

State Environmental Health Indicators Collaborative

A Collaborative, State-Based Approach to Development, Testing, and Evaluating Environmental Public Health Indicators

White Paper

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Executive Summary

Research has shown that factors in the physical environment such as air pollution can play a key role in determining health, but the true impact of exposure to these contaminants on a population's health is often unknown. A national effort to address environmental factors that affect population health requires better information. This includes development of methods as well as tools to better identify, assess and track individual factors and relationships between the environment and health over time. Once data is developed and analyzed, the information can be used to explain the importance of these relationships to the public and policy makers. Public health practitioners have traditionally monitored the impact of health determinants through surveillance. Environmental health surveillance is unique to other types of surveillance because it aims to simultaneously monitor hazards found in the physical environment, population exposure to these hazards, and related health effects. This complexity often requires surveillance at many different levels and inhibits practitioners' ability to comprehensively track these intricate relationships over time.

A number of entities have recognized the value of developing and implementing standardized indicators that reflect attributes of interest for environmental public health to enhance surveillance efforts. The European community, Australians and Canadians have been working on indicators for environmental health for some time. Similarly, environmental regulators within the United States have worked on several indicator initiatives beginning with the establishment of the US Environmental Protection Agency (EPA) in the early 1970s. One important example of indicators identified for use by the public health community in the US is a set of environmental public health indicators (EPHI) produced by the Centers for Disease Control and Prevention (CDC) and the Council of State and Territorial Epidemiologists (CSTE) {CDC, 2003 #194} . CSTE focused on identification of a number of indicators for inclusion in a comprehensive National Public Health Surveillance System (NPHSS). Concurrent CSTE efforts were also launched to address occupational, injury and chronic disease. The environmental indicators did not reach the development stage. The environmental public health tracking (EPHT) initiative, sponsored by CDC, provides funding to 17 state and local health departments and four academic centers to enhance state and national capacity for obtaining and analyzing data about environmental hazards, exposures and health effects. In the early years of this project, states worked independently, therefore development and use of indicators was not coordinated among the grantees. States recognized the value of developing consistent and standardized measures that allow for comparing public health surveillance and environmental monitoring data across jurisdictions. In 2004, the State Environmental Public Health Indicators Collaborative (SEHIC) was organized to provide a venue to convene willing collaborators to

work together to develop indicators for use within environmental health surveillance and practice at the state level. Preliminary SEHIC work established a systematic process for development of valid and reliable measures that provide some level of comparability across multiple states.

SEHIC has established a process, produced a framework, and created a vision for developing environmental public health indicators for use at the state level. This includes standard language, definitions and consistent description templates for defining the elements and attributes of indicators. The description templates are accompanied by “how-to” guides to show exactly how to calculate the measures being generated to describe the indicators. This approach builds upon previous CDC/CSTE occupational health indicator initiatives. Templates describe the significance, background, data sources and limitations of indicators and measures, and fully specify methods to derive measures in a reproducible standardized format. SEHIC selected air quality, asthma and drinking water as initial topic areas of focus because these are well recognized priorities for environmental health within the United States, measures and data sources were readily available, and because participants were interested in these areas. Working groups selected indicators and measures, defined data elements and data sources, compiled methods, completed “description” templates and “how-to” guides, and pilot tested initial products. SEHIC is now working on how best to disseminate the measures, community their intended use and purpose to policy and lay audiences, and evaluate their overall utility.

The working group process has been effective for convening practitioners from disparate regions to produce tangible products. SEHIC began with three states and one academic partner. With some financial support from CSTE and CDC’s National Center for Environmental Health, the collaborative has grown and evolved to include 17 state level environmental health practitioners, CSTE, CDC, US EPA, and other relevant partners. The group has had several face-to-face meetings to ensure consensus and increase information sharing. SEHIC has welcomed states without funding from EPHT and so provides a link to “unfunded” states for development of capacity and understanding about environmental public health surveillance. The SEHIC effort suggests that there is a growing demand for indicators as tools to improve and enhance environmental health practice within states by increasing data and information available for decision-making. A primary challenge is to ensure adequate analytic resources and staff is allocated within state health departments for indicator development, implementation and maintenance.

Contents

Acknowledgements

Executive Summary

I. Introduction

- A. What this project is about
- B. Related efforts

II. SEHIC Conceptual Approach and Framework

- A. Building the Collaborative
- B. Conceptual Framework and Principles
- C. Defining purposes for environmental public health indicators
- D. Develop Common Language and Terminology
- E. Develop Tools
 - i. Description Templates and “How-to-Guides” definitions and Terminology

III. Results

- A. Steps to Indicator Measure Development and Pilot Testing
 - 1. Select topic areas.
 - 2. Explore existing data and resources available.
 - 3. Identify indicators and select feasible and practical measures that can be used to quantitatively summarize the indicators and meet their intended purpose and goals.
 - 4. Review, evaluate and revise.
- B. Summary of Indicators and Measures Developed to Date
 - 1. Air Quality

2. Asthma

3. Drinking Water

IV. Discussion

V. Commentaries from participants

References Cited

Appendices

1. Contacts with SEHIC
2. Steering committee members and participants
3. Working Definitions
4. Example Template
5. Abstracts and presentations

I. Introduction

The environment affects people's health in many ways. Most people recognize that environmental contaminants like air and water pollutants can cause disease. However, diverse factors such as pollutants in household products and the ways that communities are designed and built can also affect health. While there is growing understanding that environment impacts health, data and information that can be used to describe key environmental determinants impacting health within and across different communities are not often readily available. Lacking systematic methods to quickly gather relevant information for health assessments makes addressing environmental health problems challenging for practitioners, researchers and policy audiences.

Many kinds and sources of information and data can be useful in understanding how the environment affects health. These include data and information about pollution sources, levels of contaminants in the environment, roads, traffic, buildings, people and their activities, and the ways communities are built. The diversity and complexity of the relevant data and information mean that compilation, analysis and presentation require close attention.

Indicators can provide one way to represent and interpret data for particular audiences. In their most basic form, environmental public health indicators (EPHI) are descriptive measures that summarize environmental monitoring or public health surveillance data. Indicators can put data into a form that is useful and understandable to variety of audiences, including policy and lay audiences. When developed in a consistent manner, they can be used to make comparisons across states or areas. They can inform policy decisions regarding key environmental sources, hazards, exposures and their potential relationship to priority environmental health outcomes or effects across space and time. They can represent key environmental determinants of health and their relationship to other determinants. Indicators can be designed to assess whether there is a need for action, which could include further investigation, public education, intervention or policy development.

In 2004, the State Environmental Public Health Indicators Collaborative (SEHIC) was organized to provide a venue for willing collaborators to work together to develop indicators and measures for use within environmental public health surveillance and practice at the state level. The group started with four members representing three state health departments (WI, WA, OR) and one academic center (UC Berkeley). With some financial assistance from the United States Centers for Disease Control and Prevention (CDC) National Center for Environmental Health's (NCEH) Environmental Public Health Tracking (EPHT) program and the Council of State and Territorial Epidemiologists (CSTE),

representatives from other state and federal agencies, including other CDC branches, the US Environmental Protection Agency (US EPA), US Geological Survey (USGS), and several states and organizations not receiving funding through the EPHT program joined the collaborative (See Appendix I for participating states and agencies).

A. What this project is about

The purpose of the State Environmental Health Indicators Collaborative (SEHIC) is to promote a systematic approach to indicator development and provide a venue to develop environmental public health indicators (EPHIs) useful to states. The goal is to help improve environmental public health practice and capacity at the state level. SEHIC was founded to share resources, expertise, and perspectives. While this effort is targeted at the state level, it can also serve as a resource for a broader spectrum of environmental health practitioners. For example, SEHIC members rely on the expertise and knowledge of partnering federal agencies including the Centers for Disease Control and Prevention (CDC), US Environmental Protection Agency (US EPA), and US Geological Survey (USGS) as part of the indicator development process. Similarly, the federal agencies gain valuable insight into indicator development, technical and content expertise of states. Academic partners provide important technical expertise and guidance in all areas of indicator development. By bringing together these collective experts and skills, SEHIC provides an opportunity for states to collaboratively develop, test and document measures that are useful and relevant for public health and are feasible given the often limited resources and capacity at the state level.

Environmental public health indicators (EPHIs) uniquely address the area of public health practice that represents the convergence of “environment” and “health.” Such indicators are not identical to those produced through initiatives that are focused on either the environment or on health. For example, the indicators included in the draft Report on the Environment (ROE) developed by the US EPA address the full range of environmental factors and conditions that impact both the ecological and human health but is not focused specifically on those conditions particularly relevant to public health (Analogously, the chronic disease indicators developed by the Centers for Disease Control and Prevention (CDC) address chronic diseases overall and do not focus specifically on those relevant to the environment).

SEHIC has defined a set of tasks that could be accomplished by a voluntary group of willing environmental health practitioners from state and federal agencies and organizations. The group selected topic areas believed to be important to environmental health practice in the United States— air quality,

asthma and drinking water. The group identified a guiding conceptual framework and process to develop and pilot indicators in these three areas. The group adapted a model from a CSTE occupational health group that relied on “how-to” guides and templates. This involves use of a “description” template to consistently specify indicators and quantitative summary measures for describing the indicators and “how to” guides that explain exactly how to calculate the various measures, including identification of data sources, specification and/or derivation of relevant data elements and analytic methods. The collaborative group believes that it is valuable to develop both the conceptual elements, such as models and definitions, and to implement proposed approaches, such as specific indicators and measures, and to discuss each based on the experience with the other. This allows theory to inform practice and practice to inform theory.

In addition to establishing a process of state level EPHI development within a collaborative of willing participants, another important contribution of SEHIC has been to increase awareness regarding the importance and utility of EPHIs to the larger practice community. The steering committee has provided presentations demonstrating the conceptual approach and the specific indicators at numerous meetings, to ensure that the ideas and approaches are well vetted within the environmental health community. These have included presentations at the national meeting of CSTE in Albuquerque in June 2005 and in Anaheim in June 2006, at the EPHT network meeting in Atlanta in August 2006, a series of presentations and posters at the meeting of the International Society of Environmental Epidemiology in September 2006, a panel at the national environmental public health conference sponsored by NCEH in Atlanta in December 2006. Titles for some of these presentations are included in the Appendix X.

B. Related Indicator Development Efforts

Indicators are not new to environmental regulatory agencies or public health and are used in many programs to describe current conditions, identify needs, describe key activities, assess goals and track progress. Development of indicators that bridge between the environmental protection and public health sectors is a newer endeavor.

Several entities have undertaken the task of developing indicators relevant to environmental public health. The CDC and CSTE proposed a set of EPHI establishing the initial CDC/CSTE EPHI partnership around 2000 (CDC, 2003). Beginning in 2001, the EPHT initiative sponsored by CDC provided funding to selected state and local health departments and academic institutions to enhance capacity to obtain and analyze data surrounding environmental hazards, exposures and health effects. This initiative now involves 16 states, New York City, and four academic centers (ADD REF). During the

first three years, the CDC EPHT program asked states to evaluate the CDC/CSTE indicators, but coordination of indicator development across multiple states was not a focus. Consequently, these activities were conducted in isolation. Based on lessons learned from the first phase of the EPHT cooperative agreements, the EPHT program has now recognized that nationally consistent and comparable measures are critical outputs from a national EPHT network.

Environmental health indicators have been a focus in Europe for more than a decade. The World Health Organization (WHO) has published conceptual pieces that describe approaches to developing indicators {Corvalan, 1996 #76; Corvalan, 1996 #75} {Briggs, 1996 #69}. The WHO has also participated in efforts worldwide {Briggs, 2003 #273} and in Europe to develop environmental health indicators relevant to children and to increase environmental health capacity for the region {WHO European Region, 2003 #323}. The Commission for Environmental Cooperation (CEC) has also released environmental health indicators for children relevant to North America {Commission on Environmental Cooperation, 2006 #486}.

In 2003, US EPA released the second edition of America's Children and the Environment, which included indicators relevant to children's environmental health for the topic areas under the general jurisdiction of US EPA {Woodruff, 2000 #324; Woodruff, 2003 #268}. The process for developing these indicators {Kyle, 2006 #456} has been adopted in many respects by SEHIC. Some of these were later incorporated into the CEC approach.

In addition, the US EPA has proposed indicators in its draft Report on the Environment (ROE) that, in some respects, addresses health issues (US EPA 2003). These are yet to be adopted. In its Protocol for Assessing Community Excellence in Environmental Health (PACEH) process for environmental health assessment at the local level, the National Association of City and County Health Officials recognize the importance of using indicators that are also cognizant of state and national needs (<http://www.cdc.gov/nceh/ehs/PIB/PACE.htm>).

II. The SEHIC Conceptual Approach and Framework

A. Building the Collaborative

A group of interested collaborators founded SEHIC in the fall of October 2004 after discussions about the potential value of using indicators as part of a systematic approach to environmental public health and environmental public health surveillance activities. The initial steering committee, consisting of three state representatives and one academic institution, met in person in October 2004 in San

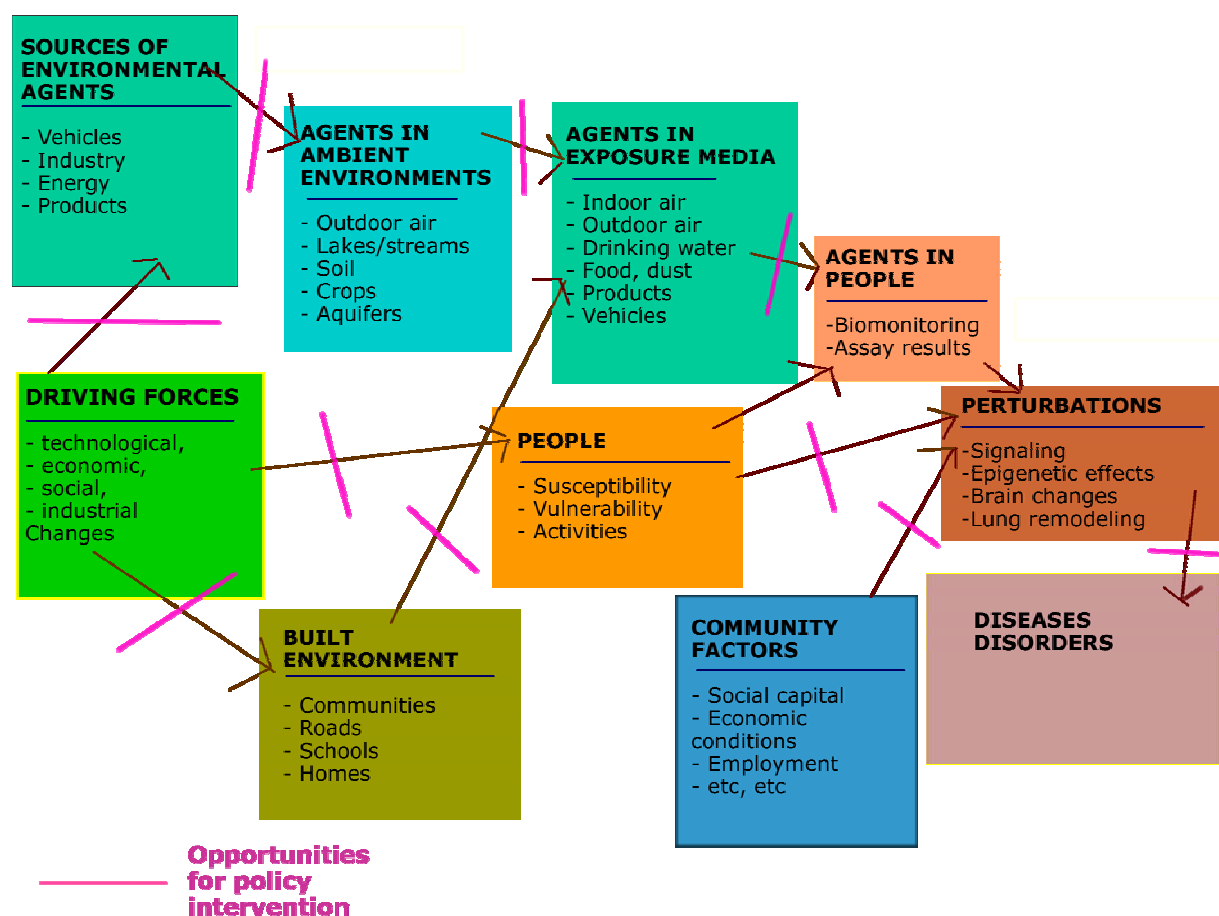
Francisco, CA, December 2004 in Madison, WI, and via several conference calls. In Madison, the initial group developed the essential conceptual approach and agreed to form working groups in three areas that represented important environmental public health issues: air quality, asthma, and drinking water. As the collaborative grew, the full collaborative met in person in September 2005 in Atlanta, GA, in February 2006 in Phoenix, AZ, and in March 2007 in San Francisco, CA. Partial support for the travel costs for individuals to attend these meetings came from the CDC NCEH through support to CSTE.

SEHIC is a collaborative of willing participants; consequently, work has progressed based on the time available by participating members. Questions about appropriate approaches or data sources, as well as the content of the templates and “how-to” guides were addressed within individual working groups. The Steering Committee, consisting of originally founding members and working group co-chairs, continue to meet to ensure consistency in approach between the groups and to plan and implement in-person meetings and conference calls. The conceptualization of indicators required one face-to-face meeting and several subsequent working group phone calls and meetings to develop what the group believed to be tangible and useful products. These products included some initial examples of what the measures might look like visually using preliminary data. The conceptual framework, definitions and documentation include summarized steps identified throughout the initial two years of the collaborative.

B. Conceptual Framework and Principles

The development of environmental health indicators raises a number of conceptual issues, some related to environmental public health surveillance and how it has been discussed and defined and some related more broadly to what it means to see, understand and explain conditions in ways that are relevant for action. The conceptual frameworks adopted by SEHIC are based on those developed and used in other projects. The framework shown in **Figure 1** adapted the approach published by Steve Thacker and colleagues in 1996 (Thacker et al. 1996) and further developed from a framework used in the development of a set of environmental health indicators applicable to children (Kyle et al. 2006), which incorporated elements of the “DPSEE” model from the WHO [add ref].

Figure I. Conceptual framework for relationships between environmental factors, exposures, and disease in human populations. Note: to be revised to address comments received.



The framework specifies the various elements that can be measured relevant to hazards and exposures, and it adds the concept of measuring precursors to adverse health effects. This framework emphasizes the venues in which conditions or attributes can be measured or for which they can be estimated. It focuses on the environment rather than the individual. The framework recognizes the concept of “determinants” and how they may be useful for environmental health indicators and environmental public health tracking. Research studies can establish that actions or conditions are determinants of hazard, exposure or disease. Once such relationships are well established, there may be no additional benefit from a policy perspective to conducting additional surveillance or monitoring to measure all of the conditions in the series of events from beginning to end. It may be possible (and more

cost effective) to focus on the more upstream determinants of downstream results. For example, the cost of a pack of cigarettes has been established to be a determinant of the rate of youth smoking. It might be equally as informative to measure the tax on cigarettes in general as to measure the cost of individual packs, because the tax has a known effect on the overall cost of cigarettes [add ref].

The framework also recognized that both community level conditions and individual level conditions and actions are relevant to predicting health outcomes and that those multiple factors may contribute to individual health outcomes. Both of these raise conceptual and analytic issues that remain to be addressed in the context of environmental public health in general and also for surveillance and indicator development. Some of these factors can be measured directly with existing administrative data resources available to state practitioners and others cannot.

C. Defining purposes for environmental health indicators

Once a guiding framework was established, SEHIC felt it was important to define the purpose and goals of indicator development specifically at the state level. The overarching purpose of EPHIs is to define the elements of the environment that are relevant for health and the elements of health status that are known or suspected to be affected by environmental factors such as, sources of hazardous releases, amount of hazardous contaminants in air, land and water, and the actual or potential for human exposure to these hazardous contaminants. Indicators can also reflect positive and negative environmental determinants of health, including measures of the built environment and “healthy people in healthy places.” EPHIs serve as communication tools that make environmental health information available to stakeholders, including environmental health partners, policy makers and the general public. Finally, EPHIs can identify areas for intervention and prevention and provide information helpful for evaluating the outcomes of specific policies or programs aimed at improving environmental public health.

D. Develop common language and terminology.

Early on SEHIC developed common terminology for the key elements to be addressed and developed a core set of working definitions. These definitions were important to keep development consistent across groups and are important for describing key concepts identified within the tools such as, key components of the description templates. As indicator development evolves, these working definitions have evolved to more accurately reflect the different concepts and elements required to ensure consistency across groups. The most updated set of working definitions to date are provided in Appendix III.

An initial goal of SEHIC is to increase practitioners' ability to describe and track the key environmental determinants of health and the health outcomes that are related to environmental risk factors. The complexity of environmental health relationships can make this process feel paralyzing. It was recognized early on that a tiered level of indicators that breaks down relationships into their fundamental parts before integrating them is an important element of the SEHIC approach to EPHI development.

Tier one indicators are defined as “**stand-alone.**” The development of stand-alone indicators that reflect key sources, releases of contaminants, concentrations of pollutant in air, land and water, population exposure to contaminants, or related health effects provide important information for developing the first tier of EPHI. EPHI are important measures for assessing spatial and temporal trends one determinant at a time. Stand-alone measures either describe health effect measures to highlight their environmental health significance or they can provide baseline estimates of factors that have not yet been described in an environmental health context. For example, it has been documented that ozone and fine particulate matter (PM 2.5) are related to adverse health outcomes including asthma. Consequently, standalone measures that reflect relevant ozone and PM2.5 levels describe important environmental determinants of health can be used in **an indicator suite** with related health outcome measures such as statewide or county asthma hospitalization rates. Simultaneously tracking several stand-alone measures together within the same context helps to tell important environmental health stories using quantitative data to illustrate phenomenon and qualitative information to explain their significance in an environmental health framework. Development of comparable standalone measures requires common methods, data sources and capacity. SEHIC recognized this and found it important to focus first on stand-alone measures. Environment and health specialists were brought together through SEHIC to provide careful consideration and the several stand-alone measures benefited from the collaborative process.

A second tier of indicators aims to better characterize areas and populations at greatest risk for either potential exposure to environmental factors at un-safe levels for human health or for disproportionately sharing the burden of a disease with known or suspected environmental etiology. To do this, we move beyond stand-alone indicators to **targeted indicators** that can specifically identify areas or populations at risk. Such indicators can more specifically define issues and concerns in environmental health and would most commonly combine the types of factors or outcomes addressed through the stand-alone measures in ways that focus on high risk groups or areas. For example, a targeted indicator might reflect the percentage of asthmatics who live in areas with high values for air pollution, thereby showing a population at risk due to initial health status (asthma) and impacted by higher levels of an environmental hazard (air pollutants).

A third tier of indicators integrate analysis of relationships between hazard/sources and health effect measures. SEHIC has not developed such indicators at this point, but the CDC EPHT program is working in this area, and SEHIC considers these to be important indicators to address in the future for state health departments with adequate capacity and resources to do so. The PHASE project, a collaboration of US EPA, CDC, and EPHT partners, provides an example of the amount of analytic effort and collaboration needed to generate this third tier of integrated measures. PHASE explored relationships between asthma hospitalizations and PM 2.5 and ozone, as well as between PM 2.5 and myocardial infarctions. The PHASE project used a case-crossover approach to look at the relationship in three states (Bateson TF, Schwartz, J. Control for seasonal variation and time trend in case-crossover studies of acute effects of environmental exposures. *Epidemiology* 1999 Sep;10(5);539-44; [add ref] CITE DRAFT Document for PHASE). The project produced state-specific estimates of the relationship between asthma hospitalizations and PM2.5. The resulting odds ratio can now be used to track trends in potential environmental contributions to estimated asthma and myocardial-infarction hospitalizations over time.

E. Develop tools

SEHIC sought to have tools available that would facilitate development of indicators in a consistent and compatible way across multiple states. The occupational health indicators developed by states in conjunction with CSTE include a concise, specific guide on how to implement each indicator [add ref]. It also shows exactly how to obtain the data for the data elements needed to produce the indicators and it also shows how to do the computation. SEHIC adopted and adapted this model. Members of the individual SEHIC working groups used description templates and “how-to” guides to describe the measures and develop some level of consistency between groups.

1. Description Templates and “How-to” Guide Definitions and Terminology

A description template is used to assemble the background information about the indicator and measures. A “how-to guide” explains exactly how to obtain and process the data and any other information needed to develop the measure. It became clear that due to the unique nature of environmental health surveillance, some adaptations needed to be made to the existing templates to accurately reflect key elements required for developing consistent and comparable EPHI. A copy of the description template is shown in **Figure II** along with instructions for filling in each of the individual components. One template is derived per indicator. For each topic area there can be several indicators. Within each indicator, there can be several different measures quantitatively summarizing some aspect of the indicator. The template consists of 1) a summary description of the topic area; 2) indicator and

measures and date the template was generated; 3) documentation of the data elements required for generating measures; 5) data sources used to generate the measures; 6) supporting information and context. Given the breadth of topic areas and potential different types of measures that one could potentially develop, SEHIC generated this template while considering the trade-offs between consistency with other CSTE indicator initiatives and development of tools that more adequately address elements specific to EPHI development.

Figure II: SEHIC Description Template and Instructions

Instructions for Templates for SEHIC	
Title	Letter, number code and short name for measure. SEHIC measures are denoted by a letter that represents the topic area and then a number that represents the measure. A - air quality, B - drinking water; C - respiratory disease; D - climate change mm.dd.yyyy and name of person
Last updated	e. g. air quality, drinking water, respiratory disease, climate change
Topic Area	The name for the series of measures
Indicator	Detailed name of measure
Measure	
Data Elements Used to Compute the Measure	
Data element 1	A data element is an observation, estimate, measurement, etc that is to be used in the computation of the measures. Examples: 24 h average of measured PM10; number of cases per year; number of people who live in a county
Data element 2	
Data element n	
Data Sources	
Source for data element 1	Specify the source of the data used for each data element. Examples: EPA air quality system monitoring data; US census
Source for data element 2	
Source for data element n	
How the Measure is Constructed or Computed	
Geographic unit for computation	e. g. county, census tract, metropolitan statistical area, state
Geographic scope	total area included in measure (if applicable)
Time period addressed by measure	e. g., year, day
Time period included in computation	what time period is to be included, e. g. 1999 to 2004
Demographic group and/or subgroup	
Computation	e. g. calculate annual average of 24 hour values, divide the number of cases by the target population, etc. Can show multiple computations if relevant
Supporting Information	
Significance and rationale for selecting this indicator	why the subject of the indicator is important
Rationale for this measure	Why you chose this approach to represent the indicator
Limitations of this measure	What this measure does not do well, how is it less than ideal as a way to represent the indicator and topic area
Limitations of the data	What limitations exist for the data sources used. These limitations could be addressed by better data but would not be affected by changing the measure.
Key references	
Context	
Related SEHIC measures	Identify other SEHIC measures that are related. For environmental indicators, this could be health outcomes that are associated with the environmental factor.
Other related measures	Healthy People 2010, US EPA, etc.
Recommendations	suggestions for future development or other issues to examine
File name	Name of this file - use naming convention

III. Results

A. SEHIC Process for Indicator Development

Four basic steps in the development of indicators emerged as a result of the first two years of indicator development by SEHIC members:

- 1) Select topic areas.
- 2) Explore existing data and resources available.
- 3) Identify indicators and select feasible and practical measures that can be used to quantitatively summarize the indicators and meet their intended purpose and goals.
- 4) Review, evaluate and revise.

These steps outline key aspects of indicator development that needed to be considered by SEHIC participants and actions that were taken in order to develop measures that build on collective expertise and make use of the collaborative. These steps provided a mechanism by which working groups could identify and address critical gaps in knowledge, information and data currently available. The process also facilitates the development of indicators and tools that will help practitioners generate and disseminate information that is both meaningful and relevant to environmental health decision-making.

1. Select topic areas

In its first phase, SEHIC established working groups for air quality, asthma, and drinking water. As previously mentioned, these topic areas reflected public health importance, largely as reflected in the presence of a topic area on the consensus list and the significance within individual states. Each working group discussed sources of data, indicators and related measures, independently.

2. Explore existing data and resources available

The steering committee initially identified data sources, based on existing knowledge. Indicator development needed to be feasible and practical for a broad range of environmental health practitioners. Data had to be available to generate the indicator at the state level for at least one state. For example, within the drinking water workgroup, the biggest challenge to assessing the public health implications of

drinking water contaminants was a paucity of data on actual population exposure. In addition, there is a large gap in data and information available for assessing private well and public well data. The most common dataset available to all state level practitioners were the state-specific Safe Drinking Water Information System (SDWIS) database. The state SDWIS data have traditionally been collected for regulatory purposes and contain contaminant specific information on levels and trends in data. While all states are required to collect and analyze these data for compliance monitoring, the public health relevance of this data has not been systematically assessed.

3. Identify Indicators

Once a primary datasets had been identified, the next step was to determine assessment goals and identify specific indicators and measures. Like selection of the topics, the development of indicators and measures requires some consideration of their intended purpose, use and recognition of who the target audience might be. Complex statistical measures may be appropriate for analytic audiences while simple summary measures with clearly defined benchmarks for comparison may be more suitable for policy or public audiences. The majority of SEHIC measures fall in the latter category.

For example, an indicator of outdoor levels of ozone might include daily eight hour averages of ozone concentrations over a specified time period. The purpose of these measures would be to show temporal variation in ozone within a particular geographic region to identify when ozone has the potential to cause the greatest health effects and where problems might be greatest. The goal of this indicator might be to assist environmental health practitioners in prioritizing when air quality alerts need to be sent out. Also, what times of the year they need to be most concerned about conveying to the public the need to change behaviors because air quality is poor or to identify what times of the year people should be encouraged to take alternative modes of transportation to work. Identifying a primary audience for the indicators and their intended purpose and goals can help both in identifying appropriate measures as well as evaluating their utility for their intended purposes. It became apparent through the development process that it was also important to consider how measures relate to opportunities for education, prevention, action, intervention or evaluation of previous actions or interventions. This is an area for additional work for SEHIC to address as part of the development process.

The water group found it wanted to focus on using the existing SDWIS data to determine the public health significance of contaminant levels by exploring potential population exposures to varying levels of contaminants over time. Because the SDWIS data addresses a large range of potential contaminants, a next step was to prioritize which measures to focus on first. The group chose to focus on

arsenic and total-trihalomethanes as two contaminants of concern for the majority of participating states, but with very different origins and issues in terms of sources, regulatory monitoring and compliance issues as well as health effects. From here the group began to work out specific details of the measures using the templates and “how-to” guides as references of what types of information need to be considered.

4. Review, Revise and Evaluate

Developing the documentation to support indicator development required several phases of review and revisions. The working groups found the collaborative approach to indicator development takes time, and is an iterative and dynamic process. Building on the collective expertise of participants was found to strengthen the outcomes, but took considerable time. A pilot phase was also considered necessary to review, revise and evaluate the feasibility and utility of the proposed measures. The initial workgroups are currently in the final stages of pilot testing. Proposed methods, preliminary results, proposed templates and models, have been made available to interested parties through web-based dissemination, meetings and presentations. The coordination of these efforts would not have succeeded without the development of a SEHIC web-site housed at UC Berkeley. As the collaborative grows, these functions are being transferred to CSTE to help with the coordination, assessment and distribution of information and documentation.

B. SEHIC Indicators and Measures Developed To Date

The indicators and related measures shown in the following section are currently under development. (Details about these indicators and measures and the results of pilot testing are forthcoming.) The description templates and ‘how-to’ guides are available on line at <http://envirohealth.berkeley.edu>. For its second phase, SEHIC has established a working group to address issues related to climate change and preliminary documents supporting these efforts will also be made available via the CSTE website (INSERT CSTE WEBSITE HERE)

A. Air Quality Working Group

Topic Area: Outdoor Air Pollution

Indicator: Ambient Concentrations of Ozone and Particulate Matter

Measure A1. Ambient concentrations of particulate matter (<10 microns in diameter)

Measure A2. Ambient concentrations of particulate matter (<2.5 microns in diameter)

Measure A3. Ambient concentrations of Ozone.

Indicator: Air Quality Index

Measure A4. Number of Persons in each Metropolitan Statistical Area and Person-Days of Air Which Was Rated as Very Unhealthy, Unhealthy, and Unhealthy for Sensitive Groups

Measure A5. Percent of population in counties and metropolitan statistical areas with monitors that live in areas that exceed the EPA NAAQS and California standards.

Indicator: Traffic

Measure A6. Percentage of Population living near busy roads (by county)

Indicator: Hazardous Air Pollutants (developmental)

Measure A7a. Percent of population living in counties with hazardous air pollutants estimated to exceed health benchmarks for cancer.

Measure A7b. Percent of population living in counties with hazardous air pollutants estimated to exceed health benchmarks for non-cancer effects.

Indicator: Emissions of Greenhouse Gases

Measure A8. CO₂-Equivalent Greenhouse Gas emissions per capita (developmental)

B. Asthma and Respiratory Outcomes

Asthma 1. INDICATOR: ASTHMA HOSPITALIZATION.

Asthma 2. INDICATOR: CHRONIC LOWER RESPIRATORY DISEASE AND ASTHMA MORTALITY

C. Drinking Water

DW1. ARSENIC DRINKING WATER INDICATOR: Distribution of the total population and percent of population served by level of arsenic in finished water.

DW2. ARSENIC DRINKING WATER INDICATOR: Geographic and Geologic Distribution of Arsenic in Groundwater Used for Drinking Water.

DW3. TTHM DRINKING WATER INDICATOR: Distribution of the total population and percent of population served by level of Total Trihalomethanes (TTHMs) in finished water (users of public water supplies only).

IV. Discussion

The SEHIC work is the first collaborative effort among state environmental health practitioners and interested supporters to develop and test indicators that uniquely address topic areas that represent the convergence between environment and health. The collaborative has been successful to date in part because of leadership from a core group of willing participants. SEHIC believes that indicators need to be developed to meet specific needs for identified audiences and to address particular assessment questions. Environmental public health indicators (EPHI) can be used for several purposes. EPHI enhance environmental health practice by improving the accessibility, availability and distribution of data from existing environmental monitoring and public health sources and increase the amount of information available for decision-making.

SEHIC measures are geared towards producing results that have some level of comparability across states. SEHIC recognizes that there is a tradeoff in seeking comparability in that some states may have data sources that allow them to develop better measures than other states. A state may develop a measure that is initially feasible only in that state but then becomes a model for other states. SEHIC has recognized that indicator development is an ongoing and iterative process. As indicators are identified, measured and pilot tested, their value and use vary. SEHIC is looking towards the future to examine ways to address these issues while also producing tangible products for state environmental health practitioners.

Several areas need additional development. These are generally applicable to the state of indicator development overall, in addition to SEHIC. These include evaluation, representation, and conceptual development. SEHIC has focused initially on measures that allow comparisons across states. Consequently, the initial measures are presented at the state level. They can also in many cases be broken down to more resolved geographic scales, such as counties. This differs by measure and by state, based in part on data availability. SEHIC recognized that it is important to be able to accurately reflect conditions at the national and local levels, as well as the state level. Efforts to address these different geographic scales are needed. SEHIC also recognizes that issues of presentation of results need to be addressed through the templates and “how-to” guides, and a group is working on this. Similarly, SEHIC recognizes that indicator and measure need to be evaluated. This will require that intended uses be more specifically identified as an initial step. It will also require a process for further assessment of their value for these purposes. Representation of the measures is also an area that requires additional work. As noted

in the previous section, SEHIC is looking at models for representation and assessing them. This is also recognized as a need for EPHT.

Data limitations are important for all of those working in environmental health. SEHIC recognizes that data will always have limitations. Moreover, even when based on relatively high quality or complete data, indicators will always reflect estimates of actual conditions. SEHIC seeks to achieve the best and most valid estimates possible but also wants to retain the capability to include all of the topic areas relevant to environmental health, data sources are limited and it is necessary to use surrogate data sources. A surrogate is a measure that provides relevant information about the indicator but in a way that is less direct than might be ideal. Surrogate measures are used when data sources are not available or not reliable for direct measures. This means that careful consideration needs to be given to when it is better to include a less complete or lower quality source of data, rather than to omit a topic completely.

SEHIC also recognized that the state of knowledge about how environmental factors affect health varies significantly. Our approach should be scientifically based, in that it should draw on the best available information and the most current and complete knowledge about relationships between environmental factors (hazards), exposures, and outcomes. However, it may be appropriate for purposes of public health policy and surveillance to consider factors or conditions that are of potential concern, even before relationships are fully established {Kyle, 2006 #455}. We recognize that there are several types of data that can be used to characterize the environment, people, and the policy system.

As the group becomes more formalized and products are produced, there are an increasing number of requests from practitioners outside of the collaborative interested in the products as tools to assist in their daily efforts to assess environmental health. This poses challenges for coordination and organization, as the need for attention to these areas increases with the size of the group. How to provide resources and effective coordination for a group of the size the SEHIC that has the potential to involve representatives from all 50 states and numerous federal and other agencies is yet to be addressed.

Looking to the future, SEHIC hopes to remain a strong and influential part of state-level environmental health indicator development in the United States. Future success will require increased efforts to address gaps identified during SEHICs first phase including the need to develop some standardization for the presentation and display of indicators as well as evaluation along with continued piloting of existing measures. SEHIC is beginning to expand its scope beyond the initial workgroups to address emerging environmental health concerns such as climate change and community environmental

health. Future success of SEHIC efforts will be dependent upon the continued interest and willingness of its many participants and partners.

V. Commentaries from Participants

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Appendices

Appendix 1. Contact information for SEHIC

Address for listserve: <sehic@lists.berkeley.edu>. This is an un-moderated list serve; anything sent to this email address will be automatically forwarded to the email addresses of everyone on the list. To be added to this list serve, notify <adkyle@berkeley.edu>

Web site: <http://envirohealth.berkeley.edu>

Appendix 2. Steering Committee and Participants

Steering Committee

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Lesa Roberts (KS), co-chair
Paul English (CA)
Amy D. Kyle (UCB)
Catherine Thomsen (UCOP)
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Appendix 3. Working Definitions

SEHIC has adopted a hierarchy of terms, beginning with **topic areas**.

Topic Areas -- major areas of interest for environmental health. Examples of topic areas are outdoor air pollutants, drinking water contaminants, respiratory diseases, or body burdens of metals. Within a topic area can be multiple indicators.

Indicator -- an attribute or condition that is of interest to be measured or estimated. A topic area such as air quality or drinking water can have multiple indicators.

Suite of indicators- The term **suite of indicators** refers to the set of indicators that, together, address a topic area. For each indicator, there may be multiple measures.

Measure – something that can be specifically calculated or constructed to reflect an important aspect of an indicator. Measures are constructed by methods that manipulate by specified data elements (variables) using identified data sources. Values for data elements are then derived through the use of data from specified sources. The method to construct or compute each measure is specified. Data elements and data sources are related but not identical. For a given data element, it may be possible in some cases to choose from more than one data source. For example, for air quality measures, one data element may be the average value for particulate matter over a year. This could be obtained either from a data set built from air quality monitoring data or it would be obtained from a data set built using combined methods, such as the “PHASE” data.

Data element -- a specific variable that is used to calculate or derive a measure.

Data source – a specific, identified source that is consulted to provide a value for a data element. A data source will be described generally and the method by which it can be accessed included.

Example: A **measure** that describes the total population served by public water supplies that exceed a maximum contaminant level (MCL) for total trihalomethanes (TTHMs) includes three **data elements**. One data element describes the concentration of TTHMs within each public water supply calculated in ug/l. A second data element identifies the distribution of public water supplies by census tract. The third data element is comprised of the population estimate by census block that corresponds to the distribution of public water supplies. The Safe Drinking Water Act (SDWA) reporting system

(sometimes referred to as the Safe Drinking Water Information System- SDWIS) is the **data source** for the first two data elements and the 2000 US Census is the **data source** for the population estimates.

Types of Measures

SEHIC has identified three tiers of measures and developed measures in the first two tiers to date.

“Stand-alone” measures are developed for the elements of the environment that are relevant for health and the elements of health status that are known or suspected to be affected by environmental factors. For example, key “stand alone” indicators would be developed to address outdoor air quality, a key environmental factor, and respiratory effects, a key health outcome. Both are important to track. **Targeted measures** are developed to identify particular groups, populations, or areas of concern. One example would be a targeted measure that reflects individuals at particular risk, such as asthmatics from air pollution..

Related measures – Measures that reflect related elements on the conceptual framework. For example, measures representing air pollutants that contribute to asthma would be considered to be “related” to measures that represent asthma. This is a way of showing relationships along the sequence from sources to releases to ambient concentrations to exposures to effects in a qualitative way that may be more understandable to non-technical audiences than a quantitative presentation or that may be more appropriate when data are not sufficient to allow for a quantitative presentation.

Appendix 4: Logic Model for Drinking Water/Example Template

Topic Area Overview:

- cover page and description of topic area
- conceptual model of topic area
- list of indicators for that topic area

Indicator Section: For each indicator:

- Table of measures for that indicator and revision history
- For each measure:
 - description
 - rationale
 - table of data elements, and for each element, the source(s) for those elements, and data quality issues
 - How to (exactly) use the data elements to compute the measure (cookbook recipe)
 - Brief narrative of limitations of measure
 - Brief narrative re issues of validity and interpretation

Topic Area: Drinking Water

Conceptual model

Diagram of the conceptual model of the process of hazard release, fate and transport; exposure process, and subsequent disease process, and the part of the process that each indicator is trying to capture. Sets boundaries of Topic Area.

Topic Area: Drinking Water

Measure1. Percent of state population served by PWS which had, in the past three years, at least once exceedance of a NPDWS MCLG for any chemical contaminant which is known or suspected carcinogen, stratified by race and ethnicity.

Is this measure part of Health People 2010? Yes / No

A. Rationale:

Most of the state's population is served by Public Water Supplies. This risk of cancer to the population due to consumption of drinking water is related to the level of these known or suspected carcinogens in drinking water. The Maximum Contaminant Level Goal (MCLG) is an estimate of the contaminant level in drinking water, which would not be expected to pose an appreciable risk of an adverse health effect from a lifetime of consumption. If the water provided by PWS exceeds this level then consumption of the water may lead to a risk of cancer. Any PWS which has had a measured value in the past three years of any known or suspected carcinogen at levels above the MCLG may lead to an increased among their consumers.

B. Data elements:

Data Element	Sources and contact	Quality Issues
Block-level population count by race and ethnicity	US Census web site www.census.gov/ >>	From 2000, may not represent current populations
GIS layer of block groups	US Census	
Actual or approximate extent of PWS service areas	PWS purveyor	may not be accurate
Number of connections for each PWS	State drinking water database: Sentry for WA	often not updated
WQ monitoring results, by PWS, past 3 years, including CASRN	State drinking water database: Sentry for WA	
List of monitored contaminants which are Category A or Category B1 carcinogens	IRIS, www.epa.gov IARC	
MCLGs for regulated contaminants	NPDWS, www.epa.gov/ ??	

C. Metric – How-to:

1. Estimate total number of residents served by PWS, by race and ethnicity
2. Identify contaminants which are known or suspected carcinogens
3. Identify PWS that had any sample above the MCLG for any of the listed contaminants.
4. Identify the approximate spatial extent of the PWS service area.
5. Determine the block groups and parts of block groups within the service area.
6. Sum the population for the BGs within the service areas and estimate the proportion of BGs partially within the service areas..
7. Sum to get total population within service areas, by race and ethnicity.
8. Divide the total served by PWS with at least once sample > MCLG by the total population served by PWS, by race and ethnicity.

Appendix 5 Abstracts and Presentations

Catherine Thomsen, Kristen Malecki, Amy D. Kyle, James VanDerslice. **US approach to environmental health indicators and potential for international collaboration.** Oral presentation at the International Society for Environmental Epidemiology annual conference. September 2006.

Catherine Thomsen, Kristen Malecki, Amy D. Kyle, James VanDerslice. **US approach to environmental health indicators: initial steps, data, and collaboration.** Oral presentation at the International Society for Environmental Epidemiology annual conference. September 2006.

James VanDerslice, Washington Department of Health, Kristen Malecki, Wisconsin Department of Health, Amy D. Kyle, University of California Berkeley, Catherine L. Thomsen, Oregon Department of Health. **State Environmental Health Collaborative: Developing indicators for use by state environmental health practitioners.** Breakout Session at the National Meeting of the Environmental Public Health Tracking Network. Atlanta. April 2005.

Background: Indicators were an element of many state applications for EPHT funding. In the absence of finalized and detailed guidance on the existing environmental public health indicators, grantee states were working separately, potentially duplicating efforts and likely developing measures that were not comparable.

Objective(s): Our collaborative is working toward efficient and effective measures that can be rapidly generated, and monitored over time. Our goal is to compare results among partners and share insights into the indicator development process to demonstrate the utility of the measures for environmental public health practice.

Method(s): A core group of EPHT tracking partners met to scope and develop a plan for rapidly developing a pilot set of measures. The foundations for indicator selection and development will build on the collective experience working with current CDC/CSTE EPHI and other indicator initiatives, including national and international efforts within the US EPA and WHO. We will discuss our process and the analytical approach used.

Result(s): Products include feasible pilot indicators that can be used at the state or smaller geographical level, and “how to” guides, documentation to ensure comparability. Specific indicator topic areas and measures were selected and are being piloted in at least three states.

Discussion/Recommendations: What measures are being used elsewhere and how are they being documented? Are other states/cities interested in this approach and the tools we employed? Identify others interested in joining the collaborative to pursuing this process to test measures and refine guidance documents.

Amy D. Kyle. **Defining a role for indicators in the environmental public health tracking network.** Presentation to plenary session. National meeting of the Environmental Public Health Tracking Network. October 2004. San Francisco.

Amy D. Kyle. **The role of indicators in environmental public health tracking.** Presentation to seminar series at the Centers for Disease Control and Prevention. August 2004, Atlanta.

Updates from the State Environmental Health Indicators Collaborative (SEHIC)

Environmental public health indicators were first described by the CDC/CSTE environmental public health indicators project in 2000. Since that time, the national environmental public health tracking program has begun to enhance state level capacity for tracking environmental hazard, exposure and health effect data. A mechanism to develop key summary measures of these systems that are consistent across multiple states was needed. In 2004, the State Environmental Public Health Indicators Collaborative was established. While work is being lead by state-level environmental epidemiologists, support for the program's efforts is being provided by the CDC's National Center for Environmental Health and the Council for State and Territorial Epidemiologist (CSTE).

Goal of the Project

The primary goal of SEHIC was to convene a group of willing collaborators to begin to work together to develop and compare indicators for use within environmental health surveillance and practice.

Methods

The indicator development process was established by the workgroup, and is documented in a plan of action, a list of definitions and templates for the measures and for guidance documents. Pilot indicators were selected based on the interests of collaborators and perceived ease. Once preliminary topic areas were selected, the working group engaged CDC programs and additional state partners interested in piloting the indicators, to participate in refining tools and provide feedback on background materials framing the project. Two working group meetings were held, in September 2005 and February 2006. Plans for development of a preliminary document with indicator results are underway and scheduled for release in June 2006.

Results

Results from the preliminary SEHIC work include the formation of three working groups including air quality, asthma and drinking water. Nine preliminary measures were identified and developed within these topic areas. Each indicator is presented in a template based upon previous CDC/CSTE work, which describes the significance, background, data sources and limitations of the indicator, with a "how to" guide for replicating the methods of deriving the measure in a standard way. Future goals of SEHIC are to evaluate preliminary findings and refine indicator templates, guidance documents and reporting formats, expand the number of indicators and topic areas, and development of practical, user friendly templates and how to guides for state level environmental public health indicator development.