of community stakeholders. To promote such a sustainable, inclusive approach for obesity prevention, there have been a number of recent large-scale community-level initiatives including The California Endowment’s Healthy Eating Active Communities initiative (Samuels et al., 2010), the W. K. Kellogg Foundation’s Food and Fitness Initiative (W. K. Kellogg Foundation, 2009), the Robert Wood Johnson Foundation’s Health Kids/Healthy Communities initiative (Robert Wood Johnson Foundation, 2009), Kaiser Permanente’s Community Health Initiatives (Cheadle, Samuels, et al., 2010), Shape up Somerville (MA; Economos et al., 2007), and the Centers for Disease Control (CDC) and Prevention’s Communities Putting Prevention to Work (Communities Putting Prevention to Work, 2010). The goal of these initiatives is to bring about population-level improvements in healthy eating and active living (HEAL) behaviors, and ultimately reduce obesity rates and the health consequences that follow (Kumanyika et al., 2008). They are for the most part place-based, focusing on populations defined by geographic neighborhoods, cities, or counties.

These community initiatives typically involve a portfolio of strategies at multiple levels (e.g., individual, family, community) across multiple sectors (e.g., school, worksite, neighborhood) following some variant of the socioecologic model (McLeroy, Bibeau, Steckler, & Glanz, 1988), with a particular focus on policy and environmental change. (See Cohen, Scribner, & Farley, 2000 for applications of the socioecologic model that highlight environmental changes for health promotion.) We define what we mean by a “strategy” more carefully below. Briefly, a strategy is a set of coordinated activities designed to lead to a sustainable “community change” that supports improved dietary and PA behavior (e.g., a change in community programs, policies, systems, or the environment). For example, creating a new farmers’ market, or building a new walking trail, or changing school cafeteria policies to promote the use of local fresh food all qualify as community changes.

Two critical questions that arise in designing and implementing community initiatives are (1) which strategies will maximize the impact of the initiative, given available resources; and (2) how to evaluate the individual and collective impact of the implemented strategies. The strategy selection question is most often addressed by limiting the choice to “evidence-based” strategies. A number of recent reviews and consensus documents have been published that lay out a menu of evidence-based obesity prevention strategies, including two large-scale reviews conducted by the Centers for Disease Control and Prevention (2009) and the Institute of Medicine (IOM, 2005) (Parker, Burns, & Sanchez, 2009). However, most of these reviews do not provide estimates of the relative impact of different strategies; for example, whether more behavioral change will result from building new sidewalks versus enhancing public park amenities. Knowledge about the magnitude of strategy-level effects is needed to make cost–benefit estimates for strategy selection.

Regarding the evaluation question, the impact of a community-level initiative is ideally measured at the population level, that is, by tracking changes in dietary and PA behaviors among representative members of the community target population. For example, if the target population is defined by a geographic area (e.g., a rural county or an urban neighborhood), surveys might be conducted of randomly selected adults preinitiative and postinitiative and the changes compared to national trends or trends in comparison communities. A population-level measurement approach is preferred to
detect a synergistic effect of intervening at multiple levels across multiple sectors, which will not be captured using strategy-level evaluations. However, there are challenges to population-level measurement (Koepsell et al., 1992; Merzel & D’Affliti, 2003). Population surveys are expensive to conduct (Atienza & King, 2002), and it is becoming more difficult to obtain response rates that are representative of the entire population of a community (Bunin et al., 2007; Curtin, Presser, & Singer, 2005). In addition, changes are often relatively small and difficult to detect, given the measurement and sampling error associated with population-level surveys (Merzel & D’Affliti, 2003). The difficulty of using this method to measure impact is illustrated by the few community-based obesity prevention initiatives that have demonstrated effectiveness at the population level. Supplementing population-level measures with more proximal estimates of individual strategy-level impact is one possible approach to enhancing our ability to evaluate community initiatives.

The above suggests that it could be useful for both planning and evaluation purposes to have a quantitative estimate of the impact of individual obesity prevention strategies. We have created a measure of estimated strategy-level impact that we refer to as “population dose” that builds on the RE-AIM (Glasgow, Klesges, Dzewaltowski, Estabrooks, & Vogt, 2006) approach of combining “reach” and “effectiveness” (or strength) to create an overall estimate of the impact of a strategy on HEAL behaviors. We provide a definition and examples of measuring population dose and illustrate how the concept has been used in the Kaiser Permanente Community Health Initiative.

Defining the Term Strategy for Community-Level Initiatives

The word strategy is used in many different ways (Patrizi, 2011) and it is worth spending some time defining more carefully what we mean by a strategy in the context of community-level initiatives. As noted earlier, we define a strategy as a set of coordinated activities designed to lead to a sustainable community change. Two critical phrases in the definition that need further exploration are “community change” and “set of coordinated activities.” We follow Fawcett and colleagues (Fawcett & Schultz, 2002) in defining a community change as a change in community programs, policies, or the environment; in this case, changes in support of improved food and PA behaviors. The following are examples of community changes from the Kaiser Permanente Community Health Initiative:

- **Programs**—Putting in place youth gardening education programs, after-school PA programs.
- **Organizational-level policies**—Implementing Body Mass Index screening in health clinics, changing vending machine and cafeteria practices in schools to promote healthy eating.
- **Public policy**—Shaping community redevelopment to promote more walkable neighborhoods.
- **Community environment**—Creating new community gardens to increase the availability of fresh produce, creating a “bike depot” to promote bicycling.

The challenge is in empirically defining a community change, coming up with meaningful groupings of a potentially large and diverse set of changes that may be taking place, some much more significant than others. For example, a school may implement four separate changes to promote healthier diet and PA among its students: (1) implementing a new physical education (PE) curriculum, (2) changing the cafeteria menu and vending machines to offer healthier food choices, (3) putting HEAL-promoting signs in the hallways, and (4) changing snack policies to stop offering candy as a reward. A community change for the purposes of strategy definition in this case could range from one overarching community change (e.g., the school environment is transformed to promote HEAL), to four separate changes, including the relatively minor “HEAL-promoting signs are installed in hallways.”

What rules can we apply in grouping a potentially very heterogeneous set of changes into a single community change for the purposes of defining a strategy? Possible criteria include: (1) grouping by
the behavior being influenced by the change (e.g., nutrition vs. PA behaviors) and (2) grouping to create a set changes of comparable “significance”—combining smaller scale changes (e.g., hallway signs) to reflect community changes with similar levels of potential impact. We have used both of these criteria in defining community changes for strategy definition in the Kaiser Permanente Community Health Initiative.

The second key phrase in the strategy definition is “set of coordinated activities”—that is, how to identify the activities that are included in a strategy as leading toward the same community change goal. Some authors include all events or actions that contribute to achieving a strategic objective, regardless of how intentional or coordinated they are (Patrizi, 2011). For example, school HEAL-promoting changes may be the result of a variety of actions by school staff and leadership over several years, few of which were planned or coordinated. However, given our focus on planning and evaluation, we include in a strategy primarily planned, coordinated activities undertaken by a defined group of actors (individuals, organizations, or coalition). Obviously, other unplanned, uncoordinated actions may influence the success of the effort (e.g., passage of state-level laws requiring school HEAL-related policy changes), and these need to be accounted for in some way in both the planning process and the evaluation.

One additional note regarding activities to include within a strategy: In our definition, the set of coordinated activities comprising a strategy can include efforts to promote and enhance the impact of a community change. For example, in the case of a farmers’ market, such activities might include providing payment systems (Electronic Benefits Transfer [EBT]) that allow low-income residents to use their Supplemental Nutrition Assistance Program (formerly Food Stamps) benefit to purchase the food, offering nutrition education programs during the market, and doing community outreach to promote the market and identify ways it can be improved.

“Population Dose”: Definition and Measurement

We define “population dose” as the estimated community-level change in the desired outcome expected to result from a given community-change strategy. Population dose is operationalized as the product of “reach” and “strength,” where reach is the number of people touched by the community change (e.g., living near a newly installed walking trail), and strength is the estimated effect on each person reached (e.g., the estimated increase in minutes of daily walking for each person living near the trail). “High-dose” strategies that reach a large number of community members with a strong effect would be expected to produce the greatest community-level change in the desired eating and physical active behavior, and subsequently, health outcomes such as obesity rates.

The word “estimated” in the definition highlights the fact that we often have incomplete and/or subjective information about the reach and strength of interventions. At the beginning of an initiative before strategies have been implemented, dose is the expected impact based on projections of reach and knowledge of strength/effect size derived from other, similar interventions. As the initiative proceeds, we obtain more refined estimates of actual reach and better strength estimates based on the characteristics of the strategies being implemented. For example, if a grocery store initiative winds up making very substantial changes that increase the amount of healthy food available, we will revise the strength rating upward.

We follow the RE-AIM formula (Glasgow et al., 2006) in creating a quantitative measure of population dose, where our “strength” corresponds to the RE-AIM “effectiveness.” Reach is measured by “penetration,” or reach divided by the size of the target population, to adjust for differences in community size. For example, if there are 10,000 people in the target community and 1,000 are living near enough to a new walking trail to be regularly exposed to it, the penetration is (1,000 living near the trail)/(10,000 target population) = 10%. Note that the target population used in the denominator will be constant across all strategies being implemented in the same community.
Although, in some communities with significant school-based strategies we have two denominators—community population and total K–12 school enrollment.

Strength is measured by “effect size” or the estimated relative change in the desired outcome for each person reached (i.e., the average absolute change divided by the baseline level). For example, if each person living near a new walking trail increases the amount they walk by 3 min per day on average, and the average baseline amount of walking is 20 min per day, the effect size is \((3 \text{ min})/(20 \text{ min}) = 15\%\). For binomial or categorical variables (e.g., meeting recommended PA standards), the effect size is defined as the count of people changing categories divided by the total number reached. For example, if 100 people living near the new trail were meeting the recommended PA standard prior to the trail being installed (of the 1,000 living near the trail) and 150 are now meeting the standard, the effect size is \((50 \text{ newly meeting the standard})/(1,000 \text{ reached}) = 5\%\).

Population dose is then measured as the product of penetration times effect size. Using the walking trail example above (the continuous case where changes in minutes are known), population dose is \(10\% \times 15\% = 1.5\%\). This is equivalent to the relative increase in PA resulting from the trail installation if the effect size in those reached was averaged across the entire target community population. This standardizes for community size and is unit free, allowing us to compare strategies with widely varying reach and strength and with different units. For example, another approach to increasing PA might be to create walking clubs. If 150 people join clubs in a target neighborhood of 10,000 (penetration = \(150/10,000 = 1.5\%\)) and each participant doubles the daily amount they walk (effect size = 100\%), the population dose is the same as for the new trail: \(1.5\% \times 100\% = 1.5\%\).

If the effects of different strategies are independent (i.e., not synergistic or redundant), we can add together the population dose estimates to get an estimate of overall community impact. For example, if the walking clubs are taking place in a different part of the community from the trail, the overall community dose is \(1.5\% + 1.5\% = 3\%\). This corresponds to the effect size we might expect to find in a community-level survey sampling representative people from the entire population of 10,000.

An example drawn from the literature can provide another illustration of the population dose calculation. A study in Leeds, United Kingdom (Wrigley, Warm, & Margetts, 2003) found that when a new supermarket was opened in an area with limited availability of fresh produce, servings of fruits and vegetables reported in a household survey increased by .25 servings (from 2.56 to 2.81) among those living within 750 m of the new store (population = 10,800). The overall target area for the store intervention was two neighborhoods in Leeds (population = 38,000). The target population penetration is therefore \(10,800/38,000 = 28.4\%\). The effect size is the percent increase in fruit and vegetable consumption = \(.25/2.56 = 9.8\%\), and the population dose is \(28.4\% \times 9.8\% = 2.8\%\). This figure gives the effect size of the new store averaged across the entire target population of the two neighborhoods. Put another way, if a community-level survey sensitive enough to detect a 2.8\% change were conducted of all 38,000 residents in the target community, it would be expected to show a change in fruit and vegetable consumption of that same magnitude.

One note about the use of the term estimated in the definition of population dose: the term is included because in the majority of cases we will not have an accurate estimate of effect size (and in some cases penetration), either because the strategy is not yet fully implemented or because an evaluation could not be conducted to give an accurate estimate of behavioral impact. However, in some cases (e.g., the Leeds grocery store example above), the population dose calculation gives a reasonable estimate of the actual impact of a particular strategy.

**Population Dose Versus RE-AIM**

The formula for population dose (reach times strength) is the same as the “RE”—reach times effectiveness—part of RE-AIM, so why invent a new term? There are two main ways we see added value in a separate term. First, although RE-AIM is a very flexible framework, its primary purpose is in
looking at the impact and spread of specific health promotion programs that are being adopted by organizations, as opposed to the environmental and policy interventions that are increasingly the targets of community-level prevention programs. The “AIM” part of RE-AIM focuses on the adoption, implementation, and maintenance of programs by organizations, for which there is not a direct analogy for policy and environmental interventions (although sustainability is obviously important). Second, most place-based community initiatives have a single, fixed target population, and while RE-AIM is again flexible enough to accommodate that, using “population” dose emphasizes that a the target population for all community change strategies is an entire (typically geographic) community.

Why “Dose”?
The term dose, typically used to describe an amount of medicine, may not resonate with public health practitioners. For this reason, we tested the term with a number of audiences, including health department practitioners, community groups, funders, the Federal Government, and researchers. Most of those consulted felt that in ordinary usage, dose often means the amount of an “active” ingredient in a medication, hence a higher dose results in a greater impact on an individual’s health. In this case, the active ingredient is the community change being implemented and the ingredient is being applied to an entire community (population) rather than a person. While this is a medical analogy, it is a simple term that wide audiences and community members understand.

Variability and Uncertainty in Measuring “Population Dose”
One limitation of the population dose measure is that effect sizes for policy and environmental change strategies are generally unavailable. As noted above, despite the strong advocacy for environmental approaches in the CDC and IOM reports, and in the research literature in general, there is a lack of empirical evidence about the relative impact of most environmental approaches to obesity prevention (Cheadle, Schwartz, et al., 2010). For example, the CDC recommendations were based solely on expert panel ratings of strategies that have been mentioned prominently in the literature (Centers for Disease Control and Prevention, 2009). The IOM panel on local government action, assembled a wide range of literature and reports in support of their recommendations, but did not attempt a systematic meta-analysis of the available intervention studies (IOM, 2005; Parker et al., 2009). The CDC Community Guide (Guide to Community Preventive Services, 2010a), which does rely on evidence in making recommendations, has no recommended strategies involving environmental change for either nutrition or obesity. The Community Guide does recommend built environment interventions to promote PA, including community-scale and street-scale urban design and land use policies and the creation of enhanced access to places for PA combined with outreach (Guide to Community Preventive Services, 2010b). However, the urban design policy recommendation is based entirely on cross-sectional, observational studies (Heath et al., 2006), leaving access to places for PA combined with outreach as the only environmental intervention with systematic evidence supporting its effectiveness. Other reviews from the epidemiological (Pappas et al., 2007) and dietetic (Booth, Pinkston, Walker, & Poston, 2005) literature have also found largely cross-sectional studies examining the relationship between the built environment and obesity.

One reason for the lack of evidence is that the field is relatively new, and results from intervention studies are just now beginning to appear with regularity. In addition, the effects of policy and environmental change strategies are difficult to estimate using experimental designs since both the structure and the impact of these interventions can be very community-specific. The lack of evidence about effect sizes means that we confront a great deal of variability and uncertainty in estimating population dose. We use the term variability when there is enough information about effect size
estimates to compute sample variances and confidence boundaries, and uncertainty when the information is either unavailable or so limited that we can make only rough guesses about effect sizes. The remainder of this section describes how variability and uncertainty can be accounted for in using population dose for planning and evaluation purposes. (Note: there is also variability in reach estimates that must be taken into account, but reach is more easily estimated for each strategy using data from process evaluations [e.g., counting program participants or using census data]).

**Within-Study Variability**

In the simplest case, an evaluation is conducted that provides an effect size estimate of a particular policy and environmental change strategy in the target community. The population dose measure then gives an estimate of actual impact, if the impact were averaged across the entire community population (e.g., the Leeds grocery store example above). A sample variance (standard error) is typically available for the effect size estimate and a confidence interval (CI) can be constructed. For example, in the Leeds study, a variance estimate can be inferred from the $t$ statistic provided on the pre/post change in servings of fruits and vegetables. The 95% CI based on this estimated variance is $[-1.0\%, 20.5\%]$ around the point estimate of effect size of 9.8% (Note: the lower bound is negative since the authors used a significance threshold of 10% so the $p$ value of .077 was deemed significant). Applying this CI to the penetration estimate of 28.4% yields a 95% CI for the population dose measure of $[-0.3\%, 5.8\%]$.

**Cross-Study Variability**

A more common situation is that either population dose is being used for planning purposes or resources are not sufficient to conduct a rigorous evaluation of every policy and environmental change strategy implemented in a target community. In this case, we must rely on effect size estimates from other, similar studies. Ideally, review articles for particular strategies would standardize outcome measures and provide summary tables or plots of effect size estimates, as is frequently done in clinical reviews and meta-analyses (Anderson, Kendall, & Jenkins, 2003). However, we were unable to find a single review article in the obesity prevention literature that presents a quantitative summary of effect sizes to use as an example. Such a review might have both effect size estimates (with variances) for each included study and enough contextual and implementation detail so that a community contemplating the use of that strategy could find the situation most similar to their own. For example, a rural community considering a monthly farmers’ market during the summer months might focus on studies assessing the impact of infrequent, seasonal markets on produce consumption. An alternative is to use the mean or median effect size across all studies to estimate the likely effect size from a planned or newly implemented strategy. A confidence bound can be put around the mean/median effect size either formally, using meta-analytic techniques that incorporate variances from the underlying studies, or informally, using the inter-quartile range of the estimates from all studies.

**Uncertainty**

Unfortunately, given the state of the obesity prevention literature, there is typically not enough information to generate empirical estimates of effect sizes with CIs. As noted above, much of the evidence is cross sectional and not based on intervention studies. Significant associations are often reported without giving actual magnitudes of effect, or magnitudes are reported that cannot be converted to effect sizes (e.g., correlation coefficients). In many cases, the interventions are dependent on community context, so it is difficult to generalize the results to other communities. For example, many built environment interventions (e.g., completing sidewalk networks, adding bicycle lanes, improving existing walking paths) will have very different impacts in different communities depending on geography, demographics, and existing transportation patterns.
In the face of uncertainty, we use rating schemes for effect size that factor in whatever information is available from the literature with an assessment of the relative strength of the intervention for the people that are or will be touched by it. Factors incorporated in that assessment include the intensity of the intervention (e.g., magnitude of changes made to the built environment to promote walkability), frequency of exposure (e.g., one-time walk to school event vs. a daily Walking School Bus), and the degree to which the environmental changes restricted choices to healthier ones (e.g., removing all unhealthy snacks from a closed-campus school vs. adding a few healthy snacks but leaving the unhealthy ones in place). Multiple raters review and rate each strategy and any differences between raters are reconciled through discussion of how the criteria are being applied and, in some cases, further investigation into the way the strategy is being implemented through follow-up contacts with community representatives.

Validating the Population Dose Concept in the Kaiser Permanente Community Health Initiative

The concept of population dose grew out of our work evaluating the Kaiser Permanente (KP) Community Health Initiative (CHI), which is also the first initiative where we have tested the concept. CHI was created in 2003 to promote HEAL in communities served by KP. KP’s Framework for Community Health Initiatives identifies core design principles (Kaiser Foundation Health Plans, 2004) that have guided regions where CHI has been implemented. These include a place-based focus; an emphasis on change at multiple levels, particularly environmental and policy change; a multisectoral collaboration that involves sectors such as health care, neighborhoods, schools, and work sites; and community engagement and community ownership. KP is the principal sponsor of place-based initiatives that feature all of these elements in over 40 communities, including 3 in Northern California and 25 in Colorado—the first regions to implement the initiative. The national cross-site evaluation design and more details about the initiative can be found elsewhere (Cheadle, Samuels, et al., 2010).

If population dose is to be a useful concept, it must have predictive validity. In particular, individual strategies or clusters of strategies identified as being high dose through our rating process must ultimately be associated with measured population-level changes in the relevant outcomes. For example, if a number of built environment changes are rated as high dose for promoting walking, then a survey of community residents should show measurable increases in minutes walked. Such comparisons to test validity require dose estimates and pre/post population-level surveys conducted at intervals reasonable to expect population-level change. For the built environment example, this means that the post survey should be conducted only after the changes have been implemented and residents have had enough time to adjust their recreational/shopping/commuting to conform to the changes.

The first KP CHI communities where we have both dose estimates and pre/post population-level data are three communities in the Northern California CHI initiative: Kaiser Permanente Healthy Eating Active Living—Community Health Initiative (HEAL-CHI). Three low-income neighborhoods within larger cities were selected for 5 years of HEAL-CHI funding (2006–2010). A more complete description of the HEAL-CHI initiative along with final evaluation results can be found elsewhere (Cheadle et al., in press).

A total of 62 strategies were planned across the three communities, of which 49 (85%) were implemented successfully by the end of the Initiative. We used progress report data to estimate the reach of the implemented strategies and several sources of information to estimate strength. In some cases, the strength ratings were based on strategy-level evaluations that measured behavioral impact on those exposed; for example pre/post surveys of employees were used to assess the strength of some worksite interventions. However, in most cases, the ratings were based on an assessment of
the intensity or likely impact of the intervention. For example, strategies were given a high rating if the intervention was particularly promising for changing behavior (e.g., a multisession program) or creating healthier default choices (e.g., if a school policy removes all of the sugar-loaded beverages from all vending machines, classrooms, and cafeterias, rather than simply adding a few healthier drinks).

Multiple raters, including community project coordinators, reviewed and rated each strategy and any differences among raters were reconciled through discussion and further investigation into the way the strategy was implemented. The population dose ratings (i.e., reach and strength) were compiled and grouped by associated outcome measures (e.g., minutes of PA) and population segment (e.g., school-age youth, adults/families). For example, strategies attempting to increase minutes of PA among school-age youth in a community might include an enhanced PE curriculum, exercise components in after-school programs, and Safe Routes to School programs to encourage walking and biking to school. These combined strategies were then assessed and an estimate made of the collective impact of the strategies on the indicated behavior; in particular, whether the combined impact was likely to be high dose—defined as greater than 20% reach (the 20% threshold was somewhat arbitrary) using different reach thresholds did not alter the results.

We identified nine cases where there were high-dose strategies or clusters of strategies targeting particular outcomes in the HEAL-CHI communities. For example, in one community, the high-dose strategy focusing on youth PA was a single strategy—a PE curriculum reform. In another community, it was a cluster of strategies that included PE changes, adding exercise to an after-school program, a Safe Routes to School intervention, and schoolwide promotion of PA. All nine high-dose strategy clusters were targeting youth in schools; none of the neighborhood-based strategies targeting adults or families were rated high dose.

We then compared pre/post changes in the relevant youth survey measures for these nine high-dose strategy clusters and found positive and significant findings for four of the nine comparisons (Cheadle et al., in press). For example, the percentage of children reporting exercising at least 20 min per day increased from 61% to 67% in a community implementing a high-dose after-school PA program, a statistically significant ($p < .05$) increase relative to comparison schools. These results focusing on high-dose strategies were in contrast to our overall analysis that combined all communities together and looked at all outcome variables (using sign tests) and found no significant overall changes.

### Approaches to Increasing “Population Dose”

The population dose concept can provide a useful framework for thinking about ways to increase the impact of obesity prevention strategies. Population dose represents potential impact and will increase as a function of the increases in either reach or strength. Table 1 gives examples of how to increase the reach and strength of selected policy and environmental obesity prevention strategies. The sample strategies include two school and two neighborhood strategies, with two that focus on healthy eating and two that focus on increasing PA. Note that for both of the PA strategies (school PE and neighborhood walkability) the reach can only be increased by adding additional schools or neighborhoods; people are automatically exposed to the interventions either by living in the neighborhoods or attending the school (since all students are typically required to attend PE classes). For the healthy food retail strategy, residents must shop in the store to benefit, and reach can be increased through outreach and community marketing combined with EBT to allow low-income shoppers to more easily purchase fruits and vegetables in the store.

There are a variety of ways to increase the strength of the four listed policy and environmental change strategies. In-store and in-cafeteria marketing can be used to increase the number of people who choose healthier food items. Education programs can give people skills in how to prepare healthier foods (e.g., using more fresh produce). The strength of the neighborhood walkability strategy...
can be increased by addressing neighborhood safety concerns (e.g., improving lighting, organizing a block watch) and creating walking groups. Finally, the school PE program strength will be a function of the ability of the curriculum to increase active minutes and the fidelity with which it is implemented by teachers.

These approaches to increasing dose are currently being implemented in all CHI sites. In December 2009 a “strategic refresh” was held to review progress and make adjustments to the Initiative. One preliminary finding from the cross-site evaluation was that many communities were overly ambitious in the number of significant policy and environmental change strategies they attempted to implement with CHI resources ($200,000–250,000 per year in most communities) and overly ambitious in the size of the population whose health behaviors they hoped to influence. Consistent with CHI principles, multisector, multilevel strategies were being attempted. However, spreading resources across sectors and levels resulted in strategies either not being implemented successfully (e.g., overly ambitious built environment or healthy food retail outcomes) or being fully implemented with limited reach (e.g., small-scale programmatic strategies). One conclusion from the strategic refresh was to focus on fewer high reach/high strength (high population dose) strategies in order to concentrate efforts toward improving their impact. Currently, CHI staff, evaluation staff, and technical assistance providers work with the communities to identify and monitor strategies that combine both high reach and high strength. The CHI cross-site evaluation team has been developing evaluations of specific strategies to estimate the effect sizes needed to calculate population dose and provide feedback early on if a strategy should be strengthened or dropped and tell the story of the impact of the Initiative.

**Summary and Recommendations**

We have introduced the concept of “population dose,” given examples of how it can be used to promote and assess the impact of community-level obesity prevention strategies, and presented
some preliminary evidence supporting the validity of the concept. Population dose is defined as the estimated community-level change in the desired outcome expected to result from a given community-change strategy, operationalized as the product of penetration (reach divided by target population) and effect size. Population dose estimates can be used to compare the potential community impact of different strategies, and to combine the estimates from multiple strategies where efforts are not duplicative to get an estimate of cumulative impact. When an evaluation of a policy and environmental change strategy provides an effect size estimate for that strategy in the target community, the population dose measure represents an estimate of the actual impact, if the impact were spread across the entire target population.

The principal limitation of the population dose approach is a lack of information about key parameters, particularly the effect size of different strategies. Our main recommendation is to address this lack of information by conducting strategy-level evaluations when possible and reporting those results in the scientific (or at least searchable) literature. The IOM recently completed a review of the literature of the state of the evidence in obesity prevention (IOM, 2010), and we strongly endorse all of their action items related to generating evidence—“(1) Take full advantage of opportunities to generate evidence from ongoing policy and practice. (2) If obesity prevention actions are taken when the evidence is very limited, evaluate the success of the intervention and build credible evidence for use in future decision making. (3) Treat natural experiments, emerging innovations, and ongoing programs as potential sources of useful evidence. (4) Consider forms of evidence and research designs from a variety of disciplines, including systems approaches that can handle complexity. (5) Explore research designs that can be used as alternatives to randomized experiments and that may be more feasible in relation to complex environmental and policy interventions. (6) When reporting results of obesity prevention efforts, include useful aspects of the research related to its generalizability to individuals, settings, contexts, and time frames of their recommendation” (IOM, 2010, p. S-9).

The last two IOM recommendations—being open to alternative research designs and reporting research details related to generalizability—are particularly important for population dose. Policy and environmental change strategies are very difficult to evaluate using experimental designs and information from multiple studies using weaker designs may be more productive than attempting a single, large scale experimental study. Reporting details about community context and the way strategies were operationalized can help communities choose approaches most relevant to their own situation.

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