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Addressing Asthma from a Public Health Perspective

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1. Introduction

Asthma's prevalence, treatment costs, an impact on quality of life make it one of the most pressing global public health issues, especially in developed nations (Asher et al., 2006). Despite tremendous progress over the past 3 decades in the quality, variety, and efficacy of asthma treatment and prevention options, improved coverage by medical managed care organizations, and greatly improved air quality, the prevalence, morbidity, and related costs of asthma have not decreased over this same time period. (Moorman et al., 2007).

Many well-designed clinical and prevention-oriented interventions in various settings have been able to demonstrate short-term reductions in asthma morbidity for individuals and small groups of participants in controlled settings (Coffman et al, 2008; National Heart Lung and Blood Institute 2007). However, these interventions often fail to have an impact on a larger scale. There is still a compelling need to identify how best to reduce the burden of asthma for a defined population, such as a city, state, neighborhood, or membership of a health plan.

The population perspective is the hallmark of public health (Glasgow et al., 1999). Interventions that impact populations are important because they have the potential for reducing societal costs of treating the disease and promoting the health of a larger number of individuals (McNairm et al., 2007). The questions and issues that go into planning interventions on populations is not simply the "scaling up" of clinical or small-scale interventions that have demonstrated efficacy in controlled settings, but is fundamentally different.

The preliminary steps that commonly constitute public health program planning--conducting a needs assessment, constructing a logic model, and building a coalition of stakeholders--are well documented (Centers for Disease Control and Prevention 2010a, 2010b; Institute of Medicine 1988). However, guidance for directing limited resources to affordably maximize the effect on population-level measures of asthma is extremely limited. To achieve sustainable population-level impacts interventions must not only be effective, but also have high reach, wide adoption, and affect change among patients and institutions over the long term (Glasgow et al, 1999). Public health's challenge is to have an impact on large numbers of individuals with asthma using effective interventions, which are implemented in complementary ways at reasonable cost.

Between 2001 and 2008 the US Centers for Disease Control and Prevention's *Controlling Asthma in American Cities Project* (CAACP) sought to use a public health approach to reduce the burden of asthma in seven cities in the United States. Coalitions of diverse stakeholders at each site were funded and charged with developing and implementing a comprehensive set of asthma interventions based on local needs. Details of the project's purpose, design, strategic plan, and evaluation are described elsewhere (Herman 2011).

This chapter draws on the CAACP experience and the available literature to introduce and articulate questions implicit when planning a public health approach to impact asthma in a population. The chapter is organized into three main topics: Measures and Outcomes, Selection of Interventions, and Targeting Resources. Each topic has two or three subtopics that represent many of the key questions planners must address due to their importance to the planning process and the relative lack of guidance in the existing literature. The chapter does not seek to definitively answer or resolve these questions. Rather, its purpose is to explore the many issues and challenges that must be considered when planning an asthma intervention in a large group or population. The information presented is intended to help inform government agencies, non-governmental organizations, managed care organizations, health systems, community coalitions, and funders who are stakeholders in combating asthma, and also serves to identify areas for future research.

2. Measures and outcomes

2.1 What population-level outcome measures are available and appropriate for evaluating asthma interventions?

Small scale research trials typically form the basis for testing the efficacy of interventions among a relatively small group of individuals. In such settings tools that have been validated for clinical use, such as the Asthma Control Test (Liu et al., 2007), may be used to evaluate the intervention's impact. However, data from such clinical tools are seldom available for large populations of persons with asthma. Demonstrating an intervention's impact in a population requires data representative of the entire population at multiple points in time. As the development of population-level databases is typically expensive and time consuming, most disease-specific public health efforts use existing data available for general use. These might include (a) publicly available databases, such as vital statistics and disease registries, hospitalization discharge records, or emergency department data; (b) proprietary medical records or claims data; or (c) surveys from a representative sample of the population. The asthma-related data available for a given population might be quite limited. To ensure that a program's targeted outcomes are measurable, realistic, and consistent with the level of funding,available databases and the information needed from them should be identified at the beginning of the planning process.

Types of population-level measures of asthma can be conceptualized in a pyramid, with the least common events at the top (Fig 1) (Centers for Disease Control and Prevention 2001). Asthma mortality is seldom used as an outcome measure for small to moderate sized populations because it is too rare an event to detect statistically significant changes over time. Although also fairly rare, and representative of only the most acute cases of asthma, asthma hospitalizations (overnight stays in a hospital) are much more commonly used to

measure success of an asthma intervention. In the U.S., hospitalization data are collected at the state level, although quality and availability varies (Love et al., 2008). Asthma related emergency department visits are 3–4 times as common as asthma related hospitalizations (Moorman et al., 2007). Two of the seven CAACP sites were able to obtain emergency department data from a central source. Other sites had to collect and collate information from individual hospitals and health plans serving their populations to estimate population ED utilization rates.

One site analyzed patterns in asthma medication prescription fills and estimated use in a population by utilizing a pharmacy chain's administrative database (Davis et al., 2011). Measures of asthma control, adherence to clinical guidelines, and types of symptoms and their frequency are available from national and a few state-level surveys, as well as some health plans, but are generally not available for a small geographic catchment areas (Centers for Disease Control and Prevention 2010c). Measures of underlying asthma severity, as it is defined by the NHLBI, can vary over time in an individual and would not be expected to necessarily change as the result of a clinical or public health intervention.

Several sites were able to monitor asthma-related school absences at the school-district level. Measures of asthma prevalence such as "lifetime prevalence" or "current asthma" change very slowly over time. Furthermore, since there is no known cure for asthma, nearly all of the available interventions focus on secondary prevention, rather than the primary prevention or elimination of the disease. Although the reduction of certain occupational exposures is now known to reduce risk of developing asthma, these exposures are limited and affect relatively few individuals.

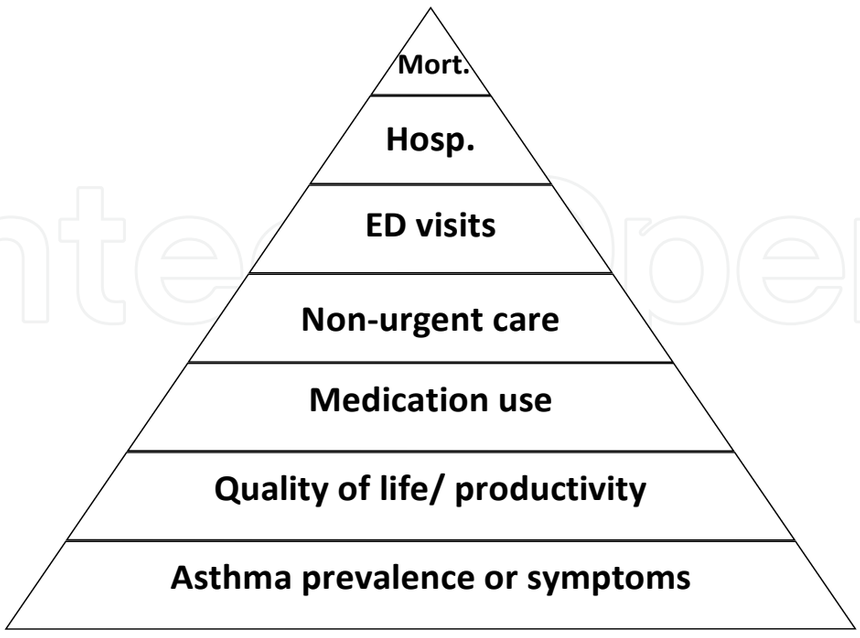

Fig. 1. Types of population level outcome measures for asthma

In some cases, seemingly "successful" asthma interventions may cause some outcome indicators to shift in an unintended direction. For example, providing asthma education to individuals who were previously unaware of asthma's seriousness or unfamiliar with its symptoms may lead to greater emergency department utilization or symptom reporting. A parent of a toddler with asthma, upon learning for the first time that asthma can be fatal, or about what happens to the airways during an asthma episode, may be more inclined to take her pre-verbal child to the emergency department upon hearing a wheeze.

Furthermore, the desirable direction for an indicator can be ambiguous. For example, most asthma interventions have aimed to increase use of inhaled corticosteroids (to prevent asthma episodes) and to decrease bronchodilator use (to relieve existing symptoms). Since bronchodilators are taken by individuals to relieve asthma symptoms, they are used as a marker of poorly controlled asthma. However, some individuals, prior to an intervention, do not have access to bronchodilators or are not using them prior to exercise or when they actually need them. For those individuals, filling a prescription for a bronchodilator and using one may be a positive change. Likewise, increased use of inhaled corticosteroids could mean better adherence to the asthma management plan by the patient or better adherence to clinical guidelines by the provider, but it may also mean a larger percentage of a population is developing persistent, as opposed to intermittent, asthma.

Outpatient visits as a measure of an asthma intervention's effectiveness can be ambiguous to interpret as well. One hopes to reduce urgent, unscheduled asthma visits and increase routine "well" visits, but many data systems do not make a distinction between the two types of visit. The reduction of emergency department visits is a common measure of success for asthma interventions but this reduction may also lead to an increase in non-emergent outpatient services as people shift to more appropriate preventive care. Although this shift should be seen as a positive behavioral change, it could appear to be "harmful" or costly if not viewed in the proper context.

Similarly, most patients hospitalized for asthma present at the emergency department. When someone is hospitalized for asthma, even if the patient initially presents at the emergency department, the hospital records this as an inpatient visit and not an emergency department visit. Thus, if a smaller percentage of patients are presenting to the emergency department with symptoms necessitating hospitalization it could actually work to increase emergency department visits, and vice versa.

Reduction of the cost of asthma is a derivative measure that may be paramount for some stakeholders.

Successful asthma interventions will decrease some preventable costs (e.g. acute care visits), but may lead to increased costs elsewhere (e.g. increased use of inhaled corticosteroids, preventative office visits). Public institutions and coalitions should be aware that stakeholders may not all agree on how to target costs. Cost shifting hospitalizations may cause acrimony between two otherwise well-intentioned organizations. For example, an asthma intervention that reduces asthma-related hospitalizations may help a health plan's bottom line, but may hurt the hospital's bottom line depending on the characteristics of the particular patient (private or public insurance, capitated or not capitated). Ultimately, the "best" measures to evaluate an intervention will depend on what is available as well as what the particular goals of the stakeholders are.

2.2 Scaling interventions: How many individuals need to be reached and with what effectiveness to achieve desired outcomes for various population sizes?

To produce change at the population level, the number of individuals reached and the effectiveness of the intervention(s) must be commensurate with population size. Even the most effective interventions will not result in population-level change unless enough people are affected. For example, even if a hypothetical intervention that is 100% effective at preventing a subsequent asthma hospitalization for one year were given to every patient hospitalized for asthmain a large city in an entire year, it would reduce hospitalizations the following year by only a small amount (Holgate 1999), as only a fraction of hospital admissions for asthma in a population in a given year are readmissions (Centers for Disease Control and Prevention 1997).Estimating the number of individuals who must be reached, and with what effectiveness, to demonstrate significant change in a particular population-level outcome is an important step in planning a community-based intervention.

This task differs from power calculations used to determine the minimal sample size or experimental group necessary to achieve statistical significance in a study. That calculation requires estimates of the population parameters. The intent here is to achieve an actual change in the population parameter itself. Estimating the number of individuals who must be reached to achieve that change requires the following three pieces of data: the prevalence of asthma in the population; the frequency of the event to be measured among those with asthma (e.g., the rate of hospitalizations, emergency visits, or office visits); and the random variation associated with that event. The change in the number of events that must be achieved in a given population (in order to exceed random variation and thus reach significance) can be calculated. The intended direction of change can be either positive or negative. The number of people who must be reached to achieve that change can be calculated from the change in the number of events needed, the frequency of that event, and the effectiveness of the intervention or project.

For example, recent national data indicate that the prevalence of asthma is 7.3% and approximately 66 office visits, 8.8 emergency department visits, and 2.5 hospitalizations occur per 100 persons with current asthma (Moorman et al., 2007). As shown in Table 1, in a hypothetical population of 500,000 (the approximate size of CAACP target populations), one would expect 36,500 people with current asthma (500,000 X 0.073); 24,090 office visits (36.500 X 0.66); 3,212 emergency department visits (36,500 X 0.088); and 913 hospitalizations (36,500 X 0.025) for asthma annually. Estimating the change in the number of events needed to achieve significance requires multiplying the standard error of that event by 1.96.[#] In Table 1, the standard error is approximated by taking the square root of the number of events in the population. This approximation, based on the Poisson distribution, is derived from the formula for relative standard error used for mortality data (Arias et al, 2003). Thus, in a population of 500,000, the number of emergency department visits that must be eliminated to reach significance ($p < .05$) is the square root of 3,212 multiplied by 1.96, or 111 events.

[#] 1.96 is the critical value of the z distribution for a two-tailed test at the 0.05 level of significance.

Population Size	Number with asthma†	Office visits for asthma‡		ED visits for asthma§		Hospitalizations for asthma¶	
		number	change**	number	change	number	change
5,000,000	365,000	240,900	962	32,120	351	9,125	187
2,500,000	182,500	120,450	680	16,060	248	4,563	132
1,000,000	73,000	48,180	430	6,424	157	1,825	84
500,000	36,500	24,090	304	3,212	111	913	59
250,000	18,250	12,045	215	1,606	79	456	42
100,000	7,300	4,818	136	642	50	183	26
50,000	3,650	2,409	96	321	35	91	19

† Based on a prevalence of 7.3%
‡ Based on a rate of 66 per 100 with asthma
§ Based on a rate of 8.8 per 100 with asthma
¶ Based on a rate of 2.5 per 100 with asthma
** Change = 1.96 · Standard Error; Standard Error ~ Square Root (number of expected events)

Table 1. Expected and associated change in the number of events required to reach significance in populations of various sizes*

The number of individuals who must be reached to achieve the necessary change in number of events can be estimated by dividing the needed change in number of events by the rate for the event. Table 2 illustrates this calculation for a population of 500,000. As stated above, to significantly reduce the population-based emergency department visit rate for asthma, at least 111 visits must be eliminated by the intervention(s). If the intervention is 100% effective in eliminating emergency department visits among those with asthma and there are 8.8 emergency department visits for every 100 with current asthma, then approximately 111 / 0.088 or 1,261 participants with current asthma must be reached. If less than 100% effective, that number is divided by the estimated effectiveness. An intervention that is 50% effective will need twice as many participants. Continuing with the above example, if the intervention eliminates half the emergency department visits among those enrolled, then 2,522 must be reached (1,261 / 0.50 = 2,522) to significantly decrease the emergency department visit rate for asthma. Further adjustments may be needed to allow for dropouts and incomplete participation, for population mobility (people who received the intervention moving out of the area, people who did not receive it moving in) as well as the uneven distribution of events in the population (some people having frequent events, others having none). Furthermore, directing interventions to populations most likely to experience the adverse event the intervention seeks to reduce would serve to decrease the total number of individuals who need to be reached.

*Refers to count of events such as a hospitalization, ED visit, or office visit

	Number of participants with asthma needed to demonstrate significant change in the event of interest*		
Effectiveness of the intervention	Office visits for asthma	ED visits for asthma	Hospitalizations for asthma
100 %	461 (304/0.66)	1,262 (111/ 0.088)	2,360 (59/0.025)
50 %	921	2,522	4,720
25 %	1,842	5,045	9,440

* Number needed = (number needed to change / rate of event) / effectiveness, e.g., for an intervention 50% effective in reducing emergency department (ED) visits for asthma, number needed = (111/0.088)/0.50 = 2522

Table 2. Number of participants with asthma needed for a population of 500,000 By effectiveness of the intervention (assuming 7.3% prevalence of asthma)

These calculations, although rough estimates, permit planners to determine whether the fit between target population size, available resources, and the outcome to be measured is realistic.

2.3 What external contextual factors are likely to influence the effectiveness of the intervention(s)?

A variety of external factors and changes over time can influence asthma-related outcomes. These factors may include but are not limited to demographic and economic changes, revision of reimbursement or coding policies, changes in Medicaid eligibility requirements, closing or opening of safety-net health service providers, concurrent interventions, changes in environmental exposures, and fluctuation in the intensity of cold/flu seasons (Johnston et al., 1996). Changes in a community that improve access to quality medical care or reduce environmental asthma triggers, for example, may make it difficult to attribute improved asthma outcomes to a project. Conversely, changes in external factors that negatively impact persons with asthma may mask the accomplishments of an asthma intervention.

Population movement out of a project area, a common occurrence, can theoretically affect outcome measures in a variety of ways. Each year 14% of people in the U.S. change their address with the rate tending to be higher in lower socioeconomic neighborhoods (U.S. Census Bureau 2010). Although individuals and families participating in asthma interventions may continue to benefit after leaving a project area, their improved outcomes would not be reflected in a population-based measure. Because asthma prevalence varies among ethnic groups (Davis et al., 2006), a change in racial or ethnic distribution may result in different rates of healthcare utilization that mirror a demographic shift rather than project impact. While the direction of change in asthma outcomes due to demographic changes is difficult to predict, increasing the estimated "number needed to reach" to accommodate the potential loss to follow up of individuals and families would be a conservative approach.

Over the seven-year CAACP project period, a number of external factors that had the potential to affect hospitalization rates and other outcome measures occurred in the CAACP sites. For example, new management at the major hospital at one of the sites relaxed the threshold for hospitalizing an asthma patient in order to fill more beds, effectively

increasing the number of asthma hospitalizations quite significantly. When interpreted out of context, one could reasonably conclude that asthma in that community was getting worse and that the various interventions at that site were at best, not effective, and at worst, harmful. The sites addressed the complexity of external factors in a variety of ways. Davis et al. analyzed pharmacy-fill data using multiple complementary techniques (time trends, comparison of the project area with similar areas in the city, analysis by age group) to provide different perspectives and strengthen the attribution of improved patterns to the project (Centers for Disease Control and Prevention 2001). In the final analysis of hospitalization data, all sites will superimpose a contextual analysis of significant changes over the timeline of the projects' interventions and trends in hospitalization data. Although no analytic techniques can completely control for contextual factors, documenting and acknowledging them can facilitate a realistic interpretation of outcome data.

3. Selection of interventions

3.1 What criteria should be considered when choosing interventions to achieve population-level outcomes?

Reaching large numbers of people, in a variety of settings, in complementary and synergistic ways, and at reasonable cost, requires interventions at multiple levels(National Heart Lung and Blood Institute 2007). The Spectrum of Prevention (Box 1) (Cohen & Swift 1999) is one framework for categorizing the levels and types of interventions for asthma. Selecting interventions that are most likely to be effective is a critical part of the local planning process. Asthma clinical guidelines, review papers, and meta-analyses provide an overview of the evidence base behind different types of interventions, and are based on a systematic review of multiple studies. These publications typically give greater weight to randomized, controlled trials, and to studies with large sample sizes. Planners should also base their assessment of effectiveness on individual papers and when possible, discussions with authors and program staff of the intervention(s) being considered. When doing so, a critical assessment of the methodology and data collection methods of published studies is important.

For example, many published evaluations of asthma interventions rely on self-reported behaviors or symptoms. The accuracy and precision of self-report is likely to vary by the type of question, the person collecting the information, time transpired since the reported event, and provider of the information (e.g., a patient or guardian) (Mathiowetz & Dipko 2000). Evaluations that do not have a control or comparison group might show a positive change based on a phenomenon called "regression to the mean," meaning that, when a series of events is tracked, the events will tend to return to a predictable mean on their own even without intervention (Tinkelman & Wilson 2004). Regression to the mean can lead to an incorrect conclusion that attributes an asthma outcome to an intervention when it was actually due to chance. This effect might be especially pronounced in asthma interventions that focus on individuals with a recent event, or with high utilization at baseline (Tinkelman & Wilson 2004).For example, if a given patient is recruited into an intervention as a result of a recent asthma hospitalization, statistically it is unlikely that this same patient would have re-experienced another asthma hospitalization during or after the study period. Hospitalizations due to asthma are relatively uncommon, even among those with previous asthma hospitalizations.

Influencing Policy and Legislation
- Clean outdoor air policies and legislation
- Clean indoor air policies and legislation
- Occupational regulations
- Healthcare delivery and financing

Strengthening Social/Organizational Practices
- Quality improvement initiatives
- Information systems
- Local school policies

Educating/Training Healthcare Providers
- Educating primary care providers
- Specialized training for medical residents
- Educating pharmacists
- In-services for school and childcare center staff

Promoting Community Education
- Group asthma education in community settings
- Group asthma education in schools
- Social marketing, public service announcements

Strengthening Individual Skills and Knowledge
- Case management (home, school, clinic)
- Patient education in hospitals and emergency rooms
- Phone follow up or nurse monitoring

Clinical Care/Treatment
- Specialty asthma or allergy clinics, mobile clinics
- Telehealth applications

Box 1. Types of asthma interventions using the Spectrum of Prevention as a framework to categorize(Cohen & Swift, 1999).

The effectiveness of any intervention is dependent upon context (Wang et al., 2006). In their comprehensive review of community based public health interventions, Sorensen, Emmons, and Dobson present a persuasive argument that the efficacy-based research paradigm that dominates in research journals may not be the most appropriate way to evaluate public health interventions (Sorenson et al., 1998), and tend to produce interventions that are intensive and expensive. Efficacious interventions conducted under rigorous study design with carefully screened and motivated participants, by the most skillful professionals, may prove ineffective in other settings (Glasgow et al., 1999; Sorenson et al., 1998; Starfield 1998). Even if they are highly effective, they will have little population based impact if they cannot be widely adopted (Glasgow et al., 1999).Planners should give greater weight to interventions that have proven effective in similar environments and circumstances and where applicable and when possible, pilot test them on the population the planners hope to impact.

Local political considerations may prove be more influential in the final selection of the intervention than the literature. The CAACP sites selected their interventions during a planning process that involved reviewing the literature on asthma interventions, conducting a needs assessment, soliciting stakeholder interests, and performing small pilot studies of proposed interventions. Some coalitions reached agreement on the mix of interventions through consensus; others followed structured procedures. As documented in annual reports, the Minneapolis/St Paul site actively engaged 115 people in intervention selection. Six workgroups met monthly for seven months to move through a formal process that resulted in a prioritized list of interventions, an evaluation plan, and a proposed budget. A leadership team then identified areas of overlap and synergy from the six plans to compose a strategic project plan. All sites had a coalition-based process that balanced local needs and resources, stakeholder preferences, and evidence supporting intervention effectiveness.

While most interventions were evidence-based, CAACP sites implemented some interventions for which an evidence base was not yet available. They justified these interventions with logic models that linked the interventions and desired outcomes (Cheadle et al., 2003). For example, the St. Louis site's needs assessment identified healthcare system fragmentation as one of the target area's major challenges. The site implemented the Asthma Friendly Pharmacy intervention, although not supported by pre-existing evidence, because it appeared to be a critical link in a communications network among patients and their families, healthcare providers, and schools. Evaluation of that intervention focused on its success in establishing and maintaining those lines of communication (Berry et al., 2011) and now contributes to the evidence base for pharmacy interventions.

3.2 How should resources be allocated across multiple asthma interventions?

Little practical guidance exists for allocating public health resources for asthma across the range of interventions listed in Box 1, and no studies have tested the effectiveness of different combinations of interventions. Given the number of possible combinations of interventions, differences in communities, timing of interventions, and variations in external factors affecting outcomes, an empirical answer to the question of the most effective mix of interventions is unlikely.

The CAACP projects chose interventions that addressed different levels of the Spectrum of Prevention. All sites provided individualized family and home asthma services that focused on asthma self-management training and indoor-trigger reduction. The Philadelphia, Richmond, and Minneapolis/St.Paul sites reached out to parents and community members by providing asthma classes in community settings; Philadelphia site staff made extensive use of local communication networks (radio, newsletters, newspapers) to increase community awareness of asthma and the CAACP. Training for primary healthcare providers on NAEPP guideline implementation was also included in all strategic plans. The Oakland and Minneapolis/St Paul sites implemented interventions to institutionalize the reinforcement of key asthma messages into routine care for hospitalized and emergency department patients respectively, and the Northern Manhattan, Minneapolis/St Paul, and Oakland sites succeeded in institutionalizing asthma-friendly policies and procedures in their respective school systems. The Chicago

site worked at the policy level to support smoking bans and the regulation of power plants and demolition sites.

CAACP sites noted an implicit tradeoff between designating comprehensive resources to a smaller number of people (i.e., high intensity) or fewer resources per person to a greater number of people (i.e., high reach). High-intensity interventions included, for example, individualized home-based medical and social support for families, and practice-based systems-change interventions for healthcare providers. High-reach interventions included group trainings and classes, policy-based interventions, and mass media.

As noted by Glasgow, the "high intensity" attributes that help to make interventions efficacious in a research setting—time, expertise, resources, commitment-- may actually work *against* the likelihood that they will be effective in less ideal settings (Glasgow et al., 1999). In contrast, low intensity interventions that can be delivered to large numbers of people may have a more pervasive public health impact (Hatziandrew et al., 1995; Vogt et al., 1998). Conceptually, it is helpful to define the impact (I) of an intervention as the product of an intervention's efficacy (E) and its reach (R) (the percent of the population receiving an intervention): I=R*E (Abrams et al., 1996). Even within the context of one type of intervention there are considerations about reach and intensity. For example, among CAACP sites, the number of hours dedicated to group training of medical providers ranged from 1–8 hours, and length of home-based support for families ranged from 1–18 visits. Intensive interventions, although generally effective for participating individuals or families, cost more per person and may have had a limited effect on population measures when the number of people or clinics reached is a small proportion of the population (Glasgow et al., 1999). Low-intensity interventions may not be effective in changing behaviors or achieving outcomes, or may take many years to demonstrate an effect (Glasgow et al., 1991).

Glasgow's RE-AIM framework expanded on the I=R*E equation by adding three additional dimensions that more fully capture the real-world impact of an intervention. The additional dimensions are: adoption ("A", the percentage of organizational settings that will adopt an intervention), implementation ("I", the extent to which the intervention is implemented as intended in the real world), and maintenance ("M", the extent to which an intervention is sustained over time) (Glasgow et al., 1999). Traditional intervention trials emphasize only the efficacy component at the exclusion of the other components. Although efficacy may be of most interest to clinicians, it is insufficient to evaluate the impact of an intervention in a population. The RE-AIM framework provides a conceptual public health model for determining what programs are worth sustained investment in the real world.

4. Targeting and reaching individuals and communities

4.1 What factors should be considered when deciding which individuals or groups of individuals to target within a given community or project area?

Asthma is a complex and heterogeneous condition with multiple phenotypes. It can be described in terms of its control and severity, types of symptoms, frequency and intensity of exacerbations, impairment, and responsiveness to medications. Furthermore, these

characteristics change over time for every individual with asthma. Interventions that provide a service must decide which individuals with asthma should receive the service in order to maximize the intervention's goals. In a study of limited scale, where the goal is to maximize efficacy, there is an incentive to recruit individuals that are most likely to respond favorably to the intervention. On the other hand, if the goal is to impact asthma outcomes for a population, then identifying and targeting individuals who are most at-risk for the outcome that the intervention is designed to improve is essential for maximizing the intervention's impact.Even small differences in characteristics between participants and non-participants can have a significant impact on an intervention's effectiveness when conducted on a large scale (Vogt et al., 1998).

The national asthma guidelines frequently refer to "high risk" individuals, but use the term inconsistently (National Heart Lung and Blood Institute 2007). One challenge planners face is the lack of correlation among different measures of asthma. Underlying severity and measures of current impairment, such as symptoms, functional limitations, or quality of life, are not reliable predictors of future risk of asthma exacerbation or adverse events (National Heart Lung and Blood Institute 2007). Furthermore, different adverse events may not necessarily correlate with one another; someone who frequently misses school because of asthma may not necessarily be at risk for a hospitalization.

Selecting an age group on which to focus is another consideration for maximizing the population impact of an intervention. Young children have the highest rates of asthma-related acute visits and have likely received the greatest amount of attention from government and private funders in the US, but this risk decreases significantly in the teen and adult years (Centers for Disease Control and Prevention, 1997). It is difficult to predict which children will be at "highest risk" as they age, and therefore which ones should be the targets of intervention. Provision of resources to a given child may thus have only a short-term impact. Senior individuals with asthma have the highest asthma-related mortality, and hospitalization costs that are on average two times that of young children per visit (Bahadoriet al., 2009)but for reasons that can only be speculated, are far less commonly the subjects of intervention trials.

Risk assessment models have used empirical data to successfully predict, in the short term, who is most at risk for various outcomes and thus most likely to have an impact on those outcomes in the future (Eisner et al., 2002; Li et al., 1995; Magid et al., 2004; Vollmer et al., 2002). These models include many variables, such as demographic data, various indicators of current asthma control, prescription patterns, and healthcare utilization history. Such models are limited because they differ for each population and require a richness of data that may not be available to the intervention planners.

Despite the fact that the CAACP sites had the same outcome goals, their definition of "high risk" and the selection criteria and methods that the different sites used for determining eligibility for interventions varied greatly. For instance, the criteria the different sites used for enrollment in a home-based asthma case management program included one or more of the following: asthma severity, various measures of asthma control, history of asthma-related hospitalizations, socioeconomic factors, school absences, and physician referral. The more resource-intensive interventions were generally more selective (CAACP personal

communication 2008), in keeping with evidence that most asthma morbidity and cost can be attributed to relatively few individuals (Smith et al., 1997).

4.2 How can projects effectively reach large numbers of individuals to participate in interventions?

The efficient identification, recruitment, and retention of a large number of individuals who drive adverse outcomes are particularly important when the goal is to impact population outcomes. Although the challenges of participant recruitment and retention are not unique to public health projects, they can dramatically limit a project's ability to achieve a population-level impact. Individuals and groups who are high priority from a public health perspective may be the least able to participate in interventions.

Schools and daycare centers were logical partners for CAACP sites because they offered access to a large proportion of a community's children and had an interest in reducing absences caused by poorly controlled asthma. Three sites—Oakland, Northern Manhattan, and Chicago—used questionnaire-based case identification of students with asthma in the schools as the primary method of identifying and recruiting students for interventions. Those sites also used the frequency of self-reported symptoms as a means of prioritizing students for interventions of high intensity and cost. Oakland was successful at engaging 76% of all students identified with asthma. In the Northern Manhattan site, 35% of parents of children identified with asthma participated in at least one asthma education activity offered by the daycare center.

Hospitals are potential venues for identifying and educating large numbers of patients with uncontrolled asthma(National Heart Lung and Blood Institute 2007), as patients can be easily enrolled in an intervention while in the hospital or ED without the traditional barriers of time and transportation (Castro et al., 2003; Teach et al., 2006).The Oakland CAACP site found that working with patients who were hospitalized for asthma to be an effective way to reach high risk children with asthma.

Many health plans, have an interest in reducing costs and improving performance measures, and generally have data that can be used to identify high-risk members or evaluate interventions (Hoppin et al., 2007; Kantor 2007; United States Environmental Protection Agency 2008a, 2008b). Some health plans referred children to CAACP services.Other CAACP site recruitment methods included referrals by medical providers (Chicago), distribution of flyers (Philadelphia), partnerships with social service agencies (Richmond and St Louis), outreach to parents of children in daycare (Northern Manhattan and Richmond), and door-to-door solicitation (Minneapolis/St Paul).

4.3 What are some considerations for addressing population level asthma disparities?

The reduction of disparities in disease burden among socio-demographic groups is an important public health goal, and one that requires focusing resources on certain populations and communities. Although all CAACP sites were selected because their populations suffered a high, disparate burden of asthma, they received no direction about addressing disparities within the sites. Many of the children with asthma in those

communities were considered to have a disparate burden of asthma because of low socioeconomic status (SES), unstable living situations, disorganized families, limited access to care, poor housing conditions, or some combination of these determinants of health.

Social, economic, and psychological factors are important determinants of whether an individual will benefit from an intervention (Weil et al., 1999). Individuals in challenging circumstances may have unique incentives or disincentives that affect behavior. For example, families enrolled in government insurance may have a low threshold for deciding to use the ED, which requires no appointment and whose cost is negligible to families, and may in effect use the ED as a replacement for regular primary and preventive care. This phenomenon may be a reason that so many patients present to the ED with mild symptoms (Macias et al., 2006).The economic dynamics which affect behavior likely vary by insurance provider and by extension, by state and country.

All CAACP sites offered referrals to address substance abuse, psychiatric, housing, and financial problems to the extent that those services were available locally, but varied in their efforts to actively address social determinants of health. The Richmond site was most proactive in partnering with a local agency to provide a range of social services as well as asthma education and case coordination for children "who had failed every other intervention." Similarly, the St Louis site contracted with a social service agency to address families' socioeconomic priorities to enable the families to also focus on controlling their children's asthma.

Reaching people and groups who experience health disparities primarily for social and economic reasons often requires labor-intensive, time-consuming, costly interventions. Intensive interventions focused on a small group of people may not necessarily be the most cost effective strategy if the goal is to improve asthma for a diverse population. However, if the priorities are reducing disparities and/or reaching individuals who are most "in need", then interventions that address recidivism and include social services are indicated. It is important to clarify among the stakeholders early in the planning stages if reduction of health disparities is the goal.

5. Conclusion

Public health efforts aiming to improve population-level outcomes are fundamentally different from projects seeking to improve outcomes for patients or for study participants, yet little guidance exists for making choices necessary for planning and implementing public health interventions addressing asthma. Consideration of appropriate population-based outcome measures, the number of people needed to reach to improve outcome measures, the choice and mix of interventions, and priorities in targeting and methods of recruiting participants all need to be addressed explicitly during the planning phase. The authors hope that future research will provide additional guidance on implementing projects aiming to reduce the burden of asthma at a population level.

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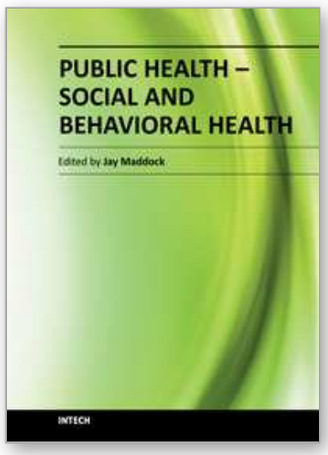

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Human behavior accounts for the majority of morbidity and premature mortality throughout the world. This book explores several areas of human behavior including physical activity, nutrition and food, addictive substances, gun violence, sexual transmitted diseases and more. Several cutting edge methods are also examined including empowering nurses, community based participatory research and nature therapy. Less well known public health topics including human trafficking, tuberculosis control in prisons and public health issues in the deaf community are also covered. The authors come from around the world to describe issues that are both of local and worldwide importance to protect and preserve the health of populations. This book demonstrates the scope and some of the solutions to addressing today's most pressing public health issues.

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