PREPARED
NATIONAL HEALTH SECURITY PREPAREDNESS INDEX

Methodology for the 2016 National Health Security Preparedness Index

The National Health Security Preparedness Index tracks the nation's progress in preparing for, responding to, and recovering from disasters and other large-scale emergencies that pose risks to health and well-being in the United States. Because health security is a responsibility shared by many different stakeholders in government and society, the Index combines measures from multiple sources and perspectives to offer a broad view of the health protections in place for nation as a whole and for each U.S. state. This document summarizes the measures and computational methodologies used in constructing the 2016 release of the Index.

I. Rationale and History of the Index

The U.S. Centers for Disease Control and Prevention (CDC) initiated development of the National Health Security Preparedness Index in 2012 to create a platform for measuring the nation's progress in preparing for, responding to, and recovering from disasters and other large-scale emergencies that pose risks to health and wellbeing in the United States. As a measurement tool, the Index is designed to summarize levels of preparedness achieved within individual states and for the nation as a whole, with the goal of disseminating and using this information for multiple purposes: (1) to enhance public awareness and understanding of national preparedness components and capabilities; (2) to encourage coordination and collaboration among the multiple sectors and stakeholders that contribute to preparedness capabilities; (3) to inform planning, policy development, and quality improvement activities across the preparedness field; and (4) to stimulate and guide future research on how to measure and improve preparedness and health security.

Supported by CDC, the Index was developed through a broad collaboration of stakeholders led by the Association of State and Territorial Health Officials (ASTHO), the Oak Ridge Associated Universities (ORAU), the University of Pittsburgh Medical Center's Center for Biosecurity, and Johns Hopkins University's Center for Public Health Preparedness. More than 30 additional organizations have contributed to development of the Index over time, including federal state, and local public health agencies, emergency management agencies, health care organizations, research institutions, and professional associations. Developed as an annual measurement tool, the first edition of the Index was released in December 2013, and a second edition was released in December 2014. This second edition of the tool included a total of 197 measures drawn from more than 40 data sources. The measures are aggregated into domain and subdomain composite measures, and further aggregated into an overall preparedness measure, based on conceptual framework of preparedness developed for the Index.

In January 2015, responsibility for publishing and maintaining the Index transitioned from CDC to the Robert Wood Johnson Foundation (RWJF). RWJF selected a Program Management Office based at the University of Kentucky's Center for Public Health Services and Systems Research and Center for Business and Economic Research to lead efforts to refine and update future editions of the Index. The Robert Wood Johnson Foundation also appointed a 14-member National Advisory Committee for the Index to provide overall scientific and strategic guidance regarding the Index design, operation and use. Additionally, the Program Management Office established three Workgroups to provide operational advice on future updates and revisions to the Index, drawing from a workgroup structure used during development of earlier editions of the Index.

II. Refinements to the Index Methodology and Measures

Upon release of the second edition of the Index in December 2014, the Index Program Management Office initiated a series of activities to examine the existing measurement properties of the Index and to identify strategies for improving the Index as a measurement tool. The aims of these activities were threefold: (1) to determine the construct validity and reliability of the Index domains and subdomains in order to identify strategies for improving these measurement properties; (2) to determine the accuracy of comparisons made across Index domains and subdomains and across states in order to identify strategies for improving the accuracy of comparisons; and (3) to determine valid and feasible methods for supporting longitudinal comparisons of Index values so that changes in preparedness over time can be accurately tracked.

Four sets of activities were completed in pursuit of these aims:

1. We conducted measurement validity and reliability analyses that examine the performance of existing Index measures in characterizing core preparedness constructs reflected in Index's conceptual framework, including the Index domains and subdomains. These analyses include (a) internal consistency reliability tests

performed at the subdomain, domain, and overall Index level; and (b) multi-trait scale analysis tests performed at the subdomain and domain levels.[1]

2. We conducted sensitivity analyses that examine the relative influence of each measure on overall Index results, including the impact of the Index's methods for scaling, imputing, and aggregating individual measures into subdomains, domains, and overall Index values.

3. We solicited ideas for new and modified measures to include in the Index through an Open Call for Measures and through monthly Index Workgroup meetings with content experts and stakeholders in the preparedness field.

4. We assessed the availability, completeness, quality, timeliness, and longitudinal consistency of data sources for existing and proposed new Index measures, including whether data sources are updated at least every three years.[2]

The results of these activities were discussed and refined with preparedness experts and stakeholders during monthly Index Workgroup meetings and during quarterly meetings of the National Advisory Committee. Based on this feedback, the program management office drafted a set of recommended changes to the Index measures and methodology that were proposed for implementation as part of the 3rd release of the Index. Proposed changes were developed with the following broad goals for methodological refinement in mind:

- Improve the methods used for grouping and weighting individual measures within domains and subdomains so as to improve the internal consistency and discriminant power of the Index.

- Consolidate and simplify the overall Index set of measures by reducing unreliable and noisy measures that have high levels of measurement error.

- Expand the breadth and composition of the Index by adding new measures reflecting important dimensions of preparedness and resiliency not currently represented in the Index, including measures that align with established national frameworks for preparedness and health security, such as the National Health Security Strategy and the preparedness objectives of Healthy People 2020.

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[1] Staiger D, Dimick JB, Baser O, Fan Z and Birkmeyer JD. Empirically derived composite measures of surgical performance. Medical Care 2009;47: 226-233. Hays RD, Hayashi T.Beyond internal consistency reliability: rationale and user's guide for multitrait analysis program on the microcomputer. Behavioral Research Methods 1990;22(2):167-75.
[2] This criterion for data source periodicity and timeliness is based on the National Quality Forum's measure selection criteria.

- Improve the methods used for scaling individual measures so as to more accurately reflect the distributional properties of the measures and to enable more accurate comparisons across states and over time.

- Improve the accuracy of the methods used for imputing missing values for Index measures.

- Incorporate new data and analytic methods that allow for accurate comparisons of Index values over time (trending).

Results of validity and reliability tests were combined with findings from the data source assessments in order to develop a detailed recommendation about the status of each of the 197 individual measures included in the 2014 release of the Index. For each of these measures, we recommend one of several possible actions: (a) retain the measure as specified on the 2014 Index; (b) modify the way the measure is specified and calculated in order to improve its validity and/or reliability; (c) reclassify the measure into a different domain and/or subdomain in order to improve the validity and reliability of the underlying domain and/or subdomain composite measure; or (d) exclude the measure from the next edition of the Index. Measures were recommended for exclusion only if they fail multiple tests of measurement value, including: (i) the measure performs poorly on construct validity and reliability tests at both the domain and subdomain level, as indicated by an adjusted multi-trait item-to-scale correlation coefficient of less than 0.3;[3] (ii) the measure's construct validity and reliability does not improve when reclassified into another domain or subdomain scale; (iii) the measure's validity and reliability has not been established through previously published studies; and (iv) the measure is constructed from a data source that has not been updated within a 3 year periodicity period. By design, these criteria for measure selection and retention place priority on measures that help the Index discriminate preparedness levels across different domains and subdomains, across U.S. states, and across years.

A document summarizing all proposed changes to the Index methodology and measures was posted for public comment in August 2015. Over a 30 day period, more than 70 comments were received. During October and November 2015, the Index National Advisory Committee reviewed the public comments and made a final set of recommendations regarding changes to the Index methodology and measures for the

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[3] We use a relatively weak correlation threshold of 0.3 given the relatively constrained degrees of freedom available for an Index measure in any given year (maximum n=50). See for example: Staiger D, Dimick JB, Baser O, Fan Z and Birkmeyer JD. Empirically derived composite measures of surgical performance. Medical Care 2009;47: 226- 233. Hays RD, Hayashi T. Beyond internal consistency reliability: rationale and user's guide for multitrait analysis program on the microcomputer. Behavioral Research Methods 1990;22(2):167-75.

2016 release. The sections that follow reflect these changes as adopted for the 2016 Index.

III. Index Conceptual Framework and Structure

The 2016 Index retains the conceptual framework and structure developed for the original 2013 Index release by a broad collection of preparedness stakeholders. The Index conceptual framework includes a set of six domains of activity that research and experience have shown to be important in protecting people from the health consequences of disasters and other large-scale hazards and emergencies:

1. ***Health security surveillance***: actions to monitor and detect health threats, and to identify where hazards start and spread so that they can be contained rapidly;

2. ***Community planning and engagement***: actions to develop and maintain supportive relationships among government agencies, community organizations, and individual households; and to develop shared plans for responding to disasters and emergencies;

3. ***Information and incident management***: actions to deploy people, supplies, money and information to the locations where they are most effective in protecting health and safety;

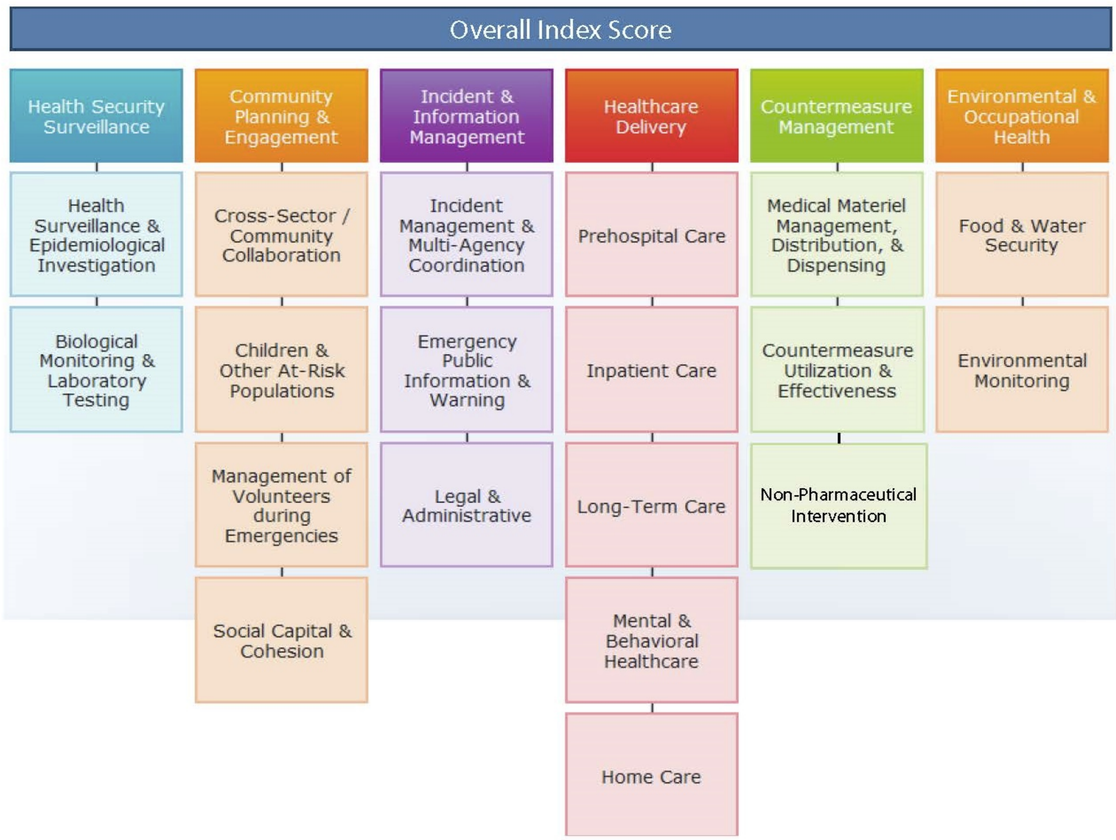
4. ***Healthcare delivery***: actions to ensure access to high-quality medical services across the continuum of care during and after disasters and emergencies;

5. ***Countermeasure management***: actions to store and deploy medical and pharmaceutical products that prevent and treat the effects of hazardous substances and infectious diseases, including vaccines, prescription drugs, masks, gloves, and medical equipment; and

6. ***Environmental and occupational health***: actions to maintain the security and safety of water and food supplies, to test for hazards and contaminants in the environment, and to protect workers and emergency responders from health hazards while on the job.

Each of these domains is further divided into a set of subdomains that reflect more specific areas of practice and policy. Finally, each subdomain contains individual measures that reflect specific preparedness capabilities. A total of 19 subdomains are operational in the 2016 Index by virtue of containing at least one, but in most cases multiple, related measures. Each measure is defined and constructed for a particular state and year, and standardized to a common scale using a methodology described below. Due to data availability, the 2016 Index includes measures for the 50 states only, and does not include measures for the District of Columbia or U.S. territories. Adding measures for the District of Columbia is a high-priority goal for the 2017 Index release.

Figure 1: 2016 Index Domains and Subdomains



Index values are calculated using a series of sequential calculations that follow the Index structure:

- State-specific summary measures are constructed for each subdomain by computing a weighted average of the measures within each subdomain;
- State-specific summary measures are constructed for each domain by computing a weighted average of the subdomain summary measures;

- A state-specific overall Index summary measure is constructed by computing a weighted average of the domain summary measures;

- National summary measures are computed at the subdomain, domain, and overall Index level by computing a linear average of the 50 state summary measures.

The use of a linear average of state measures rather than a population-weighted average in constructing national summary measures reflects a key principle of the Index conceptual framework: national health security requires that the nation be prepared to respond to disasters regardless of where they occur and how many people are affected. As a consequence, the preparedness capabilities of each state are defined to contribute equally to national health security.

IV. Measure Selection

Construction of the 2016 Index began with a pool of 197 individual measures identified by stakeholders involved in prior releases of the Index and used in the 2014 Index release. A public call for new measures was held during January to March 2015, yielding more than 30 additional measures as candidates for addition to the Index. All candidate measures were assessed for data availability, and measures for which updated data could not be obtained at least every 3 years for each U.S. state were screened out from inclusion in the 2016 Index.[4] This resulted in the elimination of 42 measures that were used in the 2014 Index release, and the elimination of 26 proposed new measures.

For all measures used in the 2014 Index release, we used a series of measurement validity and reliability tests to weed out redundant measures and measures lacking a strong empirical association with the Index domain and subdomain areas. We used multi-trait analysis to examine the construct validity of each measure at both the domain and subdomain levels. These tests rely on the assumption that subgroups of measures related to a common underlying preparedness construct should demonstrate at least a moderate level of correspondence among measures. Based on the Central Limit Theorum of mathematics and statistics, we assume that combining unrelated measures in to summary measures at the subdomain and domain levels produces undesirable measurement noise that weakens the ability of Index summary measures to detect meaningful differences in preparedness levels across domains, across states, and over time. We test this assumption empirically using multi-trait analysis.[5] For these multi-

[4] This criterion for data source periodicity and timeliness is based on the National Quality Forum's measure selection criteria.

[5] See for example: Staiger D, Dimick JB, Baser O, Fan Z and Birkmeyer JD. Empirically derived composite measures of surgical performance. Medical Care 2009;47: 226- 233. Hays RD, Hayashi T. Beyond internal consistency reliability:

trait analysis tests, we used a relatively weak correlation threshold of 0.3 given the relatively constrained degrees of freedom available for an Index measure in any given year (maximum n=50) and given an assumption that individual preparedness capabilities within a domain or subdomain may exhibit relatively high heterogeneity and differentiation. Measures that fall below this threshold are considered to have low construct validity and contribute more noise than signal to Index summary measures.

Measures were recommended for exclusion from the 2016 Index if they showed evidence of low construct validity, including: (1) the measure performs poorly on construct validity tests at both the domain and subdomain level, as indicated by an adjusted multi-trait item-to-scale correlation coefficient of less than 0.3; (2) the measure's construct validity does not improve when reclassified into another domain or subdomain scale; and (3) the measure's validity and reliability has not been established through previously published studies. However, selected measures were retained in the Index despite low construct validity based on feedback obtained during the public comment period on proposed Index changes, and based on expert opinions expressed by members of the Index National Advisory Committee. A total of 28 measures were eliminated from the 2016 Index based on low construct validity, public comments and expert judgment.

A final group of measures was classified as Foundational Capability measures because they reflect activities that are firmly ingrained in practice in all U.S. states and therefore do not vary across states or over time. As constants, these measures could not be evaluated empirically for their construct validity, and therefore were evaluated for Index inclusion solely based on expert opinions of members of the Index National Advisory Committee. The measure weighting methodology, described below, was used to determine how to incorporate Foundational Capability measures into Index summary measures.

The final measure set for the 2016 Index consisted of 134 individual measures, including the group of 18 Foundational Capability measures.

V. Measure Scaling and Normalization

The 2016 Index uses a normalization method to convert each measure to a standardized scale before combining measures into subdomain, domain, and overall composite measures of preparedness. Normalization improves the validity and reliability of

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rationale and user's guide for multitrait analysis program on the microcomputer. Behavioral Research Methods 1990;22(2):167-75.

composite measures by placing component measures on a uniform scale before combining them.

The 2013 and 2014 releases of the Index used a normalization methodology for continuous measures that expresses each value as a proportion of the maximum value observed for that measure, after trimming (Winsorizing) any maximum values that exceed 2.5 standard deviations of the measure. In many cases, this method of normalization distorts significantly the distribution of the original measure because it does not incorporate information on the measure's variance or range into the scaling. For the Index, this prior method of scaling has the additional, unintended effect of making dichotomous measures much more influential in the Index compared to continuous measures, because continuous measures are normalized to restricted ranges that are much less likely to contain values at or near zero.

To prevent these distortions in scaling, the 2016 Index uses an alternative method of scaling that normalizes each measure to a common 0- 1 range based on the full range of original data for all time periods from 2013 to 2015. This method, known as Min-Max scaling, calculates normalized values using a method that preserves the relationships among the original data values, as follows:

$$Standardized\ Value = \frac{(Original\ Value - Minimum\ Value)}{(Maximum\ Value - Minimum\ Value)}$$

where the minimum and maximum for each indicator are calculated across Sates and years in order to allow for longitudinal comparisons of Index values over time.

This method assigns each continuous and dichotomous variable to a common 0-1 scale based on the full range of observed values, placing both types of variables on equal footing when aggregating them into subdomain and domain measures.[6] This normalization method is similar to the z-score in its distributional properties but produces more stable values than the z-score when used in small samples, as is the case with the Index's 50 state sample size.

After normalizing each measure using the min-max method, each measure is multiplied by 10 to place it on a ten point scale with 10 being the highest possible level of preparedness.

[6] Organization for Economic Cooperation and Development. *Handbook on Constructing Composite Indicators*. Paris: OECD and European Commission; 2008.

The normalization method employed in the 2016 Index uses the maximum state value to define the upper boundary or "frontier" of preparedness for each measure. As such, this method defines "optimal" preparedness based on observed state values rather than based on a theoretical maximum value, an a priori goal, or an evidence-based standard derived from research. In the absence of a strong theoretical or evidence-based approach for defining the preparedness frontier, this "experience-based" method of scaling measures relative to the maximum state value provides a feasible approach to scaling that is commonly used in quality improvement applications.

VI. Weighting

The 2013 and 2014 releases of the Index use the linear (unweighted) average as the method of aggregating individual measures into subdomain measures, aggregating subdomain measures into domain measures, and aggregating domain measures into the overall composite index of preparedness. This method implicitly assigns greater weight to measures located within subdomains and domains having fewer measures. As a result, large differences exist in the relative influence of each measure on overall Index results, and the most influential measures may not be the measures that are considered to be the most important to preparedness and national health security.

To address this distortion in implicit weighting, we used an expert panel methodology to develop and assign explicit weights to Index measures for use in constructing subdomain, domain, and overall preparedness composite measures. An online multi-stage Delphi process was used for this purpose, eliciting expert judgements about the importance of each measure, subdomain, and domain to national preparedness and health security. A separate expert panel was convened for each domain included in the Index model, with each panel comprised of 15-20 subject matter experts who were identified through a nomination process and reviews of the preparedness scientific and professional literature. In total, 223 experts were identified and invited to participate in the item measure assessment, with 119 experts participating (53 percent). A two-stage process was used in which Delphi panelists first assessed the importance of individual measures in the Index, and secondly panelists assessed the importance of each subdomain and domain as a whole. The iterative Delphi assessment of individual measures was conducted from October 9, 2015 to January 4, 2016. The Delphi assessments of subdomains and domains were conducted with 78 experts from January 11, 2016 to January 27, 2016.

For the assessment of individual measures, electronic Delphi surveys were used to elicit expert ratings of the importance of each measure to the capability construct reflected in each subdomain. A visual analog scale (VAS) was used to elicit expert ratings of importance on an interval scale (where "0" indicates that the measure is "not important at all" to the subdomain and "10" indicates that it is "extremely important"), following methods that are well established for expert panel weighting processes.[7] Experts were also given the option of check a box indicating "they do not know" how important the measure is to the subdomain. Delphi participants were given these instructions:

> The National Health Security Preparedness Index aims to provide an accurate portrayal of our country's health security using relevant, actionable information to help guide efforts to achieve a higher level of health security preparedness. While not an exhaustive compilation of national health security measures, the Index uses existing state-level preparedness data from a variety of sources that are broadly indicative of national or state-level health security. The current Index includes 194 measures grouped into eighteen "sub-domains," which are organized into six "domains." In addition, we have identified over 50 other candidate measures for possible inclusion in the next release of the Index, many of which are included in a grouping we call "pre-event community status."
>
> The goal of this Delphi exercise is to collect input on the relative importance of various factors affecting health security. Requiring about 20 minutes to complete, we have organized the Delphi so that a rater will assess a subset of the measures—not all of them. Using a visual analog scale that ranges from 0 to 10, raters will be presented with a list of item measures and asked to assess how important each measure is to its overarching dimension of health security (or sub-domain).
>
> When making assessments, one should think about the importance of an item measure across the full spectrum of the fifteen all-hazards National Planning Scenarios. These scenarios represent a broad range of potential health threats, and as noted in the National Health Security Strategy and Implementation Plan, "they can be intentional or naturally occurring and can result from both persistent and emerging threats, including severe weather, infectious diseases, hazardous material exposures, and terrorist attacks."
>
> We recognize that some hazards are more relevant in some parts of the county than in others, and that some factors associated with health security might be more relevant to one planning scenario than another. For example, factors affecting health security preparedness in the context of Pandemic Influenza might be quite different from those in a Cyber Attack. An assessment of relative importance might be affected by the perceived likelihood of a scenario happening, its potential impact on health security should it happen, and the perceived relevance of a sub-domain for any given scenario. We ask that you think about these issues "on average." That is, any given measure, sub-domain, or domain might have more relevance in the context of one planning scenario compared to another, but across all fifteen planning scenarios you should think about its "average" importance. Similarly, we ask that you make your assessments assuming an all-hazards approach—which is an approach for prevention, protection, mitigation, response, and recovery that addresses a full range of threats and hazards, including domestic terrorist attacks, natural and [human-caused] disasters, accidental disruptions, and other emergencies.

Three iterations of Delphi surveys and feedback reports were used with each panel in an effort to achieve convergence on expert ratings of importance.

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[7] Graham B1, Regehr G, Wright JG. Delphi as a method to establish consensus for diagnostic criteria. Journal of Clinical Epidemiology. 2003 Dec;56(12):1150-6.

Similarly, for the assessment of subdomains, expert panelists were asked to assess the importance of each subdomain to the overarching capability construct reflected in the corresponding domain. And as a final step in the process, the domain-specific expert panels were combined into a single composite panel for eliciting expert ratings on the relative importance of each domain to overall national preparedness and health security. Instead of using a visual analogue scale for the subdomain and domain assessments, experts were asked to allocate 100 percentage points across the subdomains and domains. For each domain, panelists were asked to think about the core constructs within the domain and then determine what proportion of a state's overall preparedness level is attributable to each of the subdomains making up that domain. This process was then repeated to assess the relative importance of each domain to overall national preparedness and health security.

We assessed the degree of convergence among expert panelists in their assessments of the importance of each measure, subdomain, and domain using the discrimination coefficient of variation, which is superior to conventional measures of agreement such as the kappa statistic when used with measures on a continuous scale.[8] Using the conventional threshold of convergence of less than or equal to 0.5, only 5 measures exceeded this critical value, with most measures well within the range of convergence (average = 0.18). We conclude that sufficient agreement was attained among Delphi expert panelists concerning the importance of each measure to preparedness and health security constructs.

Weights for individual measures, subdomains, and domains were derived from the Delphi ratings by using the median VAS value for each individual measure and the median percentage value for each subdomain and domain. Weights were normalized within each subdomain such that they sum up to 1, by making the following transformation on the original weights:

$$w_i' = \frac{w_i}{\sum_{j=1}^{n} w_j}$$

Where n is the number of measures within each subdomain.

These weights were then used to calculate weighted averages as summary measures at the subdomain, domain, and overall Index levels for each state and each year. Foundational Capability measures were constructed as constants and averaged into the

[8] Singh AC, Westlake M,. Feder M. A generalization of the coefficient of variation with application to suppression of imprecise estimates. Journal of the American Statistical Association Section on Survey Research Methods 2011; 4359-4365.

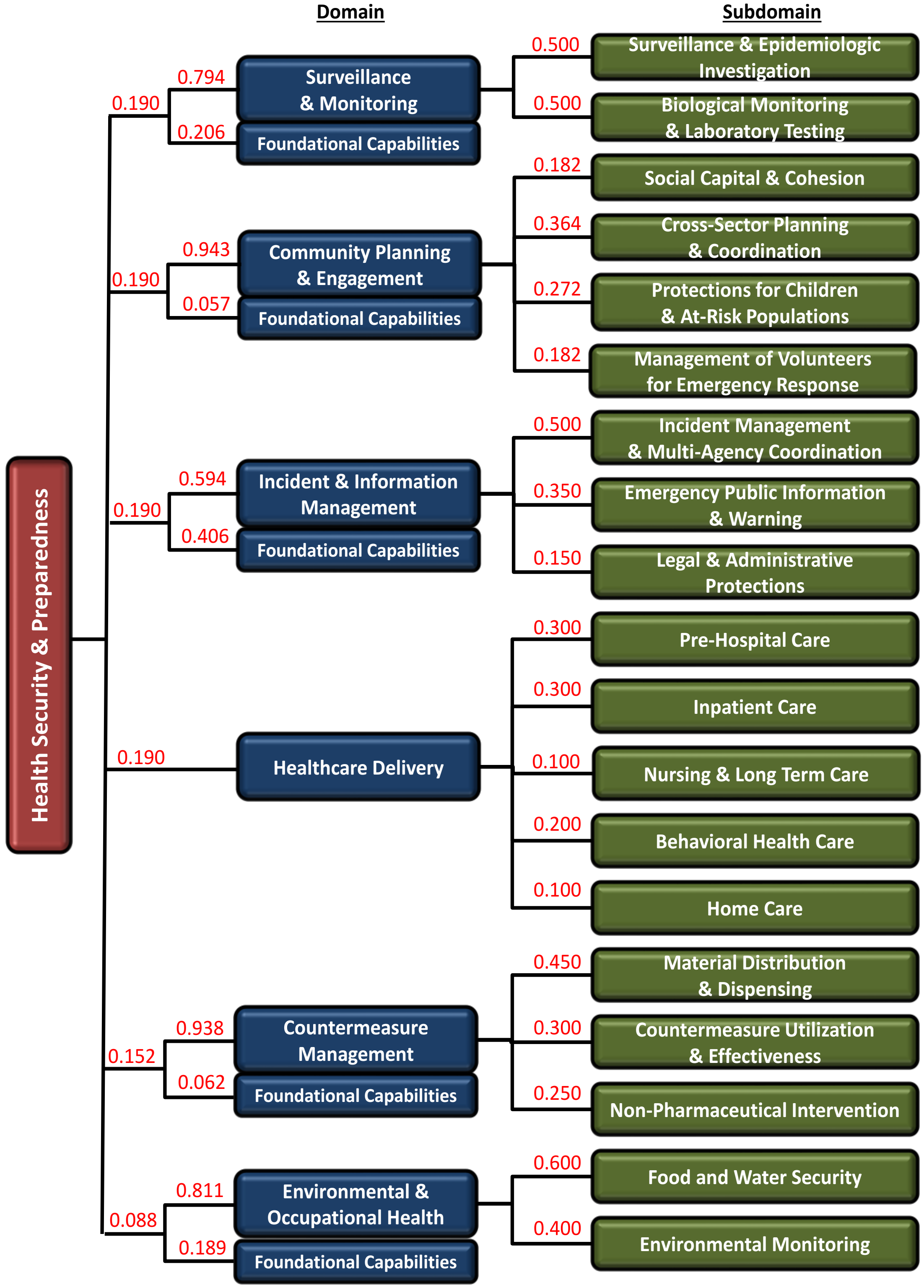
domain and overall summary measures using expert panel weights assigned to each measure defined as a Foundational Capability. Figure 2 shows the weights applied at the subdomain and domain levels.

VII: Imputing Missing Values

Some of the measures used in the Index have missing values for selected states due to incomplete response rates in the underlying data sources. The 2013 and 2014 releases of the Index address this missing values problem using a method that sets a missing value for a given measure and a given state equal to the unweighted average of that state's remaining measures in the same subdomain. This method introduces substantial measurement error into the Index, particularly given that most Index measures are not highly correlated at the subdomain level. This method also distorts the weighting system used within the Index by giving certain measures disproportionate influence on subdomain, domain, and overall Index values. A more accurate way of dealing with missing values is to use a statistical imputation method that predicts missing values using available information from a broader range of measures, including Index measures from all states and all available years.

In the 2016 Index measure set, about 2 percent of the total item measures elements used for computing Index values are missing and must be imputed in order to generate Index summary measures. To reduce Index distortions due to missing values, we use multivariate regression models for each measure to predict its missing values, using three years of data on the measure along with other covariates in the model as predictors. Other covariates used in each regression model include non-missing Index measures from the same subdomain and domain, as well as state-level demographic, socioeconomic, and geographic characteristics, including population size, educational attainment, per capita income, age distribution, land area, population distribution across urban and rural areas, and climate region. Sensitivity analyses confirm that using imputed missing values derived from the regression models do not introduce any measurable bias in the Index summary measures constructed at the subdomain, domain, and overall Index levels.

Figure 2: Delphi Weights for Constructing Index Subdomain, Domain, and Overall Summary Measures



NOTE: numbers indicate Delphi expert panel weights

VIII. Aggregating Individual Measures into Summary Measures

The 2016 Index aggregates individual measures into subdomain, domain, and overall Index summary measures for each state and year using a weighted arithmetic mean. Since the Delphi weights for each measure are normalized, the weighted mean is calculated as:

$$\bar{x} = \sum_{i=1}^{n} w_i' \, x_i$$

Where, x_i is measure, subdomain, or domain i, and n is the number of measures, subdomains, or domains.

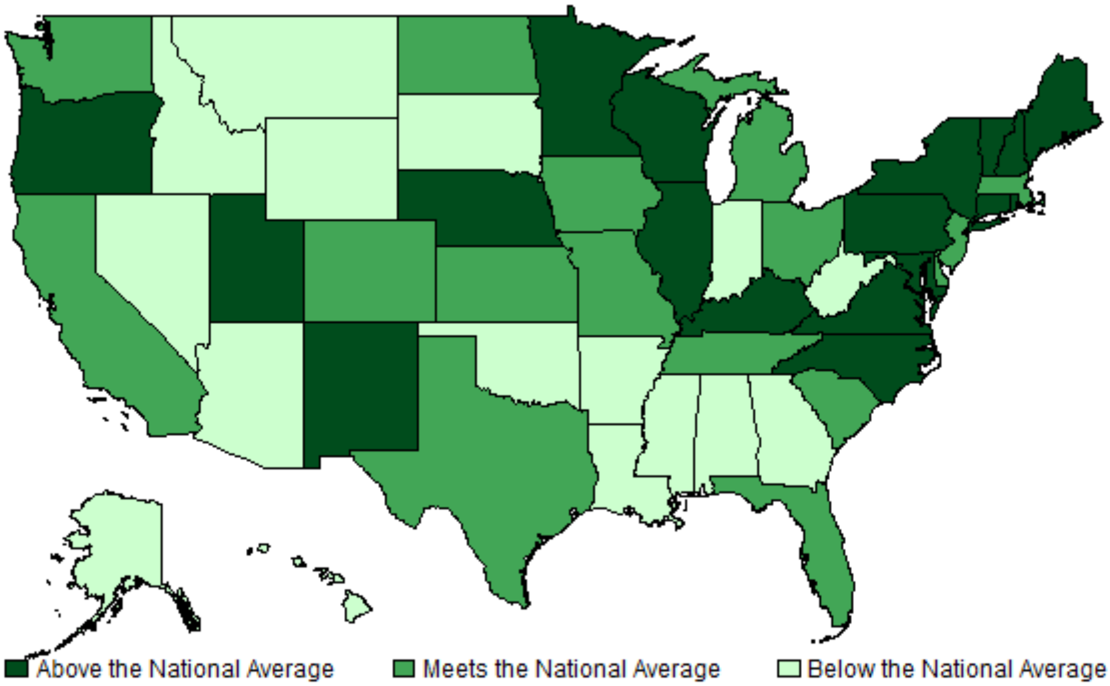
Summary measures are calculated for each state and year using this method. As final step, national summary measures are calculated at the subdomain, domain, and overall Index level for each year by calculating a linear (unweighted) mean of the 50 state summary measures.

IX. Confidence Intervals for National Summary Measures

The 2013 and 2014 releases of the Index caution that the accuracy of comparisons made across domains, subdomains, and individual states has not been established. These previous Index releases suggested using a rule of thumb that differences of less than 10% may not be meaningful, but this rule of thumb is not based on any empirical results estimated from the Index data. Users wishing to use the Index for decision support and quality improvement require more robust and reliable information about the uncertainty surrounding Index measures and comparisons.

To address this unmet need, the 2016 Index calculates confidence intervals for each of the national summary measures included in the Index at subdomain, domain, and overall levels. The confidence intervals allow summary measures for each state to be compared to the corresponding national summary measures. We use a conservative statistical threshold for Type I error of $p=0.01$ in calculating national confidence intervals, in order to account for the fact that state summary measures are also measured with error. As a result, the national confidence intervals used in the 2016 Index represent 99% confidence intervals surrounding each national mean value. As shown in the map below, we are able to display that the mean Index values of each state relative to these national confidence intervals, noting which states are significantly above or below the national average.

Figure 3: State Index Summary Measures Compared with National Averages



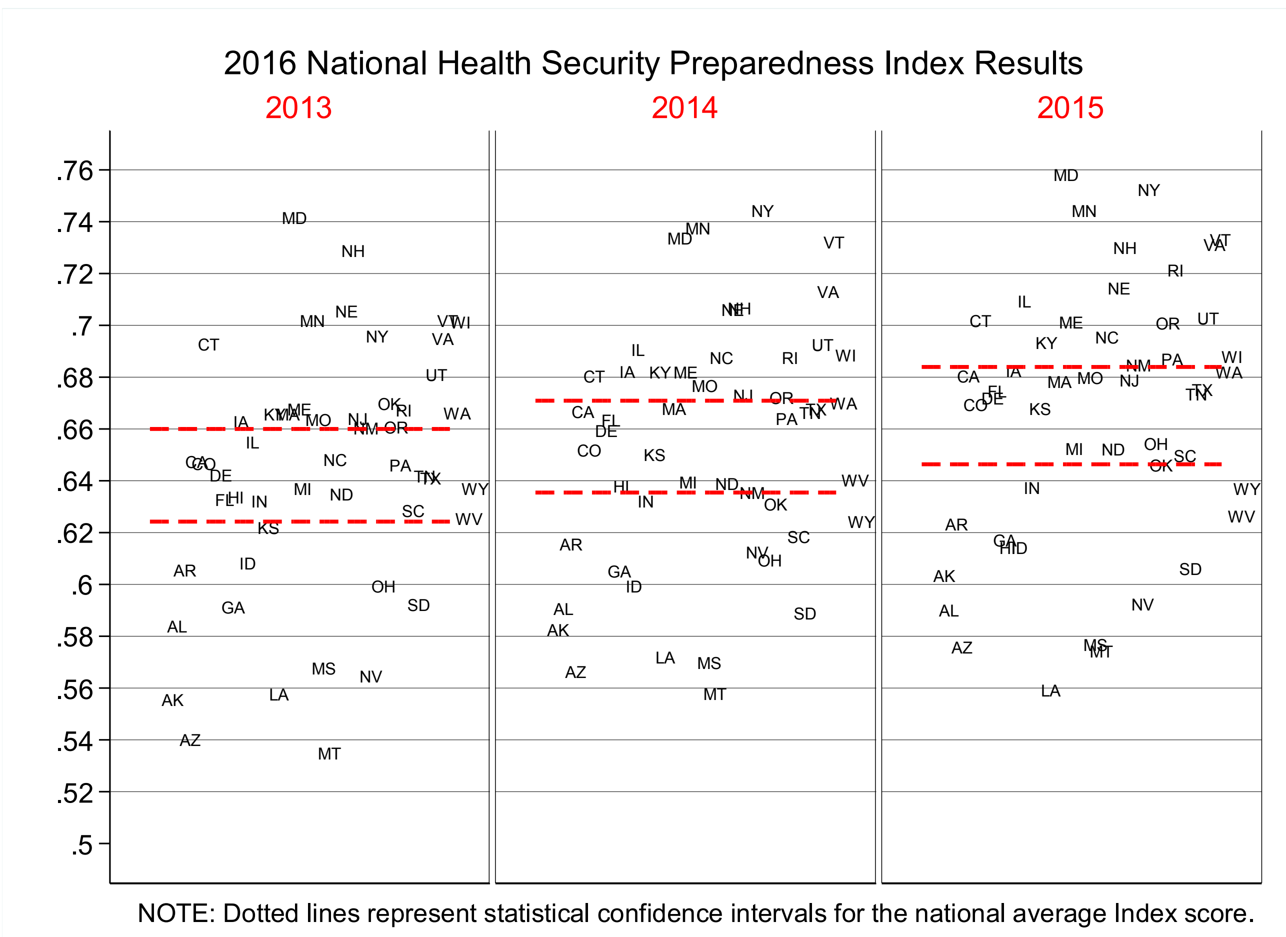
X. Longitudinal Comparisons

The 2013 and 2014 releases of the Index do not support longitudinal comparisons of Index values over time (trending) due to significant differences in the measures and methodologies used in 2013 and 2014. The 2014 release cautions users not to compare 2014 results with results found in the previous year's release. Modifications to the Index measures and methodologies are expected to occur with each annual release of the Index due to advances in preparedness science and due to changes in underlying data source availability, content, and quality. Nevertheless, if the Index is to become a valuable decision support tool in policy and practice communities, then users need to make valid comparisons of Index values over time and assess the direction and magnitude of change.

The 2016 Index release computed Index values not only for 2015, but also for 2013 and 2014, allowing for retrospective longitudinal comparisons each year dating back to the initial release year of 2013. Confidence intervals for the national average for mean Index values were also calculated at the subdomain, domain, and overall Index levels for all three annual periods, which makes it possible to track annual changes in the classification of each state's summary measures when compared to the national average.

It is important to note, however, that the time frame for each measure reflects the most recent data available for each year, which varies depending on the measure and its data source. One year differences in Index values may be conservative estimates of change because the data for some measures are updated every 2 or 3 years rather than annually. Measures used in calculating Index values for 2015, for example, reflect the most recent time periods of data collection that range from calendar year 2013 to calendar year 2015. In constructing Index values for 2014 and 2013, the time periods for individual measures are moved back by 1 and 2 years, respectively, from the most recent year of data used in anchoring the 2015 calculation. For measures that are collected every 2 or 3 years rather than annually, values are held constant during the time periods between data collection, in keeping with the policy of using the most recently available data for each time period. As a consequence, estimates of longitudinal change in Index values should be considered conservative estimates of change.

Figure 4: Longitudinal Comparisons of State and National Index Values



Acknowledgements

The National Health Security Preparedness Index is a program of the Robert Wood Johnson Foundation. The Program Management Office for the Index is based at the University of Kentucky and staffed through a collaboration between the Center for Public Health Systems and Services Research, College of Public Health and the Center for Business and Economic Research, Gatton College of Business and Economics.

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Recommended Citation: Center for Public Health Systems and Services Research. *National Health Security Preparedness Index 2016 Summary of Results.* Lexington, KY: University of Kentucky; April 2016.

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Program Consultants: Christopher R. Bollinger, PhD, University of Kentucky; Mary V. Davis, DrPH, Project Y Evaluation; Christopher Nelson, PhD, RAND; Catherine Slemp, MD, MPH, public health consultant.

Index Workgroups: This work would not have been possible without the input and feedback provided by voluntary members of the Index Analytic Methodology, Model Design, and Stakeholder Engagement and Communication Workgroups.

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