Assessment of Epidemiology Capacity in State Health Departments, 2001–2006

Matthew L. Boulton, Jennifer Lemmings, and Angela J. Beck

Objectives: To assess the number of epidemiologists and national epidemiology capacity, the Council of State and Territorial Epidemiologists surveyed state health departments in 2001, 2004, and 2006. This article summarizes findings of the 2006 assessment, analyzes trends in epidemiology workforce, and examines statistical associations between the number of epidemiologists and measures of capacity. Methods: The on-line surveys collected information from 50 states and the District of Columbia about the number of epidemiologists employed, their training and educational background, program capacity, organizational structure, and funding sources. The State Epidemiologists and/or their designees answered the questionnaire. Results: The number of epidemiologists in state health departments increased approximately 40 percent from 2001 to 2006. All programs except occupational health experienced increase in the number of epidemiologists; the greatest increase occurred in bioterrorism programs. Estimated epidemiology capacity increased in all programs except environmental health and occupational health. The Epidemiology Capacity Assessment survey indicates that state health departments need 30 percent more epidemiologists. A linear correlation existed between the number of epidemiologists and state population. Conclusions: Federal emergency preparedness funding supported most of the increase in epidemiologists, which could fall as funding decreases. To function at full capacity, states need approximately one epidemiologist per 100,000 population for all program areas. Current estimates of workforce capacity need to be refined. KEY WORDS: epidemiology, public health practice, workforce

Interest in the US public health workforce has increased since the publication of an Institute of Medicine report in 2003 documenting challenges to our health-care infrastructure.1 As noted in this report and other studies, research is needed to more accurately enumerate the public health workforce, assess workers’ training and levels of competency, estimate future personnel needs, measure program capacity, and inform strategies for worker recruitment and retention.2–8 It is important that examination of the public health workforce include epidemiology, which despite being described as the central science of public health,9 has historically lagged behind more programmatically focused areas in the number of trained workers and organizational capacity.10

Epidemiology is a recognized field of academic concentration in schools of public health, for which master’s and doctoral degrees are awarded.11 However, epidemiology in practice embodies varied skills that workers other than formally degreed epidemiologists perform, such as nurses who conduct investigations of

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a foodborne outbreak or vital records staff who analyze registry data. These professionals perform limited epidemiological functions and yet most do not possess a degree in epidemiology or often any training in this field, but these workers are frequently considered “epidemiologists” by the public health practice community."

Numerous attempts to assess the national epidemiology workforce have yielded highly varied results.\textsuperscript{12–16} Notably, the Health Resources and Services Administration’s Public Health Enumeration 2000 estimated that 927 epidemiologists or fewer than 1 percent of the entire public health workforce worked in federal, state, and territorial public health agencies.\textsuperscript{3} A 2005 national survey of local health departments found that only 25 percent had an epidemiologist on staff and epidemiology was identified as a leading area of workforce shortage.\textsuperscript{17} The Association of State and Territorial Health Officials and the Council of State Governments reported in 2006 that nearly half of the 37 responding states identified epidemiologists as the occupational class second most affected by workforce shortages, behind only nursing.\textsuperscript{18} and estimated in 2007 that 1 437 epidemiologists work in state health departments.\textsuperscript{15} Finally, in 2007, Gebbie et al estimated using Federal Occupational Employment Statistics that 2 480 epidemiologists worked in local, state, and federal agencies.\textsuperscript{16}

The Council of State and Territorial Epidemiologists (CSTE), the professional organization for epidemiologists working in state, local, territorial, and tribal health departments, spearheaded national assessment efforts in 1995, compiling a guide to aid states in self-assessment of epidemiologic capacity.\textsuperscript{19} In 1997, CSTE piloted a survey in 10 states and, in November 2001, administered the Epidemiology Capacity Assessment (ECA).\textsuperscript{20} The ECA was the first national survey of core epidemiology capacity in state and territorial health departments and a benchmark before distribution of approximately $1 billion in federal funding annually to states for emergency preparedness. Since then, CSTE has administered two ECAs: in 2004 and again in 2006.\textsuperscript{12,21}

In this article, we summarize findings from the 2006 ECA and examine trends in epidemiology capacity in state health departments during 2001 to 2006. We also analyze ECA data to determine whether significant association exists between the reported number of epidemiologists and measures of workforce capacity.

\section*{Methods}

In May 2006, we distributed the 2006 ECA in electronic and paper formats to all 50 states, the District of Columbia (DC), and the six US territories; data collection was completed by August 2006. State Epidemiologists or their delegates were the designated key informants. We provided the states with worksheets to aid in data collection and with copies of their 2004 ECA results for comparison. The survey tool is included in the CSTE 2006 ECA technical report.\textsuperscript{21}

Epidemiology capacity in states was assessed in the ECA by enumeration of all epidemiologists and through qualitative estimates by the State Epidemiologists of their states’ level of activity, knowledge, or resources in eight epidemiology program areas and estimated ability to perform four of the essential public health services most related to epidemiology. The survey comprised two parts. Part I requested a count of all the epidemiologists employed or contracted by the state health department, individual-level information about program area and training or educational background, and an estimate of the number of epidemiologists needed to reach full capacity. As in the 2004 ECA, we defined “epidemiologist” in accordance with Last’s 2001 edition of \textit{A Dictionary of Epidemiology}.\textsuperscript{22} Respondents were asked to estimate epidemiology and surveillance capacity for the following eight program areas: bioterrorism (BT), chronic diseases, environmental health, infectious diseases, injury, maternal and child health (MCH), occupational health, and oral health. States chose one of the following responses: none/not at all, minimal, partial, substantial, almost full, or full. During analysis, we grouped responses into qualitative quartiles of none or minimal, partial, substantial, or almost full to full capacity; here we report “substantial to full” capacity. Part I also requested an estimate of agencies’ ability to carry out the following four essential services of public health (ESPH): “Monitor health status to identify and solve community health problems” (ESPH 1); “Diagnose and investigate health problems and health hazards in the community” (ESPH 2); “Evaluate effectiveness, accessibility, and quality of personal and population-based health services” (ESPH 9); and “Research for new insights and innovative solutions to health problems” (ESPH 10). During data analysis, we used the same quartile rankings as for the estimates of capacity. Additional questions in Part I addressed funding (state vs federal) for epidemiology programs, use of federal emergency preparedness funds to support epidemiologists, and organizational placement of epidemiologists (program focused vs discrete unit). Part II of the ECA asked states to rate their epidemiologists on each of the 32 competencies needed by a mid-level epidemiologist.\textsuperscript{23} The ECA included additional questions about training for epidemiologists and challenges to recruitment and retention. An analysis of the workforce competency data was previously published\textsuperscript{24} and a separate article on recruitment and retention of epidemiologists based on ECA data is forthcoming.
Using simple linear regression, we examined the relation between state population and the number of epidemiologists in the state. We analyzed relations between the number of epidemiologists and variables of interest (ie, organizational structure, ESPH capacity, and program-specific capacity) using Tukey’s multiple comparison test. Data were analyzed using SAS version 8.25.

The Council of State and Territorial Epidemiologists did not seek approval of the institutional review board (IRB) for this study, as it is de-identified national survey data that do not capture individual-level data and would likely be exempt by IRB. Independent consultation with the IRB at the Michigan Department of Community Health has confirmed that the study would have been eligible for exemption under code of Federal Regulations title 45, Part 46.101(b)(2).

## Results

All states responded to the 2006 ECA. Although some territories responded to each of the three ECAs, only one responded to both the 2004 and 2006 surveys. Because of greater nonresponse and incompleteness of data from territories, we report results only from the 50 state health departments and DC. Some respondents did not answer all survey questions; therefore, denominators vary for responses to individual questions.

### Findings of the 2006 ECA

The 51 respondents (50 states and DC) reported employing or contracting a total of 2,436 epidemiologists in 2006; educational and/or program information was reported for 2,377 (98%) of these epidemiologists (Table 1). Most epidemiologists worked in infectious diseases (43%), with the remainder in BT (14%), chronic diseases (14%), environmental health (12%), MCH (10%), injury (4%), occupational health (2%), and oral health (1%).

Overall, 1,308 (55%) of the total epidemiologists reported on had a degree in epidemiology; workers with master’s degrees in epidemiology were more prevalent (864 [36%]) than were PhDs and DrPHs (193 [8%]) or physicians and other professionals (eg, DVM, DDS) with an epidemiology degree (199 [8%]). Epidemiologists with a bachelor’s degree accounted for 52 (2%)...
of the total. Epidemiologists without an epidemiology degree account for 1,069/2,377 (45%); 906 (38%) had either formal training (eg, EIS), some coursework, or on-the-job training in epidemiology; 66 (3%) had no training of any sort; and for 97 (4%) epidemiologists, respondents provided program but no educational information. More than half of the epidemiologists working in each of the six program areas held a degree in epidemiology (ie, bachelor’s, master’s, or doctoral degree in epidemiology): injury (64%), BT (61%), chronic diseases (61%), infectious diseases (55%), occupational health (53%), and MCH (52%). Forty-four percent of oral health epidemiologists and 41% of environmental health epidemiologists had a degree in epidemiology. Educational background for the 2,436 epidemiologists who reported having any degree (ie, degree may not be in epidemiology, data not shown) reveals that epidemiologists with a master’s degree (1,157 [47%]) are more common than physicians (278 [11%]), PhDs and DrPHs (347 [14%]), persons with other doctoral degrees (eg, DVM, DDS) (87 [4%]), persons with a bachelor’s degree (439 [18%]), or persons with an associate degree or no post-high school degree (65 [3%]); no degree information was provided for 64 (3%) epidemiologists. To reach full capacity in all the eight program areas, the 50 states and DC reported the need for approximately 3,172 total epidemiologists—30% more than those employed in 2006.

Estimated capacity in specific program areas and the ability to carry out ESPH varied significantly among states. The percentages of the states reporting substantial to full capacity in the four ESPH are as follows: for ESPH 1, 80 percent; for ESPH 2, 67 percent; for ESPH 9, 39 percent; and for ESPH 10, 16 percent. Most states reported substantial to full capacity for three program areas: infectious diseases (96%), BT (76%), and chronic diseases (64%). Fewer states reported substantial to full capacity for MCH (47%), environmental health (34%), injury (25%), oral health (14%), and occupational health (14%).

In the 2006 ECA, respondents reported receiving an average of 71 percent of their funding from the federal government and 23 percent from the state government (medians: 78% and 20%, respectively). Federal emergency preparedness funding supported 517 (21%) epidemiologists, and most epidemiologists funded by preparedness monies worked in BT (55%) or infectious diseases (38%). Emergency preparedness-funded epidemiologists also worked in environmental health (4%), MCH (2%), chronic diseases (1%), and injury (1%). By program area, 86 percent (285/332) of the epidemiologists working in BT were funded with federal emergency preparedness funds, as were 19 percent (195/1,017) in infectious diseases.

Twelve percent of the states reported that their epidemiologists were organized in discrete units (eg, bu-

### Table 2 - Variables of interest and their relation with the total number of epidemiologists in a state—Epidemiology Capacity Assessment, 2006

<table>
<thead>
<tr>
<th>Variable of interest (statistical test)</th>
<th>Difference in means</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (simple linear regression)</td>
<td></td>
<td>&lt;.0001b</td>
</tr>
<tr>
<td>Structure within state health departmentc (Tukey’s test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit vs program</td>
<td>26.6</td>
<td>.0107b</td>
</tr>
<tr>
<td>ESPH capacity (Tukey’s test) (high vs low capacity)d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESPH 2</td>
<td>10.1</td>
<td>.4316</td>
</tr>
<tr>
<td>ESPH 10</td>
<td>10.3</td>
<td>.7866</td>
</tr>
<tr>
<td>ESPH 1</td>
<td>19.3</td>
<td>.1169</td>
</tr>
<tr>
<td>ESPH 9</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Program capacity (Tukey’s test) (high vs low capacity)d</td>
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<td></td>
</tr>
<tr>
<td>Chronic diseases</td>
<td>0.8</td>
<td>.9523</td>
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<td>Bioterrorism</td>
<td>3.5</td>
<td>.7474</td>
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<tr>
<td>Infectious diseases</td>
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<td>.4471</td>
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<td>Maternal and child health</td>
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<tr>
<td>Environmental health</td>
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<tr>
<td>Injury</td>
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<td>Occupational health</td>
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<td>.2204</td>
</tr>
<tr>
<td>Oral health</td>
<td>36.3</td>
<td>.3372</td>
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</table>

*Difference in the average number of total epidemiologists stratified by the variable of interest.

*Significant (P < .05).

*cUnit, state health departments where epidemiologists are located together in one organizational unit; program, state health departments where epidemiologists are located within specific programs.

*dLow capacity, none to partial capacity; high capacity, substantial to full capacity.
health, and injury had a much greater average number of epidemiologists in those programs than did states reporting low capacity. Reported program capacity and the number of epidemiologists differed significantly by capacity quartiles (data not shown).


Forty-one respondents completed the 2001 ECA (40 states and DC); 51 respondents completed the 2004 and 2006 ECAs (50 states and DC). Ninety-five percent of 2001 ECA respondents (39/41) answered the enumeration questions and reported employing 1,278 epidemiologists, with almost half (49%) working in infectious diseases. Approximately 41 percent of these epidemiologists had no academic degree or formal training in epidemiology. By comparison, in 2004, the 51 respondents reported 2,498 epidemiologists working in state health departments, a 95 percent increase over the number of epidemiologists reported in 2001 (1,278 vs 2,498) and a 27 percent increase among just the 39 respondents completing the enumeration questions in 2001 and 2004 (1,278 vs 1,619). On the basis of the increase observed in the 39 respondents to the enumeration questions in the first two surveys, we estimated that the 12 states not responding to the enumeration questions in 2001 employed an additional 456 epidemiologists (95% confidence interval: 437–475), yielding an estimated 1,734 epidemiologists in 2001 or a 44 percent increase from the 2001 ECA to the 2004 ECA. In the 2004 ECA, 29 percent of epidemiologists lacked formal training, coursework, or a degree in epidemiology.

For the 2006 ECA, the 51 respondents reported 2,436 epidemiologists working in state health departments, a 40 percent increase over the estimated number of epidemiologists in 2001 (1,734 and 2,436, respectively) and a 25 percent increase among the 39 respondents completing the enumeration questions in both 2001 and 2006, showed that epidemiologists working in BT increased by 108 percent (112 and 232); MCH by 64 percent (104 and 171); chronic diseases by 42 percent (159 and 226); injury by 20 percent (49 and 59); oral health by 11 percent (18 and 20); infectious diseases by 8 percent (626 and 678); and environmental health by 4 percent (165 and 171). In occupational health, the number of epidemiologists decreased from 30 in the 2001 ECA to 22 in the 2006 ECA (–27%).

The proportion of epidemiologists with a degree, training, or coursework in epidemiology increased in each successive ECA: 58 percent (748/1,279) in 2001, 71 percent (1,371/1,934; 564 epidemiologists with unknown training level) in 2004, and 80 percent (1,908/2,372; 84 epidemiologists with unknown training level) in 2006. Similarly, the proportion of trained epidemiologists in most program areas increased from 2004 to 2006: infectious diseases (19%), oral health...
FIGURE 2 ● Percentage of state health departments reporting substantial to full epidemiology and surveillance capacity, by program area and ESPH—Epidemiology Capacity Assessments, 2001, 2004, and 2006

BT indicates bioterrorism; CD, chronic disease; EH, environmental health; ID, infectious diseases; MCH, maternal and child health; OcH, occupational health; OrH, oral health; ESPH, essential services of public health.

(17%), MCH (9%), injury (9%), chronic diseases (7%), and BT (6%); the proportion of trained epidemiologists decreased for environmental health (~5%) and occupational health (~25%).

Most respondents reported increased epidemiology and surveillance capacity. A greater proportion of states reported substantial to full capacity in 2006 than in 2001 in BT (30% increase), MCH (11%), chronic diseases (10%), oral health (6%), injury (7%), and infectious diseases (7%). Capacity declined in environmental health (~2%) and occupational health (~7%) (Figure 2). In all three assessments, respondents reported high capacity in infectious diseases programs, with 96 percent (49/51) reporting substantial to full capacity in 2006. State health departments’ capacity to carry out the four epidemiology-related ESPH increased (Figure 2). The percentage of respondents reporting substantial to full capacity increased from 46 percent in 2001 to 80 percent in 2006 for ESPH 1. Capacity in the other three ESPH were lower and varied more in all three assessments, but in each ESPH, more states reported increased capacity in 2006 than in 2001.

Federal funding for states’ epidemiology programs increased by an average of 9 percent during the three ECAs to 71 percent in 2006. In contrast, state funding decreased by 13 percent since 2001 to an average of 47 percent in the 2006 ECA. The number and proportion of epidemiologists paid with emergency preparedness funds increased from 18 percent (460/2,498) in 2004 to 21 percent (517/2,436) in 2006 (question not included in 2001). More states supported training for their epidemiologists during the preceding 12 months in 2004 (47/50 respondents [94%]) than in 2006 (38/49 respondents [78%]). Responses to questions about organization of epidemiologists in the state health department did not change from 2004 to 2006.

Discussion

Well-trained epidemiologists have been long recognized as vital to an effective and competent public health workforce,26 and Healthy People 2010 specifically called for an “increase in the proportion of tribal, state and local public health agencies that provide or assure comprehensive epidemiology services to support essential public health services”27 (objective 23-14). Monitoring progress toward national workforce objectives like this can only be done through assessments, like the CSTE ECA, carried out at regular intervals and ideally coordinated across national public health professional organizations.

The number of epidemiologists in state health departments increased substantially during the 5 years covered by these three ECAs and has been accompanied by improvements in epidemiology capacity. However, the growth in the number of epidemiologists and epidemiology capacity occurred mainly between the first two assessments followed by a slight decline from 2004 to 2006. Much of the increased support for
epidemiology programs relied on the federal emergency preparedness funding that began in 2001 in response to the terrorist attacks; more than one in five of all epidemiologists in state health departments were funded by preparedness monies in 2006, including more than 85 percent of the epidemiologists working in preparedness and 20 percent in infectious disease. Funding levels for most states’ epidemiology programs did not increase over the three surveys, and some decreased, suggesting that federal emergency preparedness dollars supplanted, rather than augmented, state funds previously allotted to epidemiology as they have in other public health programs. Thus, epidemiology programs and personnel appear highly vulnerable to loss of federal emergency preparedness support because most states would be unable to cover the resulting funding gap.

Despite the growth in epidemiologists and program capacity, State Epidemiologists reported a need for additional personnel. Approximately 3,172 epidemiologists—30 percent more than that reported in the 2006 ECA—are needed to fully staff all the epidemiology programs. This translates into approximately one epidemiologist per 100,000 population served to reach optimal capacity in state health departments. Although this estimate is based on data from all 50 states, it undoubtedly represents a simplistic approach to a complex workforce issue. However, the strong linear correlation between the number of epidemiologists and the state population may support the use of a simple ratio such as this to gauge states’ overall epidemiology capacity and serve as a standard against which state health departments could roughly assess the adequacy of their epidemiology workforce until researchers develop more refined workforce models and estimates of need. Regardless of state population, states that place epidemiologists in an organizational unit have significantly more epidemiologists than do states that separate epidemiologists into programs. Grouping epidemiologists would seem to facilitate interaction and perhaps foster more intra-agency visibility, advocacy, and political influence for epidemiology, ultimately resulting in more epidemiologists.

The proportion of epidemiologists who have a degree, training, or coursework in epidemiology increased with each survey. Because the number of epidemiologists working in state health departments remained stable from the 2004 ECA to the 2006 ECA and there is no evidence of a large-scale departure of epidemiologists between the surveys, we can reasonably assume that these are essentially the same employees but better trained. Improvements in the training and education of epidemiologists may reflect a combination of easier access to the many distance-learning and online epidemiology courses offered through CDC itself or through the national network of continuing education centers such as the CDC-funded Centers for Public Health Preparedness housed at schools of public health.

Improvement in program capacity varied widely from the first to the most recent ECA. The full capacity in infectious diseases and BT reported by almost all states is not surprising because control of infectious diseases has a strong tradition in public health and because there has been a sustained federal mandate to hire BT epidemiologists with emergency preparedness funding. In fact, BT programs increased most rapidly in the number of epidemiologists and capacity during the three surveys, confirming that sustained investment can quickly grow public health infrastructure. Capacity was moderate and growth was more modest in chronic diseases and MCH, neither of which appears to have gained capacity secondary to emergency preparedness funding. The need for additional resources in these program areas is critical since the leading causes of death in the United States are chronic diseases (which will increase as the population ages) and some public health problems characterized by the most years of potential life lost are in the MCH area. In environmental health, oral health, occupational health, and injury, already low numbers of epidemiologists and low capacity decreased further during the 5-year survey period. Given that capacity in most epidemiology program areas remained either static or decreased, the potential for crossover applicability of federal preparedness funds to broadly enhance epidemiology in the public health system appears to have been only narrowly realized.

Our study also highlights potential limitations in assessing program capacity through worker enumeration. Reported high capacity was not significantly related to the number of epidemiologists, whereas low capacity programs, such as injury, environmental health, oral health, and occupational health, were significantly related to the number of epidemiologists when analyzed by individual capacity quartiles. This may indicate that, for weaker programs, additional epidemiologists can go a long way toward improving capacity. Conversely, full capacity areas, such as BT and infectious diseases, appear to benefit little, if at all, from additional epidemiologists.

Reported improvements in states’ ability to carry out epidemiology-related ESPH also indicate enhanced capacity. However, even with progress, ESPH 9 and ESPH 10 continue to be characterized by inadequate capacity in more than half of the states—with a mere 12 percent of the states reporting substantial or full capacity for ESPH 10. The lack of a statistically significant relation between ESPH and the number of epidemiologists may point out the inherent weakness of this variable as a measure of capacity or may indicate that the ability to
carry out epidemiology-related ESPH is independent of the number of epidemiologists on staff.

Our study is subject to several limitations. Forty-one respondents completed the 2001 ECA survey compared with 51 in 2004 and in 2006, affecting comparability of results. Methods used by states to assess reported capacity and estimated need may have varied, although CSTE provided worksheets with the 2006 survey in an attempt to standardize methodology and minimize variability. Epidemiologists enumerated in the ECA may have been misclassified and, therefore, subject to overestimation or underestimation of actual numbers; however, we attempted to minimize this by collecting detailed information about the training and educational background of all epidemiologists.

In conclusion, we believe this study more accurately characterizes epidemiology capacity over time than was previously possible. The Council of State and Territorial Epidemiologists’ ECA provides a model for other national public health organizations interested in tracking changes in the size and composition of the workforce, estimating personnel needs, and assessing program capacity. Measurement of workforce capacity is an area of increasing focus by health system researchers over the past several years. Our capacity measures and estimate of need for epidemiologists are a starting point for future research, which should concentrate on developing conceptual models for measuring capacity that account for multiple variables such as available data, resources, systems and relationships, and for which number of epidemiologists would be just one input. Modeling has been used for years to assess capacity in the health sector and help project workforce needs in health professions such as nursing, but this methodology has only been applied in a limited way to public health workforce capacity. Recently, CSTE and CDC initiated a “Defining Epidemiology Capacity” project to develop a model for epidemiology workforce capacity, which will guide data collection for future ECA and create an agenda for future research priorities on public health workforce.

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