Epidemiology and Public Health Science: Core Competencies for High School Students

Kelly L. Cordeira, MPH[1,2] and Ralph Cordell, PhD[1]

[1]Career Paths to Public Health; Division of Scientific Education and Professional Development;
Center for Surveillance, Epidemiology and Laboratory Services;
Centers for Disease Control and Prevention
[2]Association of Schools and Programs of Public Health Fellowship Program

Epidemiology and Public Health Science: Core competencies for high school students was developed as a resource for teachers interested in teaching epidemiology and public health science. It is a Career Paths to Public Health product in the Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, Office of Public Health Scientific Services, Centers for Disease Control and Prevention.

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Contact Information

Please send questions and comments to scienceambassador@cdc.gov

Career Paths to Public Health

Career Paths to Public Health's (CPP) mission is to improve future workforce capacity by raising awareness, igniting interest, and developing competency in epidemiology and public health science (EPHS) among secondary school students as a means to increase health literacy and advance students into a public health career pathway at an early age.

Purpose of EPHS Core Competencies

Public health is among the fastest growing undergraduate fields in the nation.[1] A growing interest in public health at the middle and high school levels has been noted.[2-4] Secondary school curricula in public health are needed to develop basic public health competencies and allow for a smooth transition to college-level coursework. Early experiences in the field may increase the likelihood of students pursuing a public health career during later years.[5,6] Substantial value in secondary school education in public health regardless of career path trajectories has also been reported. Public health education has the potential to expose students to crosscutting public health concerns with immediate relevance. This supports development of knowledge and critical thinking skills across public health domains and other disciplines, such as physical and natural sciences, social and behavioral sciences, mathematics and quantitative reasoning, and the humanities.[3] Students will be exposed to concepts and experiences that support information and science literacy, ultimately leading to a informed generation regarding public health.

CPP developed EPHS core competencies to support high school teachers and administrators in creating EPHS-based curricula and proposals to accredit EPHS as an elective course in schools, districts, and states. Experts in both public health and education, including master teachers from around the United States have reviewed these competencies for content, usability in the classroom, and alignment with other educational resources.

Organization of Core Competencies

The core competencies are based on four core public health domains (i.e., epidemiology, surveillance, analytic epidemiology, and prevention effectiveness), which provide the foundation for a humanities perspective (i.e., a public health approach). Each domain has 3–4 core competencies supplemented with a clarification statement. The clarification statements provide content and skill information needed to meet each competency.

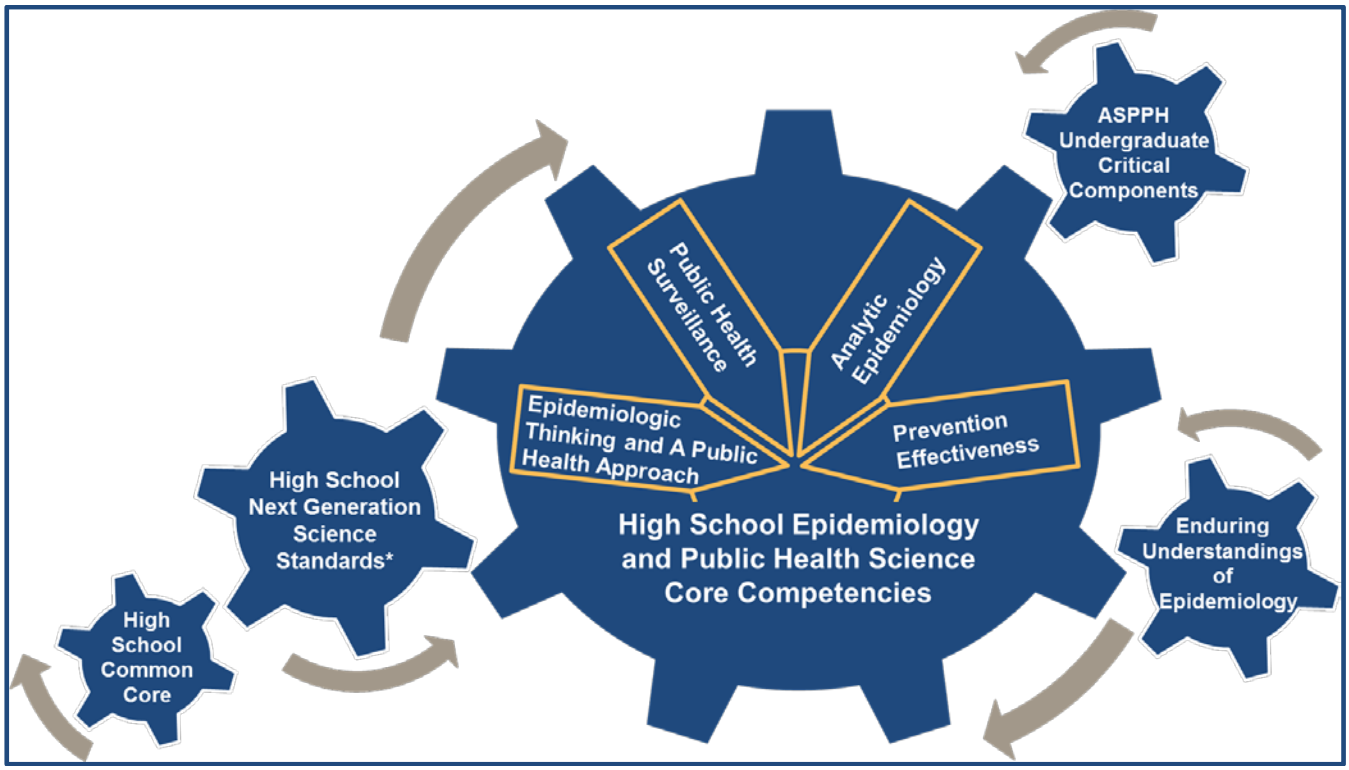
Domains

- EPHS1: Epidemiologic Thinking and a Public Health Approach
- EPHS2: Public Health Surveillance
- EPHS3: Analytic Epidemiology
- EPHS4: Prevention Effectiveness

Alignment of Core Competencies

EPHS core competencies are based on the enduring understandings of epidemiology[7], and align with Next Generation Science Standards (NGSS) (http://www.nextgenscience.org/)[*,8], and the Association of Schools and Programs of Public Health (ASPPH) Recommended Critical Component Elements of an Undergraduate Major in public health (http://www.aspph.org/educate/models/undergraduate-baccalaureate-cce-report/).[9] These associations provide both vertical and horizontal connectivity and assure that these competencies provide a foundation for future studies and are firmly grounded in the discipline and pedagogy. (See Figure 1). See appendices for detailed alignment.

Figure 1: Alignment of Epidemiology and Public Health Core Competencies for High School Students with Next Generation Science Standards*, Common Core, Enduring Understandings of Epidemiology, and ASPPH Recommended Critical Component Elements of an Undergraduate Major in Public Health.



Source: Career Paths to Public Health, Centers for Disease Control and Prevention.

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Enduring Understandings of Epidemiology

EPHS core competencies are based primarily on 12 fundamental or enduring epidemiologic understandings developed by Kaelin and coworkers.[7] Twenty-eight judges for the Robert Wood Johnson Foundation and College Board's Young Epidemiology Scholars (YES) Competition were surveyed and developed a consensus concerning major concepts and principles around which epidemiology teachers at the high school level should structure their curricula. These were further consolidated into four EPHS domains with 14 new core competencies that align with both NGSS (high school) and the ASPPH Recommended Critical Component Elements of an Undergraduate Major in Public Health. See Appendix 1 for a detailed alignment of the enduring understandings of epidemiology with EPHS core competencies.

Next Generation Science Standards (High School)*

EPHS core competencies align with high school science and engineering practices and crosscutting concepts used in NGSS. NGSS was developed on the basis of research from the National Research Council, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas[10], and was published in 2013. These evidence-based standards propose a shift in teaching pedagogy from just learning about science to teaching students how to actually do science. Teachers can use these standards to engage students in critical thinking concerning science by using discipline-specific core content, eight science and engineering practices (e.g., gathering, reasoning, and communicating) and seven crosscutting concepts (e.g., causality, patterns, and systems).[8] Practices and crosscutting concepts were considered in the development of EPHS core competencies. Each competency emphasizes 1–2 specific skills and ideas.

In NGSS, core content was also identified for each discipline and includes performance expectations for each content area. To align with NGSS, core content for EPHS was identified. The majority of content is based on Principles of Epidemiology in Public Health Practice[11], a widely used CDC self-study program for those working in public health. Ten content areas (e.g., epidemiologic thinking, surveillance, study designs, and intervention strategies) were identified and defined. These content areas and definitions were used to develop the clarification statements for each performance expectation. Alignment with NGSS in a similar visual format and language is available in Appendix 2.

ASPPH Critical Component Elements of an Undergraduate Major in Public Health

EPHS core competencies vertically align with the recommended critical component elements of an undergraduate major in public health. In 2012, ASPPH published key components by discipline, skill area, public health content area, and crosscutting areas.[9] EPHS core competencies for high school students focus on developing a necessary foundation to achieve standards at the undergraduate level. EPHS core competencies, overall, incorporate four ASPPH disciplines (i.e., science, social and behavioral sciences, mathematics and quantitative reasoning, and humanities and fine arts); two ASPPH skills areas (i.e., communication, information literacy); seven of nine ASPPH public health content areas with a focus on four (i.e., overview of public health, role and importance of data in public health, determinants of health, and health communication); and eight ASPPH crosscutting areas with an emphasis on critical thinking and creativity, organizational dynamics, research methods, and systems thinking. Alignment with undergraduate critical components is available in Appendix 3.

Epidemiology and Public Health Science (EPHS): Core Competencies for High School Students

EPHS 1: Epidemiologic Thinking and a Public Health Approach

This domain supports students' understanding of the broad picture of epidemiology and public health science and how it influences health and disease. Students can make connections among the causes of health and disease through epidemiologic thinking, and learn how a public health approach is used to improve health and prevent disease. The focus of this disciplinary core idea is concerning interdependencies of epidemiology and public health action over time, while considering the historical evolution of epidemiology.

HS-EPHS 1: Epidemiologic Thinking and a Public Health Approach		
	Competency	**Clarification Statement**
HS-EPHS1-1	Describe how epidemiologic thinking is used to provide an evidence-based explanation concerning causes and correlations of health and disease.	Emphasis is on describing what basic epidemiology is, how it has evolved and how it is used today, and the key methods and concepts of epidemiology.
HS-EPHS1-2	Discuss how epidemiologic thinking and a public health approach is used to transform a narrative into an evidence-based explanation.	Emphasis is on examining scientific literature to identify core methodology used and applied in different circumstances. Students examine steps used in outbreak investigations and explain how circumstances of an outbreak can dictate a different order be followed.
HS-EPHS1-3	Apply epidemiologic thinking and a public health approach to a model (e.g., outbreak) to explain cause and effect associations that influence health and disease.	Emphasis is on how epidemiologic thinking and methods are tailored to investigate specific health-related factors, provide evidence for their influence, and propose public health interventions.

EPHS2: Public Health Surveillance

Through identifying patterns of health and disease and formulating hypotheses, students learn how to define health problems through surveillance, identify sources and methods for gathering data, and conduct descriptive epidemiology. By examining characteristics of health and disease, including person, place, and time, students generate hypotheses and identify testable associations for study.

HS-EPHS 2: Public Health Surveillance		
	Competency	**Clarification Statement**
HS-EPHS2-1	Describe how to collect reliable data regarding priority health-related phenomena using public health surveillance systems.	Emphasis is on identifying priority health-related phenomena according to importance of the problem; ability to prevent, control, or treat the problem; and capacity of the health system to implement control measures for the health problem. Also consider how data is collected in determining which type of surveillance system (i.e., active, passive) is used.
HS-EPHS2-2	Use credible evidence to describe a public health surveillance system.	Emphasis is on describing a surveillance system and its attributes (e.g., simplicity, flexibility, data quality, stability, acceptability, sensitivity, predictive value positive, representativeness, timeliness) qualitatively and quantitatively.
HS-EPHS2-3	Use models (e.g., mathematical models, and figures) that are based on empirical evidence to identify patterns of health and disease to characterize a public health problem.	Emphasis is on identification of patterns using basic mathematical models (e.g., frequency measures) and figures (e.g., epi curves, graphs, maps) to describe health-related occurrences by person, place, and time.
HS-EPHS2-4	Use patterns in empirical evidence to formulate hypotheses.	Emphasis is on using descriptive epidemiology, what is known concerning health-related phenomena, and what others have postulated in historical or current contexts to develop testable hypotheses.

EPHS3: Analytic Epidemiology

Students test hypotheses by making group comparisons and providing mathematical evidence for associations between exposure and disease. Then, students explain associations and judge causation on the basis of this evidence. Key aspects of analytic epidemiology, including study design, causality, and other explanations of evidence (e.g., bias, chance, confounding), are targeted. The performance expectations focus on identifying appropriate study designs with considerations of the scope and limitations of each, conducting appropriate statistical testing to provide mathematical evidence, and interpreting statistical results to determine public health influence.

HS-EPHS 3: Analytic Epidemiology		
	Competency	**Clarification Statement**
HS-EPHS3-1	Describe the capacity of basic epidemiologic study designs (e.g., cross-sectional, case-control, cohort, and randomized controlled trial) to address hypotheses under different circumstances.	Emphasis is on the time, order and processes for each study design, appropriate design given the circumstances (including strengths and limitations), measure of effect, and role of the epidemiologist.
HS-EPHS3-2	Use empirical data from an experimental study (e.g., clinical trial) to mathematically quantify an association between an exposure and disease.	Emphasis is on identifying the appropriate study design to produce the desired data with the fewest number of limitations. Ability to measure association and public health affect should be considered.
HS-EPHS3-3	Use empirical data from an observational study to mathematically quantify an association between an exposure and disease.	Emphasis is on applying mathematical concepts (e.g., probability, statistics) to measure strength and significance of association between an exposure and outcome. Power, sample size, statistical tests, and ability to determine associations should be considered. Example calculations can include measures of association (e.g. risk ratio, relative risk, odds ratio, and rate ratio) and measures of risk (e.g., attack, incidence, prevalence, and mortality rates).
HS-EPHS3-4	Make a statement concerning an association between an exposure and disease with consideration of a mathematical analysis of empirical data.	Emphasis is on interpreting statistical data to construct explanations regarding strength and significance of an association between an exposure and outcome. Consideration of other explanations of evidence (e.g., bias, chance, and confounding) by other factors (e.g., social, economic, cultural, and environmental) must be made.
HS-EPHS3-5	Make a statement concerning causality with consideration of a mathematical analysis of empirical data and Bradford Hill's Criteria for Causality.[12]	Emphasis is on applying probability and statistics to measure strength and significance of association between an exposure and outcome. Consideration of Hill's Criteria of Causation[12] and of other explanations of evidence (e.g., bias, chance, and confounding) by other factors (e.g., social, economic, cultural, and environmental) must be made.

EPHS4: Prevention Effectiveness

The disciplinary core focuses on how the core sciences of public health can be transformed into action to improve health and prevent disease and how different metrics are used to determine effectiveness of those actions. Students consider the dynamic influences of other disciplines concerning public health prevention and control efforts. By identifying priorities, previous patterns of performance, and perspectives from other disciplines, students learn how to systematically design public health policies, programs, and practices and assess their influence.

HS-EPHS 4: Prevention Effectiveness		
	Competency	**Clarification Statement**
HS-EPHS4-1	Describe a model illustrating how scientific, social, economic, environmental, cultural, and political systems influence intervention performance patterns.	Emphasis is on identifying how ongoing changes in one or multiple systems across disciplines can have variable effects on individual and societal health-related decisions to improve health and prevent disease.
HS-EPHS4-2	Use a targeted health promotion and communication approach (taking into consideration scientific knowledge, the organization of systems and their performance patterns, prioritized criteria, and tradeoff considerations) to design intervention strategies.	Emphasis is on conducting research to determine if an intervention is plausible, applied research to determine if it can work, pilot projects to show that it will work, and actual implementation to show that it does work.
HS-EPHS4-3	Evaluate competing health-related intervention strategies by using a systematic assessment to improve effectiveness.	Emphasis is on program evaluation methods for planning, implementing, and assessing the effect of an intervention, and prevention effectiveness as a systematic assessment of influences of public health policies, programs, and practices on health outcomes.

Resources

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10. National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press; 2011.
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Appendices:
Supplementary Documents

Appendix 1: Alignment with Enduring Understandings of Epidemiology[1]

Epidemiology and Public Health Science (EPHS): Core competencies for high school students primarily are based on 12 fundamental or enduring epidemiologic understandings (EU) developed by Kaelin and coworkers. These are statements summarize important ideas and core processes central to the discipline, have lasting value beyond the classroom, and represent major concepts and principles around which teachers should structure their teaching. Twenty-eight judges for the Robert Wood Johnson Foundation and College Board's Young Epidemiology Scholars Competition were surveyed and developed a consensus regarding major concepts and principles around which epidemiology teachers at the high school level should structure their curricula. This document represents a consolidation of these concepts and into four EPHS domains with 15 new core competencies.

Table 1: Alignment of CDC's EPHS Core Competencies for High School Students with the Enduring Understandings of Epidemiology.

	CDC's Epidemiology and Public Health Science (EPHS) Core Competency	Kaelin and coworkers[1] Enduring Understanding(s) of Epidemiology
HS-EPHS1-1	Describe how epidemiologic thinking is used to provide an evidence-based explanation concerning causes and correlations of health and disease.	**EU 1:** The causes of health and disease are discoverable by systematically and rigorously identifying their patterns among populations, formulating causal hypotheses, and testing those hypotheses by making group comparisons. These methods are at the core of the science of epidemiology. Epidemiology is the basic science of public health, a discipline responsible for improving health and preventing disease among populations.
HS-EPHS1-2	Discuss how epidemiologic thinking and a public health approach is used to transform a narrative into an evidence-based explanation.	**EU 12:** An understanding of phenomena unrelated to health can be developed through epidemiologic thinking, by identifying their patterns in populations, formulating causal hypotheses, and testing those hypotheses by making group comparisons.
HS-EPHS1-3	Apply epidemiologic thinking and a public health approach to a model (e.g., outbreak) to explain cause and effect associations that influence health and disease.	**EU 1:** The causes of health and disease are discoverable by systematically and rigorously identifying their patterns among populations, formulating causal hypotheses, and testing those hypotheses by making group comparisons. These methods are at the core of the science of epidemiology. Epidemiology is the basic science of public health, a discipline responsible for improving health and preventing disease among populations.

Table 1, con't.

	CDC's Epidemiology and Public Health Science (EPHS) Core Competency	Kaelin and coworkers[1] Enduring Understanding(s) of Epidemiology
HS-EPHS2-1	Describe how to collect reliable data regarding priority health-related phenomena by using public health surveillance systems.	**EU 2:** Health and disease are not distributed haphazardly among a population. Patterns to their occurrence are discernable. These patterns can be identified through the surveillance of populations.
HS-EPHS2-2	Use credible evidence to describe a public health surveillance system.	**EU 2:** Health and disease are not distributed haphazardly among a population. Patterns to their occurrence are discernable. These patterns can be identified through the surveillance of populations.
HS-EPHS2-3	Use models (e.g., mathematical models or figures) that are based on empirical evidence to identify patterns of health and disease to characterize a public health problem.	**EU 2:** Health and disease are not distributed haphazardly among a population. Patterns to their occurrence are discernable. These patterns can be identified through the surveillance of populations.
HS-EPHS2-4	Use patterns in empirical evidence to formulate hypotheses.	**EU 3:** Analysis of these patterns of health and disease can help formulate hypotheses regarding their possible causes.
HS-EPHS3-1	Describe the capacity of basic epidemiologic study designs (e.g., cross-sectional, case-control, cohort, and randomized controlled trial) to address hypotheses under different circumstances.	**EU 4:** A hypothesis can be tested by comparing the frequency of disease in selected groups of people with and without an exposure to determine if the exposure and the disease are associated.
HS-EPHS3-2	Use empirical data from an experimental study (e.g., clinical trial) to mathematically quantify an association between an exposure and disease.	**EU 6:** When an exposure is hypothesized to have a beneficial effect, studies can be designed in which a group of people is intentionally exposed to the hypothesized cause and compared with a group who is not exposed.
HS-EPHS3-3	Use empirical data from an observational study to mathematically quantify an association between an exposure and disease.	**EU 4:** A hypothesis can be tested by comparing the frequency of disease in selected groups of people with and without an exposure to determine if the exposure and the disease are associated. **EU 5:** When an exposure is hypothesized to have a detrimental effect, it is unethical to intentionally expose a group of persons. In these circumstances, studies can be designed that observe groups of free-living people with and without the exposure.

Table 1, con't.

	CDC's Epidemiology and Public Health Science (EPHS) Core Competency	Kaelin and coworkers[1] Enduring Understanding(s) of Epidemiology
HS-EPHS3-4	Make a statement concerning an association between an exposure and disease with consideration of a mathematical analysis of empirical data.	**EU 7:** One possible explanation for finding an association is that the exposure causes the outcome. Because studies are complicated by factors not controlled by the observer, other explanations also must be considered, including chance, bias, confounding, and reverse time order.
HS-EPHS3-5	Make a statement concerning causality with consideration of a mathematical analysis of empirical data and Bradford Hill's Criteria for Causality.	**EU 8:** While a given exposure might be necessary to cause an outcome, the presence of a single factor is seldom sufficient. The majority of outcomes are caused by a combination of exposures that can include genetic make-up, behaviors, social, economic, and cultural factors and the environment. **EU 9:** Judgment regarding whether an exposure causes a disease is developed by examining a body of epidemiologic evidence as well as evidence from other scientific disciplines.
HS-EPHS4-1	Describe a model illustrating how scientific, social, economic, environmental, cultural, and political systems influence intervention performance patterns.	**EU 10:** Individual and societal decisions regarding what should be done to improve health and prevent disease are based on more than scientific evidence. Social, economic, ethical, environmental, cultural, or political factors are also considered in decision making.
HS-EPHS4-2	Use a targeted health promotion and communication approach (taking into consideration scientific knowledge, the organization of systems and their performance patterns, prioritized criteria, and tradeoff considerations) to design intervention strategies.	**EU 10:** Individual and societal decisions regarding what should be done to improve health and prevent disease are based on more than scientific evidence. Social, economic, ethical, environmental, cultural, or political factors are also considered in decision making.
HS-EPHS4-3	Evaluate competing health-related intervention strategies by using a systematic assessment to improve effectiveness.	**EU 11:** The effectiveness of a health-promoting strategy can be evaluated by comparing the frequency of disease among selected groups of perosns who were and were not exposed to the strategy. Costs, trade-offs, and alternative solutions must also be considered in evaluating the strategy.

Resource for Appendix 1

1. Kaelin MA, Huebner WW, Cordell RL, Szklarczuk B. Proessional development for prospective epidemiology teachers in grades 6-12. *Public Health Rep*. 2008;123(suppl 2):5-11

Appendix 2: Alignment with the Next Generation Science Standards[*,1]

Epidemiology and Public Health Science (EPHS): Core competencies for high school students align with the Next Generation Science Standards (NGSS) by incorporating three dimensions, including content, practices, and crosscutting concepts within each EPHS domain (i.e., disciplinary core area). The National Research Council's (NRC) framework for K-12 Science education describes these dimensions in detail, emphasizing that proficiency in science is learned though examination of evidence and its context, the development of models and theories, and the ongoing revision of knowledge derived from these methods of science.[2]

CDC Epidemiology and Public Health Science Disciplinary Core Content

CPP identified EPHS disciplinary core content. To teach public health at the high school level, the majority of content was derived from Principles of Epidemiology in Public Health Practice, Third Edition[3], a CDC document developed as an introductory course for public health professionals, and tailored for the purpose of these competencies. Core content includes

- epidemiologic thinking,
- public health approach,
- public health surveillance,
- descriptive epidemiology,
- epidemiologic study designs,
- measures of association,
- causation,
- influencing systems,
- intervention strategies, and
- prevention effectiveness.

NGSS Science and Engineering Practices[4] and Crosscutting Concepts[5]

Practices and concepts were adapted from the NRC Framework[2] and NGSS[1] to provide consistency and increase usability, acceptability, and usefulness. As states adopt NGSS, resources for teachers are being published regarding how to translate NGSS standards into coursework on the basis of the given format. To follow with this trend, EPHS standards are presented in the same visual format and use similar language in this supplementary document.

Practices describe a key set of cognitive, social, and physical behaviors that students should actively engage in during science-based lessons. NGSS practices include

- asking questions and defining problems,
- developing and using models,
- planning and carrying out investigations,
- analyzing and interpreting data,
- using mathematics and computational thinking,
- constructing explanations and designing solutions,
- engaging in argument from evidence, and
- obtaining, evaluating, and communicating information.

Crosscutting concepts encourage students to associate interrelated knowledge and practices from different domains of science to better conceptualize a broad view of public health and its influences. EPHS competencies do not include energy and matter. NGSS key crosscutting concepts include

- patterns,
- cause and effect,
- scale, proportion, and quantity,
- systems and system models,
- energy and matter,
- structure and function, and
- stability and change.

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Table 1: Alignment of CDC EPHS Core Competency Domain: Epidemiologic Thinking and a Public Health Approach with NGSS Science and Engineering Practices and NGSS Crosscutting Concepts[1] and CDC EPHS Core Content.

HS-EPHS 1: Epidemiologic Thinking and a Public Health Approach

Students who demonstrate competency can:

HS-EPHS1-1 Describe how epidemiologic thinking is used to provide an evidence-based explanation concerning causes and correlations of health and disease.

HS-EPHS1-2 Discuss how epidemiologic thinking and a public health approach is used to transform a narrative into an evidence-based explanation.

HS-EPHS1-3 Apply epidemiologic thinking and a public health approach to a model (e.g., outbreak) to explain cause and effect associations that influence health and disease.

Note: The text highlighted herein refers to the primary alignment of the competency to the dimension: NGSS Science and Engineering Practices (blue), EPHS Disciplinary Core Content (orange), and NGSS Crosscutting Concepts (green). If the text refers to more than one dimension, a colored text box represents the secondary alignment of the competency to the dimension.

NGSS Science and Engineering Practices[4]

Constructing Explanations and Designing Solutions

- Apply scientific ideas, principles, or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-EPHS1-1)

Obtaining, Evaluating and Communicating Information

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions or to obtain scientific or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESPH1-2)

CDC EPHS Disciplinary Core Content[3]

EPHS 1A. Epidemiologic Thinking

- Epidemiology is the study (scientific, systematic, or data-driven) of the distribution (frequency or pattern) and determinants (causes or risk factors) of health-related states and events (WHO defines health as “state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”) in specified populations (patient is community, persons viewed collectively), and the application of (since epidemiology is a discipline within public health) this study to the control of health problems. (HS-EPHS1-1)
- Epidemiology is devoted to identifying factors that influence risk for disease among populations. This is analogous to making a diagnosis in clinical medicine. The goal is to identify

NGSS Crosscutting Concepts[5]

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESPH1-1), (HS-ESPH1-2)
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-ESPH1-3)

• Communicate scientific or technical information or ideas (e.g., phenomena or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, and mathematically). (HS-ESPH1-2) **Developing and Using Models** • Develop, revise, or use a model that is based on evidence to illustrate or predict relationships between systems or between components of a system. (HS-ESPH1-3)	a cause so that appropriate public health action might be taken. (HS-EPHS1-1), (HS-EPHS1-2), (HS-EPHS1-3) **EPHS 1B. Public Health Approach** • In public health, four general steps are used to approach a problem as follows: surveillance ("what is the problem?"); risk factor identification ("what is the cause?"); intervention evaluation ("what works?"); and implementation ("how do you do it?". (HS-EPHS1-2), (HS-EPHS1-3) • Steps of an outbreak investigation are presented in conceptual order. In practice, multiple steps can be done at the same time, or the circumstances of the outbreak might dictate that a different order be followed. (HS-EPHS1-2),(HS-EPHS1-3)	

Table 2: Alignment of CDC EPHS Core Competency Domain: Public Health Surveillance with NGSS Science and Engineering Practices and NGSS Crosscutting Concepts[8] and CDC EPHS Core Content.

HS-EPHS2: Public Health Surveillance

Students who demonstrate competency can:

HS-EPHS2-1. Describe how to collect reliable data regarding priority health-related phenomena by using public health surveillance systems.

HS-EPHS2-2. Use credible evidence to describe a public health surveillance system.

HS-EPHS2-3. Use models (e.g., mathematical models, and figures) that are based on empirical evidence to identify patterns of health and disease to characterize a public health problem.

HS-EPHS2-4. Use patterns in empirical evidence to formulate hypotheses.

Note: The text highlighted in refers to the primary alignment of the competency to the dimension: NGSS Science and Engineering Practices (Blue), EPHS Disciplinary Core Content (Orange), and NGSS Crosscutting Concepts (Green). If the text refers to more than one dimension, a colored text box represents the secondary alignment of the competency to the dimension.

NGSS Science and Engineering Practices[4]

Planning & Carrying out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design; decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, and time), and refine the design accordingly. (HS-EPHS2-1)
- Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or

CDC EPHS Disciplinary Core Content[3]

EPHS 2A. Public Health Surveillance

- Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of health data to help guide public health decision making and action. (HS-EPHS2-1)
- Criteria for selecting health problems for surveillance includes public health importance, ability to prevent or control the problem, and the capacity of the system to implement such measures. (HS-EPHS2-1)
- Passive surveillance occurs when data regarding the characteristics of diseases are sent to a health agency without prompting (e.g., registries and notifications). (HS-EPHS2-2)
- Active surveillance occurs when data regarding the characteristics of diseases are

NGSS Crosscutting Concepts[5]

Systems and System Models

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-EPHS2-1)
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-EPHS2-2).

Patterns

- Mathematical representations are needed to identify some patterns. (HS-EPHS2-3)
- Empirical evidence is needed to identify patterns. (HS-EPHS2-3), (HS-EPHS2-4)

effects and evaluate the investigation's design to ensure variables are controlled. (HS-EPHS2-2) • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. (HS-EPHS2-4) **Using Mathematics and Computational Thinking** • Use mathematical, computational, or algorithmic representations of phenomena or design solutions to describe or support claims or explanations. (HS-EPHS2-2) **Engaging in Argument from Evidence** • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. (HS-EPHS2-2) **Analyzing and Interpreting Data** • Analyze data using tools, technologies, or models (e.g., computational and mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-EPHS2-3) **Asking Questions & Defining Problems** • Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify or seek additional information, that arise from examining models or a theory, to clarify or seek	prompted or solicited (e.g., surveys). (HS-EPHS2-2) • Surveillance system attributes (e.g., simplicity, flexibility, data quality, stability, acceptability, sensitivity, predictive value positive, representativeness, and timeliness) can be quantitatively and qualitatively analyzed to determine credibility.[6] (HS-EPHS2-2) **EPHS2 B. Descriptive Epidemiology** • Descriptive epidemiology organizes data by time, place, and person to characterize a problem, identify populations at risk, develop hypotheses regarding risk factors, and target control and prevention strategies. (HS-EPHS2-3) • Data can be organized by using frequency measures (e.g., incidence, prevalence, and mortality rates) and presented by using figures (e.g., epi curves, graphs, tables, and maps). (HS-EPHS2-3) • Hypotheses, on the basis of what is known concerning the disease, descriptive epidemiology, and what others have postulated, must be developed before conducting a study. (HS-EPHS2-4)	

additional information and relationships, to determine relationships, including quantitative relationships, between independent and dependent variables, and to clarify and refine a model, an explanation, or an engineering problem. (HS-EPHS2-4)		

Table 3: Alignment of CDC EPHS Core Competency Domain: Analytic Epidemiology with NGSS Science and Engineering Practices and NGSS Crosscutting Concepts[8] and CDC EPHS Core Content.

HS-EPHS3: Analytic Epidemiology

Students who demonstrate competency can:

HS-EPHS3-1. Describe the capacity of basic epidemiologic study designs (e.g., cross-sectional, case-control, cohort, and randomized controlled trial) to address hypotheses under different circumstances.

HS-EPHS3-2. Use empirical data from an experimental study (e.g., community or clinical trial) to mathematically quantify an association between an exposure and disease.

HS-EPHS3-3. Use empirical data from an observational study to mathematically quantify an association between an exposure and disease.

HS-EPHS3-4. Make a statement concerning an association between an exposure and disease with consideration of a mathematical analysis of empirical data.

HS-EPHS3-5. Make a statement concerning causality with consideration of a mathematical analysis of empirical data and Bradford Hill's Criteria for Causality[13].

Note: The text highlighted herein refers to the primary alignment of the competency to the dimension: NGSS Science and Engineering Practices (blue), EPHS Disciplinary Core Content (orange), and NGSS Crosscutting Concepts (green). If the text refers to more than one dimension, a colored text box represents the secondary alignment of the competency to the dimension.

NGSS Science and Engineering Practices[4]

Analyzing and Interpreting Data

- Consider limitations of data analysis (e.g., measurement error and sample selection) when analyzing and interpreting data. (HS-EPHS3-1)
- Compare and contrast various types of data sets (e.g., self-generated and archival) to examine consistency of measurements and observations. (HS-EPHS3-1)
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and

CDC EPHS Disciplinary Core Content[3]

EPHS3 A. Epidemiologic Study Designs

- In an experimental study (e.g., clinical trials), an epidemiologist controls the exposure (usually by random assignment to exposed or unexposed groups) of each person or community, and then tracks the persons or communities over time to detect effects of the exposure. (HS-EPHS3-1), (HS-EPHS3-2)
- In an observational study (e.g., cohort, case-control, and cross-sectional), participants unknowingly determine their exposure status and the epidemiologist only records exposure and illness data. (HS-EPHS3-1), (HS-EPHS3-3)
- In a cohort study, enrollment is based on status of exposure to a

NGSS Crosscutting Concepts[5]

Systems

- Systems can be designed to do specific tasks. (HS-EPHS3-1)

Scale, Proportion, and Quantity

- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another. (HS-EPHS3-2), (HS-EPHS3-3), (HS-EPHS3-5)

problems, using digital tools. (HS-EPHS3-4), (HS-EPHS3-5)

Using Mathematics and Computational Thinking

- Create or revise a computational model or simulation of a phenomenon, designed device, process, or system. (HS-EPHS3-2), (HS-EPHS3-3)
- Use mathematical, computational, or algorithmic representations of phenomena or design solutions to describe or support claims or explanations. (HS-EPHS3-2), (HS-EPHS3-3)
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (HS-EPHS3-2), (HS-EPHS3-3)
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. (HS-EPHS3-2), (HS-EPHS3-3)
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (e.g., mg/mL, kg/m3, and acre-feet). (HS-EPHS3-2), (HS-EPHS3-3)

Planning and Carrying out Investigations

- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and

certain factor or membership in a certain group. Populations are followed, and disease, death, or other health-related outcomes are documented and compared. (HS-EPHS3-1), (HS-EPHS3-3)

- In a case-control study, a group of persons with a certain disease, chronic condition, or type of injury (case-patients) and a group of persons without the health problem (control subjects) and differences in exposures, behaviors, and other characteristics are compared to identify and quantify associations, test hypotheses, and identify causes. (HS-EPHS3-1), (HS-EPHS3-3)
- In a cross-sectional study, a sample of persons from a population are enrolled and their exposures and health outcomes are measured simultaneously. (HS-EPHS3-1), (HS-EPHS3-3)

EPHS3 B. Measures of Association

- A measure of association (e.g., risk, rate, odds ratio) quantifies the association between an exposure and a particular health problem. (HS-EPHS3-2), (HS-EPHS3-3), (HS-EPHS3-4)
- A risk ratio compares risk for a health event among one group with the risk among another group. It does so by dividing the risk (incidence proportion, attack rate) in group 1 by the risk (incidence proportion, attack rate) in group 2. (HS-EPHS3-2), (HS-EPHS3-3), (HS-EPHS3-4)
- An odds ratio is the ratio of the odds of exposure in a group with the condition under study and the odds of exposure in a group without the condition. It quantifies the association between an exposure and health

personal impacts. (HS-EPHS3-2) • Select appropriate tools to collect, record, analyze, and evaluate data. (HS-EPHS3-2) **Constructing Explanations and Designing Solutions** • Make a quantitative or qualitative claim regarding the relationship between dependent and independent variables. (HS-EPHS3-4), (HS-EPHS3-5) **Engaging in Argument from Evidence** • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. (HS-EPHS3-4), (HS-EPHS3-5)	outcome and is the measure of choice in a case-control study.(HS-EPHS3-2), (HS-EPHS3-3), (HS-EPHS3-4) **EPHS3 C. Causation** • Attributable proportion and vaccine efficacy are measures of public health effects. They identify an association between an exposure and a disease. (HS-EPHS3-2), (HS-EPHS3-3), (HS-EPHS3-5) • Hill's Criteria for Causation[7] are a group of conditions useful to providing evidence for a causal association. They include strength of association, consistency of findings, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. (HS-EPHS3-5)	

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Table 4: Alignment of CDC EPHS Core Competency Domain: Prevention Effectiveness with NGSS Science and Engineering Practices and NGSS Crosscutting Concepts[8] and CDC EPHS Core Content.

EPHS4: Prevention Effectiveness

Students who demonstrate competency can:

HS-EPHS4-1. Describe a model illustrating how scientific, social, economic, environmental, cultural, and political systems influence intervention performance patterns.

HS-EPHS4-2. Use a targeted health promotion and communication approach (taking into consideration scientific knowledge, the organization of systems and their patterns of performance, prioritized criteria, and tradeoff considerations) to design intervention strategies.

HS-EPHS4-3. Evaluate competing health-related intervention strategies by using a systematic assessment to improve effectiveness.

Note: The text highlighted herein refers to the primary alignment of the competency to the dimension: NGSS Science and Engineering Practices (blue), EPHS Disciplinary Core Content (orange), and NGSS Crosscutting Concepts (green). If the text refers to more than one dimension, a colored text box represents the secondary alignment of the competency to the dimension.

NGSS Science and Engineering Practices[4]

Developing and Using Models
- Develop, revise, or use a model based on evidence to illustrate or predict the relationships between systems or between components of a system. (HS-EPHS4-1)

Constructing Explanations and Designing Solutions
- Design, evaluate, or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-EPHS4-2)

Engaging in Argument from Evidence
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, or logical arguments regarding relevant factors (e.g.

CDC EPHS Disciplinary Core Content[8-10]

EPHS4 A. Influencing Systems[8]
- Questions decision makers need answered regarding what should be done to improve health and prevent disease involve multiple disciplines and perspectives. (HS-EPHS4-1)
- Studies of the same problem within the same discipline often give different and sometimes conflicting answers. Meta-analysis systematically pools results and generates summaries. (HS-EPHS4-1)
- Studies of the same problem in different disciplines have different measures. No single fundamental theoretical framework to resolve conflicts across disciplines is available. (HS-EPHS4-1)

EPHS4 B. Intervention Strategies[9]
- Intervention strategies use research to determine if prevention is plausible; applied

NGSS Crosscutting Concepts[5]

Patterns
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. (HS-EPHS4-1), (HS-EPHS4-3)
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced, thus requiring improved investigations and experiments. (HS-EPHS4-1), (HS-EPHS4-2), (HS-EPHS4-3)

Cause and Effect
- Changes in systems may have various causes that may not have equal effects. (HS-EPHS4-1)

Systems and System Models

economic, societal, ethical considerations). (HS-EPHS4-3)	research to determine if it can work; pilot projects to show that it does work; and actual implementation to show that it continues to work. (HS-EPHS4-2) • Intervention strategies for health problems might be clinical, behavioral, environmental or a combination of the three. (HS-EPHS4-2) • Intervention outcomes can be measured quantitatively by using epidemiologic methods or qualitatively by examining the distributional, legal, ethical or social effects. (HS-EPHS4-2) **EPHS4 C. Prevention Effectiveness** • Prevention effectiveness is the systematic assessment of the effect of public health policies, programs, and practices on health outcomes. Modeling and methods determine efficacy, effectiveness, efficiency, and cost of public health services, policies, and interventions. Research facilitates better decision-making regarding the allocation of resources according to priorities.[10] (HS-EPHS4-3) • Program evaluation uses scientific methods to plan, implement and assess the effects of policie, programs, and practices. This involves evaluating tasks (i.e., process), and impact (i.e., outcomes). Criteria often used to measure the quality of the evaluation include validity, construct validity, internal validity, and external validity.[8] (HS-EPHS4-3)	• Systems can be designed to do specific tasks. (HS-EPHS4-2) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function. (HS-EPHS4-2), (HS-EPHS4-3)

Resources for Appendix 2

1. NGSS Lead States. Next Generation Science Standards: For States, By states. 2013. Available at: http://www.nextgenscience.org/next-generation-science-standards. Accessed February 9, 2016.
2. National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press; 2011.
3. Centers for Disease Control and Prevention. Principles of Epidemiology in Public Health Practice, Third Edition: An Introduction to Applied Epidemiology and Biostatistics. 2006. Available at: http://www.cdc.gov/ophss/csels/dsepd/SS1978/SS1978.pdf. Accessed February 11, 2016.
4. NGSS Lead States. Next Generation Science Standards: For States, by States (Appendix F: Science and engineering standards). 2013. Available at: http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf. Accessed February 9, 2016.
5. NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix G – Crosscutting Concepts). 2013. Available at: http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf. Accessed February 9, 2016.
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7. Teutsch SM, Harris JR. Introduction. In: Haddix AC, Teutsch SM, Corso PS, eds. *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation*. 2nd ed. New York, NY: Oxford University Press; 2002:1-10.
8. Centers for Disease Control and Prevention. What is Prevention Effectiveness? *CDC Steven M. Teutsch Prevention Effectiveness Fellowship* 2009. Available at: http://www.cdc.gov/PEF/WhatIs.html. Accessed February 11, 2016.

Appendix 3: Alignment of CDC's Epidemiology and Public Health Science High School Core Competencies with ASPPH Critical Component Elements of an Undergraduate Major in Public Health[1].

Epidemiology and Public Health Science (EPHS): Core competencies for high school students vertically align with the recommended critical component elements of an undergraduate major in public health. In 2012, the Association of Schools and Programs of Public Health (ASPPH) published key components by discipline, skill area, public health content areas, and crosscutting areas[1]. EPHS core competencies for high school students concentrate on developing a necessary foundation to achieve standards at the undergraduate level. Alignment with undergraduate critical components is displayed in Table 1.

Background Diciplines

The four background diciplines in the critical components of an undergraduate major include science, social and behavioral sciences, mathematics and quantitative reasoning, and humanities and fine arts. EPHS course was designed to cover all areas, with students first conceptualizing public health through critical methods by using a substantial historical element. Students are then asked to use empirical approaches by using foundations of scientific knowledge, including biological and life sciences and the concepts of health and disease, as well as mathematics and quantitative reasoning to provide evidence to support claims. Throughout this process, practice-based core competencies grounded in social and behavioral sciences are used to explore context of health and disease among populations.

Skill Areas

Two skill areas were identified for undergraduate students, including communication and information literacy. At the high school level, students are asked to obtain and evaluate materials, such as literature or technical information, and communicate information in multiple formats (i.e., orally, graphically, textually, and mathematically). All core competencies incorporate these two skill areas; further detail of skills can be found in Appendix 2 under "science and engineering practices."

Public Health Content Areas

There are nine content areas in the critical components of an undergraduate major in public health. EPHS core competencies for high school student included seven of the nine; however, as a whole, the competencies focus on four: "overview of public health," role and importance of data in public health," determinants of health," and "health communication." The deliberate use of these content areas provides a foundation of knowledge and experiences in practicing age-level appropriate skills in mathematics and communication.

Crosscutting Areas

Of the 12 crosscutting areas that undergraduate majors in public health should be exposed to, EPHS core competencies for high school students align with eight. An emphasis is placed on critical thinking and creativity, organizational dynamics, research methods, and systems thinking.

Table 1: Alignment of Epidemiology and Public Health Science (EPHS) Core Competencies for High School Students with Critical Component Elements of an Undergraduate Major in Public Health[9]

	CDC's EPHS Core Competencies for High School Students														
ASPPH Critical Component Elements of an Undergraduate Major in Public Health[1]	**EPHS 1-1**	**EPHS 1-2**	**EPHS 1-3**	**EPHS 2-1**	**EPHS 2-2**	**EPHS 2-3**	**EPHS 2-4**	**EPHS 3-1**	**EPHS 3-2**	**EPHS 3-3**	**EPHS 3-4**	**EPHS 3-5**	**EPHS 4-1**	**EPHS 4-2**	**EPHS 4-3**
ASPPH Background Diciplines															
Science			X	X		X	X		X	X		X			X
Social and behavioral sciences		X	X	X	X	X	X				X	X	X	X	X
Math and quantitative reasoning					X	X	X		X	X	X	X			
Humanities and fine arts	X							X					X		
ASPPH Skill Areas															
Communications	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Information literacy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ASPPH Public Health Content Areas															
Overview of public health	X	X	X			X	X	X				X			
Role and importance of data in public health				X	X	X	X	X	X	X	X	X			
Identifying and addressing population health challenges							X	X					X	X	X
Human health															
Determinants of health							X		X	X	X	X	X	X	X
Project implementation														X	X
Overview of the health system															
Health policy, law, ethics, and economics														X	X
Health communication	X	X	X								X	X	X	X	X

Table 1, con't.

ASPPH Critical Component Elements of an Undergraduate Major in Public Health[1]	CDC's EPHS Core Competencies for High School Students														
	EPHS 1-1	EPHS 1-2	EPHS 1-3	EPHS 2-1	EPHS 2-2	EPHS 2-3	EPHS 2-4	EPHS 3-1	EPHS 3-2	EPHS 3-3	EPHS 3-4	EPHS 3-5	EPHS 4-1	EPHS 4-2	EPHS 4-3
ASPPH Crosscutting Areas															
Advocacy for protection and promotion of the public's health at all levels of society.							X							X	
Community dynamics							X						X	X	X
Critical thinking and creativity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cultural contexts in which public health professionals work													X	X	
Ethical decision making as related to the self and society													X	X	
Independent work and a personal work ethic															
Networking															
Organizational dynamics	X	X	X	X		X	X		X	X	X	X	X	X	X
Professionalism															
Research methods								X	X	X	X	X	X	X	X
Systems thinking	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Teamwork and Leadership															

Resource for Appendix 3

1. Association of Schools and Programs of Public Health. Recommended Critical Component Elements of an Undergraduate Major in Public Health. 2012. Available at: http://www.aspph.org/wp-content/uploads/2014/04/CCE_2012-08-03-FINAL.pdf. Accessed February 9, 2016.