# Appendices

Appendix Figure 1

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Notes: NACCHO National Association of County and City Health Officials. Lines shown relate to regression approach. NACCHO FIT represents a fit line to NACCHO LHD FTE per 100,000 population by population size.

Appendix Methods: *Model Estimation Approach*

|  |  |
| --- | --- |
| **Foundational Areas** | Communicable Disease Control |
| Chronic Disease and Injury Prevention |
| Environmental Public Health |
| Maternal, Child, and Family Health |
| Access to and Linkage with Clinical Care |
| **Foundational Capabilities** | Assessment/Surveillance |
| All Hazards Preparedness and Response |
| Other Foundational Capabilities (Policy development and support, Communications, Community partnership development, Organizational administrative competencies, Accountability/performance management) |

We obtained data on an LHD’s actual current workforce and the estimated workforce needed for full implementation of core FPHS from a total of n=168 21C state LHDs. We used this current and full implementation workforce data to generate a predictive model of the gap between current and full implementation staffing for the public health workforce. The goal of the model was to apply it to LHDs for which we know current staffing but do not know full-implementation workforce (i.e., all other non-21C state LHDs).

During model building, several candidate models were explored to identify the one that best fit the data and was the most stable and parsimonious. We placed a high priority on model acceptability, interpretability, and communicability and therefore were also guided by input from the project’s steering committee and research advisory committee during all model development phases.

Several notable assumptions were made in consultation with both Staffing Up advisory groups during the model building process. First, we fixed the amount of FTEs needed per 100,000 for LHDs serving populations larger than 500,000 to match the levels modeled for jurisdictions serving 250,000-499,999 persons. Our sample contained relatively few large jurisdictions (only 11 of 168 sample LHDs served populations greater than 500,000 residents) so the model was potential subject to distortionary effects from a small number of high leverage observations. Therefore, the model does not assume economies or diseconomies of scope or scale for very large jurisdictions. Second, based on 21C data, we established a ‘floor’ of a minimum of 5 total FTE per LHD necessary to deliver the full range of the FPHS, regardless of how small a jurisdiction was. Third, we dropped from our analytic sample outliers that were either (a) greater than 300 FTEs per 100,000 population or (b) more than 3 standard deviations from the mean, by FPHS and group (reducing N=207 LHDs to the n=168 analytic sample). Our goal in removing observations that had especially high staffing ratios was to ensure that findings were not overly influenced (in the statistical sense of the term) by observations at the far end of the distribution. One important implication of this decision is that while findings may therefore be more stable and more representative of the overall picture of the staffing workforce shortage, this directional exclusion of n=39 agencies may have yielded a model likely to yield an underestimate of the true gap. We acknowledge that different assumptions could potentially yield estimates higher or lower than those presented in this analysis.

We included predictions based on models assuming various functional forms of the current versus full implementation staffing relationship. We examined linear regression, as well as non-linear or curve fitting models such as quadratic, cubic, and power models. We also examined models that accounted for factors of hypothesized relevance including population size of jurisdiction served, public health service mix, rurality, community need, and other community characteristics. Calculations were conducted for overall (total) staffing and separately for each FPHS foundational service and foundational area.

After assessing all model options described above, a locally-weighted power model regressing full-implementation FTEs on population size alone proved the most predictive and performed the best across a variety of model fitting exercises.

To assess whether the model was overfit, the generalized approach for curve-fitting the 21C data was checked against available NACCHO data (which includes total FTEs but does not collect FTEs by core vs expanded service). Microsimulation and macrosimulation strategies were employed to assess variability in total estimates through strength of assumptions. In order to estimate the current FTEs that provide FCs and FAs, we applied the ratio of core FTE to expanded service FTE from the 21C data to national estimates. For both current and full implementation, estimates were calculated by FC and FA and population size served by the LHD (< 25,000, 25,000-49,999, 50,000-99,999, 100,000-249,999, 250,000-499,999, 500,000+).

*State Health Agency Workforce Calculations*

Because of a lack of available data for states (only three of four 21C states had conducted state-level cost estimation work), we explored different analytic approaches to estimate current and full-implementation SHA workforce. As with the local workforce, we examined only the SHA FC and FA workforce. Analyses were limited to the workforce at SHA central offices (COs), and not the workforce stationed at LHDs or elsewhere.

In consultation with both Staffing Up advisory groups, the final approach to estimating the size of the SHA CO workforce gap was based maintaining the current the ‘division of labor’ between SHA COs and LHDs. We used data from the PH WINS to estimate the state versus local division of labor nationally and by FPHS For each FC and FA, the proportion of SHA central office vs LHD staff was calculated (e.g., for example a current split for communicable disease control that is 70/30 between LHDs/SHA COs). Then, LHD model was used to estimate the full-implementation staffing needs for LHDs, resulting in a staffed up number of FTEs needed at LHDs. We then applied the current division of labor calculation to commensurately staff up SHA CO. The end result is a staffed up state public health workforce that is staffed up to roughly the same degree as the local public health workforce (e.g., a full-implementation split for communicable disease control that is still 70/30 between LHDs/SHA COs). This is a significant assumption, one vetted with both the research advisory committee and the overall steering committee.

## Overview of Approach for Estimating State Public Health Agency Workforce

Multiple data sources exist regarding the state public health agency workforce. However there is no single data source that directly measures the number of full-time equivalent (FTE) workforce positions at state health agency (SHA) central office (CO) devoted to below-the-line foundational public health services (FPHS). We considered three main approaches using multiple datasets to generate a first of its kind estimate for the SHA CO FPHS workforce. We ultimately selected Approach S3 as detailed below.

### Approach “S1”

We considered using the same approach used to generate the local health department (LHD) FPHS current workforce, full implementation workforce, and staffing gap estimates. Specifically the local staffing gap estimate was calculated by using data on approximately n=168 LHDs from 4 states that participate in the PHNCI’s 21C project; LHDs received training and subsequently self-reported their current workforce FTE workforce by FPHS and an estimate of the number of FTEs by FPHS needed for full implementation of all FPHS. The difference between these two numbers is equivalent to the staffing gap at a given LHD. The approach was also used for the SHA in 21C states and analogous current and full implementation staffing data were available for n=3 SHA COs. We considered calculating a regression model using the n=3 21C state data points using the resulting model parameters to estimate full implementation FTEs for the remaining n=47 SHA COs. The Staffing Up Steering Committee and Research Advisory Committee did not select this approach due to concerns regarding generalizability of 21C SHA staffing patterns and stability of model estimates based on relatively few data points.

### Approach “S2”

We considered generating an estimate of the SHA CO workforce gap by assuming that the percentage gap between current and full-implementation employment was equal for LHDs and SHA COs. Under this approach we would use official ASTHO estimates of the size of the overall SHA CO workforce. We would then decrement that estimate using the above- versus below-the-line ratio obtained from LHD data to obtain an estimate of the SHA CO workforce that is devoted to below the line FPHS work. We would then make the assumption that the current versus full implementation workforce gap is equivalent for LHDs and SHA COs. From there it is possible to calculate the SHA CO gap (i.e., number of new FTEs needed) at SHA COs by FPHS. The Staffing Up Steering Committee and Research Advisory Committee did not select this approach due to concerns regarding the validity of the assumptions used to generate the final estimates for this approach.

### Approach “S3”

We ultimately generated an estimate of the SHA CO workforce gap by determining the current division of labor between LHDs and SHA COs and then applying that ratio nationally to preserve the current division of labor to the full implementation “staffed up” estimate of the LHD workforce. Namely, we first estimated current LHD and SHA CO workforce (using 21C, NACCHO, PH WINS, and ASTHO Profile data as applicable). We then estimated the division of labor at LHDs versus SHA COs for each FPHS (e.g., say 70% of the workforce for a given FPHS is located at LHDs versus 30% located at SHA COs). We then applied estimates of the LHD staffing gap for each FPHS to obtain a final tally for full implementation of each FPHS at LHDs. Without any changes to SHA CO staffing, the result of additional LHD staffing would alter the staffing ratio (e.g., say from 70% local to 80% local). So we therefore applied a commensurate increase in the SHA CO to yield a “staffed up” workforce that retained the current division of labor breakdown between LHDs and SHA COs.

*Appendix Figure 2: Schematic of Workforce Shortage Estimation Approach*

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Source: Public Health National Center for Innovations.27 Reproduced with permission.

Appendix Table 1: Number of new FTEs needed by foundational area / capability

|  |  |  |  |
| --- | --- | --- | --- |
|  | Local | State | Total |
| Assessment | 4,500 | 4,500 | 9,000 |
| All Hazards | 3,000 | 2,000 | 5,000 |
| Other Foundational Capabilities | 17,500 | 8,000 | 25,500 |
| Chronic Disease & Injury | 8,000 | 5,000 | 13,000 |
| Communicable Disease | 4,500 | 1,500 | 6,000 |
| Environmental Health | 7,500 | 2,000 | 9,500 |
| Maternal and Child Health | 5,500 | 1,500 | 6,500 |
| Access / Linkage | 3,500 | 1,000 | 4,500 |
| Total | 54,000 | 26,000 | 80,000 |

Appendix Figure 3: Methods and results of microsimulation model showing new FTEs needed by FPHS, state and local components of estimate

Notes: Error bars represent the 2.5th and 97.5th percentiles of the microsimulation results for the state and local components, respectively.

The microsimulation model uses a Monte Carlo approach (using Stata 15.1), with 100,000 simulated outcomes. Several parameters are varied in each simulation, including assumptions around what percent of the national workforce focuses on core (below-the-line) vs expanded (above-the-line) FPHS activities and service provision; the size of the LHD need; the size of the SHA need. The current national below-the-line workforce was derived from 21C data, and the variability allowed for 2,454 LHDs in the simulation was a uniform distribution within the IQR of the observed 168 LHDs in the 21C data. Each FPHS gap was allowed to vary by the uniform distribution of 50%-150% of the difference between the projected full implementation FTE need from the projected current FTE count.

Appendix Figure 4: Actual current versus modeled full implementation staffing at all local health departments by size of population served (n=2,454)

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Appendix Figure 5: Summary of Approaches S2 and S3 to estimate the State Health Agency Central Office workforce size and staffing gap

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## Appendix Methods: Generalizability and Comparison of 21C States (Analytic Sample) and Other States

Our analysis leverages very detailed current and full-implementation staffing data from a sample of state and local health departments and seeks to generalize staffing patterns in these states to the rest of the 50 US states. While we made efforts to remove outliers and implement data checks to for purposes of national estimates, we acknowledge that agencies included in our analyses may or may not be generalizable to all LHDs and SHAs in the US. The four states included (CO, OH, OR, WA) have decentralized public health systems. Three are located in the mountain/Pacific portion of the country and none are in the eastern time zone.

To aid in readers understanding of how well findings from these states may generalize to other states, we present data on our sample below. We focus mostly on the public health workforce and labor allocation patterns within public health agencies and comparing our analytic sample to all other LHDs in non-21C states (i.e., states other than CO, OH, OR, WA). We focus on comparisons of staffing for like-sized jurisdictions and therefore present population-stratified figures below.

Overall, the current size and composition of the public health workforce in our analytic sample of n=168 LHDs is very consistent with that seen in all other LHDs. The total number of FTE positions at analytic sample versus other LHDs has remained largely consistent dating back to 2008 (first year with comparable data available). There are some exceptions to this, most notably a somewhat higher median number of FTEs per 100,000 population observed in 2019 for LHDs that serve less than 50,000 in the analytic sample versus other LHDs. To the extent that this might impact our findings this would be expected to bias findings down (towards the null) if we begin with an estimate of the current workforce that is higher than other agencies we seek to generalize to.

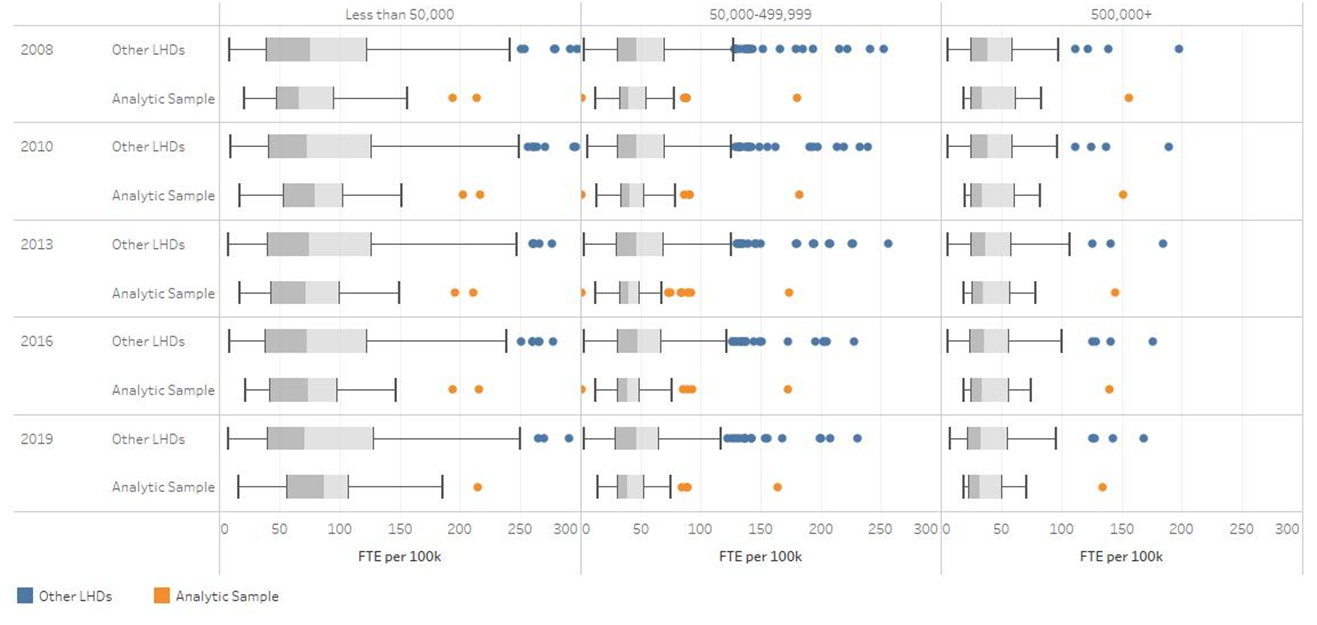
We also examined current (2019) workforce staffing for the n=168 departments in our analytical sample for selected FPHS services and capabilities and found largely consistent staffing patterns between our analytic sample and all other LHDs. Specifically, the number of FTE staff per 100,000 population that are devoted to business or finance, all hazards preparedness/response, and administrative duties are all largely consistent across analytic sample and all other LHDs. The limited exceptions to this general finding are directionally the same as detailed above (e.g., the median FTE staff per 100,000 for business/finance for departments serving 50,000-499,999 among our analytic sample is greater than the median for all other LHDs).

In addition to the composition of the current workforce being an important consideration for generalizability, we highlight two additional considerations below.

First, we believe that the inclusion of a representative set of LHDs within each state is a major strength of our sample approach. While there may be state-effects that may impact generalizability, we would have had greater concerns regarding heterogeneity arising from variation in local jurisdictional sizes. We sought to obtain estimates of current versus full-implementation staffing for small-, medium-, and large-sized jurisdictions. Our analysis includes a modest sample size of small, medium, and large LHDs which we believe is a strength. We include nearly all local agencies from each state, which is preferable to a voluntary or random sample of a few health departments from a larger number of states.

Second, supporting our general quantitative finding that the current staffing levels are roughly comparable for our analytical sample to all other LHDs is the original sample selection method. Specifically, a strength of our sample selection is that it was not performed specifically for this study. Had LHDs voluntarily opted-in to a study specifically on Staffing Up the public health workforce there would be a potential endogeneity concern. However all (or nearly all) health departments within 4 states participated in a larger state-level 21C project that, as a single component of a larger [overall body of work aimed at](https://phnci.org/national-frameworks/21c-learning-community) “intentionally transforming their governmental public health systems, modernizing, and advancing equity, through a variety of models/strategies including, but not limited to using, the FPHS model.”

Appendix Figure 6: LHD FTE Positions by 100K Population, by Jurisdiction Population



Appendix Figure 7: Number of FTE Staff per 100,000 for Business/Finance FPHS

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Appendix Figure 8: Number of FTE Staff per 100,000 for All Hazards Preparedness FPHS

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Appendix Figure 9: Number of FTE Staff per 100,000 for Administration FPHS

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