Core Courses in Public Health Laboratory Science and Practice: Findings from 2006 and 2011 Surveys

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ABSTRACT

Objectives. We identified academic training courses or topics most important to the careers of U.S. public health, environmental, and agricultural laboratory (PHEAL) scientist-managers and directors, and determined what portions of the national PHEAL workforce completed these courses.

Methods. We conducted electronic national surveys in 2006 and 2011, and analyzed data using numerical ranking, Chi-square tests comparing rates, and Spearman's formula measuring rank correlation.

Results. In 2006, 40 of 50 PHEAL directors identified 56 course topics as either important, useful, or not needed for someone in their position. These course topics were then ranked to provide a list of 31 core courses. In 2011, 1,659 of approximately 5,555 PHEAL scientific and technical staff, using a subset of 25 core courses, evidenced higher core course completion rates associated with higher-level job classification, advanced academic degree, and age. The 2011 survey showed that 287 PHEAL scientist-managers and directors, on average, completed 37.7% (n=5/13) of leadership/managerial core courses and 51.7% (n=6/12) of scientific core courses. For 1,659 laboratorians in all scientific and technical classifications, core-subject completion rates were higher in local laboratories (42.8%, n=11/25) than in state (36.0%, n=9/25), federal (34.4%, n=9/25), and university (31.2%, n=8/25) laboratories.

Conclusions. There is a definable range of scientific, leadership, and managerial core courses needed by PHEAL scientist-managers and directors to function effectively in their positions. Potential PHEAL scientist-managers and directors need greater and continuing access to these courses, and academic and practice entities supporting development of this workforce should adopt curricula and core competencies aligned with these course topics.

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Employees working in public health, environmental, and agricultural laboratories (PHEALs) comprise only 1% (5,555[1]/448,254[2] full-time equivalent workers) of the U.S. public health workforce. However, the laboratories they staff play a critical role in protecting the public by monitoring and identifying newly emerging infections, sporadic outbreaks, hazardous chemical exposures, treatable hereditary disorders, environmental hazards, and effects of natural disasters.

A well-trained cadre of PHEAL scientist-managers and directors is required to administer these laboratories. A scientist-manager is a laboratory scientist possessing an earned doctoral degree with scientific and supervisory work experience who develops, oversees, and consults on a wide range of laboratory testing and services in a particular field (e.g., environmental chemistry, microbiology, or newborn screening). A director is a scientist-manager with sufficient experience and professional certification as required to meet federal and state qualifications to direct a laboratory in one or more laboratory specialties.[3]

Until recently, a scientific or professional doctoral degree was considered sufficient to qualify someone for a leadership position in a PHEAL. While such a degree may provide the basic scientific knowledge to direct one or more scientific specialty areas in a research or diagnostic laboratory, PHEAL scientist-managers and directors require an education that prepares them to effectively carry out a much broader range of complex professional duties that include disease prevention, control, and surveillance; integrated data management; environmental health and protection; food safety; outbreak investigation; laboratory law and regulations development; public policy development; public health preparedness and response; training and education; and partnerships and communications.[4]

Despite an increasing demand for qualified PHEAL leaders, an impending shortage of laboratory professionals has been anticipated for more than a decade.[1,5–7] The need for more broadly educated PHEAL leaders combined with an anticipated shortage of these professionals makes it especially important to maximize return on the limited educational resources available to address this issue. In 2002, the Institute of Medicine's Committee on Assuring the Health of the Public in the 21st Century made recommendations that stressed integrated disciplinary learning and curricula based on core competencies.[7] In 2008, the Robert Wood Johnson Foundation (RWJF) issued a report on a strategic planning process and plan to ensure competent, sustainable public health laboratory (PHL) leadership, which highlighted the importance of both core academic and professional courses in PHL science and practice.[8]

As a follow-up to the RWJF plan, the field of PHL science and practice needs to identify workplace competencies and core courses to help students and mid-career scientists attain the competency-based knowledge and training needed to qualify as PHEAL scientist-managers and directors. PHEAL workplace competencies are currently being developed under a joint project of the Centers for Disease Control and Prevention (CDC) and the Association of Public Health Laboratories (APHL) (Personal communication, Catherine Johnson, APHL, National Center for Public Health Laboratory Leadership, March 2013).

In this article, we identify courses or course topics believed to be most important to individuals who are working toward effective leadership positions in PHEALs in the U.S. and discuss the implications of these findings as they relate to workplace competencies and the future education of these scientists. Throughout this article, the terms "course" or "core course" indicate an academic course or training topic and are not intended to identify an actual current or future course taught in any specific educational or training entity.

METHODS

This study presents findings from two separate surveys—a 2006 survey distributed to public health and environmental laboratory directors and a 2011 survey distributed to all PHEAL scientific and technical staff.

2006 survey

As part of a year-long National Public Health Leadership Institute project at the University of North Carolina, Chapel Hill, a team of four current PHL directors developed and refined by consensus a comprehensive list of 56 courses[9] presumed to be important to functioning effectively as a PHEAL scientist-manager or director. The 56 course topics were developed into survey items and submitted to APHL to be formatted into an electronic questionnaire using SPSS® MrInterview™.[10] The key designated respondents were the 50 state public health and environmental laboratory directors in the U.S. in the spring of 2006. The survey participants were asked to rank the 56 course topics as "important," "useful," or "not needed" based on their past experience and professional opinion. Survey results were collected from May 6 through June 3, 2006, with an electronic reminder to nonresponders issued in mid-May 2006. Responses to each of the 56 items were tallied electronically.

2011 survey

The respondents to the 2011 survey were approximately 5,555[1] PHEAL scientific and technical employees of the 105 laboratories comprising the APHL membership in February 2011. These respondents consisted of laboratories in all 50 states, the District of Columbia, and Puerto Rico, including 50 state PHLs, 41 local (municipal and county) PHLs, eight environmental laboratories, and six agricultural laboratories. While the total number of PHLs in the U.S. is unknown, the PHEALs of interest in this study number fewer than 150, and the APHL umbrella accounted for more than 90% of the employees in these laboratories (Personal communication, Scott Becker, APHL, February 2012). This 2011 follow-up survey[11] asked employees whether they had completed academic courses in 25 of 31 core subjects identified from the 2006 survey.

After pilot testing the survey instrument using SPSS MrInterview[12] with four directors and 13 workers in several job classifications, APHL distributed this electronic survey to 105 PHEAL directors, with instructions to disseminate the survey to all scientific and technical employees in their laboratories. MrInterview was the standard interview tool used by APHL at the time this project was undertaken. Data collection took place from April to July 2011. Throughout this period, APHL staff followed up with e-mails and telephone calls to encourage responses. Data were compiled using Microsoft® Excel.

Analysis

A core course was defined as one meeting one of two cutoffs: (*1*) ranked as important by ≥50% of total respondents in the 2006 survey or (*2*) ranked as important by ≥45% of total respondents plus ranked as useful by ≥45% of total respondents in the 2006 survey.

Data from the 2011 survey were compiled for analysis by standard job classifications (i.e., laboratory aide/assistant, laboratory technician, bench scientist, scientist supervisor, scientist manager, developmental scientist, and director);[3] laboratory type (i.e., public health, environmental, agricultural, and university); highest academic degree earned (i.e., high school, associate, bachelor's, master's, academic doctorate [doctor of philosophy (PhD), doctor of public health (DrPH/DPH), and doctor of science (ScD/DSc)], and professional doctorate [doctor of medicine, doctor of osteopathic medicine, doctor of veterinary medicine, and doctor of dental surgery]); and employee age group (i.e., ≤30, 31–40, 41–50, 51–60, and ≥61 years of age).

Each of the 31 core courses identified using the 2006 survey was assigned a numerical ranking based on its importance given as a percentage. Core courses with the same percentage received the same numerical ranking. Similarly, each of the 25 core courses employed in the 2011 survey was assigned a "completion rate" numerical ranking based on its completion rate ranking given as a percentage. Simple linear correlation between rankings of core subject "importance" and core-course "completion rate" was determined using Spearman's formula[13] for rank correlation. Chi-square tests to calculate the significance of differences in core-course completion rates between scientific and professional degree and among age cohorts were performed for equality of two independent proportions.

RESULTS

In 2006, 40 of 50 (80%) state PHEAL directors completed the survey. The 2011 survey was completed by 1,659 of approximately 5,555 (29.8%) PHEAL employees. Thirty-one of 56 courses (55%) met the definition of a core course and are listed by course type and importance by numerical rank and percentage in Table 1. Of 31 core courses, 14 (45%) were leadership/managerial and the remaining 17 (55%) were scientific. The four top-ranked core courses by importance were all in the leadership/managerial category, as were five of the next 10 core courses.

Core course completion rates and numerical rankings for 25 core subjects reported by 1,659 technical and professional PHEAL employees in 2011 are also presented in Table 1. The average completion rate of 25 core courses by all 1,659 laboratorians was 33.7% (1,659/4,923 core courses completed) (data not shown).

For 1,659 respondents, the average numbers of core courses completed per laboratorian are presented by age cohort, education, job classification, and laboratory type in Table 2. Higher numbers of completed core courses were associated with higher-level job classification, possession of an advanced degree, and increasing employee age. Laboratorians with master's degrees completed as many or more core courses as those with scientific doctorates. On average, more core courses were completed by laboratorians in local laboratories than in other laboratory types. The mean number of core courses completed by laboratorians ≥51 years of age (range: 9.5–9.8) was significantly higher than the number of core courses completed by laboratorians ≤50 years of age (range: 8.8–9.3) ($\chi^2=0.002$, $p<0.05$), although the difference between core courses completed by 41- to 50-year-olds (9.0) and 31- to 40-year-olds (9.3) was not statistically significant ($\chi^2=0.04$, $p>0.05$). The difference in the mean number of core courses

Table 1. Rankings by importance of 31 course subjects core to the education and training of PHEAL scientists in the U.S.: 2006 APHL survey (*n*=40 laboratory directors) and 2011 APHL survey (*n*=1,659 laboratorians)

Core course	*Course type*	*Importance numerical ranking*[a]	*Importance ranking as a percent*	*Completion rate numerical ranking*	*Completion ranking as a percent*
Laboratory quality assurance, mission evaluation, and government regulations	L	1	95	4	53.2
Public health laboratory management	M	2	93	22	9.9
Laboratory safety and security	L	3	85	6	50.0
Writing grant proposals	M	4	80	17	23.2
Molecular biology and molecular diagnostics	S	4	80	9	42.6
Leadership	L	6	78	12	37.2
Principles of management	M	7	75	20	13.5
Epidemiology	S	7	75	18	20.3
Clinical/medical/pathogenic bacteriology	S	9	74	5	53.0
Immunology	S	10	73	3	55.3
Virology	S	10	73	10	39.5
Ethics	L	12	70	8	46.0
Emergency preparedness and response	L	12	70	10	37.8
Surveillance systems in public health	M	14	68	24	8.7
Medical virology	S	15	65	NA[b]	NA[b]
Environmental/water microbiology	S	16	64	16	25.9
Laboratory design/workflow/operations	M	17	63	19	17.6
Politics/partners/public relations in government	L	18	60	23	9.7
Information management/communications	M	19	57	21	12.5
Epidemiology of infectious diseases	S	20	55	NA[b]	NA[b]
Writing for scientific publications	S	20	55	NA[b]	NA[b]
Public health administration	M	20	55	NA[b]	NA[b]
Doctoral-level basic/applied research	S	23	53	NA[b]	NA[b]
Environmental science/health	S	24	51	13	37.0
Biochemistry	S	24	51	1	68.4
Epidemiology of food/waterborne diseases	S	26	50	NA[b]	NA[b]
Statistics/biostatistics	S	26	50	14	30.9
Public health law	M	28	48	25	6.9
Laboratory instrumentation/instrumental analysis	S	29	45	7	46.9
Bacteriology laboratory	S	29	45	2	61.7
Virology laboratory	S	29	45	15	28.9

[a]Core courses were ranked by importance, with courses ranked 1–26 considered "important" by ≥50% of survey respondents, and courses ranked 28–29 considered "important" by ≥45% of survey respondents and "useful" by ≥45% of survey respondents.

[b]Completion data were not collected for these core courses in the 2011 survey.

PHEAL = public health, environmental, and agricultural laboratory

APHL = Association of Public Health Laboratories

L = leadership

M = managerial

S = scientific

NA = not available

completed by individuals with a scientific doctorate (11.4) and those with a professional doctorate (13.4) was not statistically significant (χ^2=0.08, p>0.05).

Completion rates for 25 core courses completed by 287 laboratory scientist-managers and directors are presented in Table 3. Average core course completion rate by job classification for 13 leadership/managerial courses (total managerial and leadership subjects completed divided by total individuals in job classification) increased in going from scientist-manager (4.4) to deputy director (5.4) and laboratory director (6.2). The average core course completion rate by job classification for 12 scientific courses (total scientific courses completed divided by total individuals in job classification) also increased in going from scientist-manager (5.3) to deputy director (5.7) and laboratory director (7.9).

On average, fewer leadership/managerial core

Table 2. Overall completion rate for 25 course subjects core to the education and training of PHEAL scientists in the U.S.: 2011 APHL survey (*n*=1,659 laboratorians)

Characteristic	*Mean number of courses completed*	*Total courses/number of laboratorians*
Age (in years)		
≤30	8.8	2,026/231
31–40	9.3	3,522/380
41–50	9.0	3,421/381
51–60	9.5	4,718/495
≥61	9.8	1,657/170
All ages	9.3	15,348/1,657[a]
Education		
High school	3.2	246/76
Associate degree	7.2	565/78
Bachelor's degree	8.8	8,969/1,022
Master's degree	11.5	3,826/332
Scientific doctorate[b]	11.4	1,563/137
Professional doctorate[c]	13.4	188/14
All education levels	9.3	15,357/1,659
Job classification[d]		
Laboratory assistant	3.7	287/77
Laboratory technician	7.2	1,272/178
Bench scientist	9.0	6,972/779
Scientist supervisor	9.9	3,089/313
Scientist-manager	11.2	2,133/190
Developmental scientist	11.8	294/25
Agricultural/environmental deputy director	10.2	92/9
Public health deputy director	14.9	538/36
Agricultural/environmental laboratory director	10.2	92/9
Public health laboratory director	15.6	766/49
All classifications	9.3	15,357/1,659
Laboratory type		
University	7.8	791/101
Environmental	7.8	2,947/376
Agricultural	9.0	234/26
Public health	9.5	13,680/1,432
Federal	8.6	172/20
State	9.0	8,479/937
Local	10.6	1,071/101

[a]Ages not provided by two respondents

[b]Doctor of philosophy, doctor of science, or doctor of public health

[c]Doctor of medicine, doctor of osteopathy, doctor of veterinary medicine, or doctor of dental surgery

[d]Adapted from: DeBoy J, Luedtke P, Warren N, Wichman M. Basic personnel tools to help ensure a future public health and environmental laboratory workforce. Public Health Rep 2010;125 Suppl 2:96-101.

PHEAL = public health, environmental, and agricultural laboratory

APHL = Association of Public Health Laboratories

courses (4.9 of 13) were completed than scientific core courses (6.2 of 12); however, this difference was not statistically significant ($\chi^2=0.04$, $p>0.05$). Combining completion data for all 25 managerial and scientific core courses from all 287 laboratory scientist-managers, deputy directors, and directors together yielded an overall average core course completion rate of 44.4% (11.1 of 25 courses) per individual, with weighted average completion rates for individual core courses ranging from 10.8% to 79.1% (Table 3).

Spearman's formula for rank correlation produced a moderately negative correlation ($r_{rank} = -0.58$) between core course numerical rankings of importance percentage and numerical rankings of core-course completion rate (Table 1) for the 25 core subjects with completion rates.

Table 3. Course completion rates for 13 leadership/managerial and 12 scientific course subjects core to the education and training of PHEAL scientists in the U.S.: 2011 APHL survey

Core courses	*Scientist-manager (n=190) Percent*	*Deputy director (n=39) Percent*	*Laboratory director (n=58) Percent*	*Weighted average (n=287) Percent*
Leadership/managerial				
Laboratory quality assurance, mission evaluation, and government regulations	56.3	51.3	58.6	56.1
Public health laboratory management	25.8	28.2	36.2	28.2
Laboratory safety and security	61.1	48.7	69.0	61.0
Writing grant proposals	34.7	61.5	51.7	41.8
Leadership	63.7	71.8	75.9	67.3
Principles of management	24.7	41.0	43.1	30.7
Ethics	54.7	69.2	51.7	56.1
Emergency preparedness and response	46.3	59.0	70.7	53.0
Surveillance systems in public health	13.2	25.6	58.6	24.0
Laboratory design/workflow operations	22.1	25.6	34.5	25.1
Politics/partners/public relations in government	13.2	23.1	27.6	17.4
Information management/communications	13.2	30.8	20.7	17.1
Public health law	7.9	7.7	22.4	10.8
Total leadership managerial courses completed, *N* (percent)	830 (33.6)	212 (41.8)	360 (47.7)	1,402 (38.0)
Average number of 13 leadership managerial courses completed per person	4.4	5.4	6.2	4.9
Scientific				
Molecular biology and molecular diagnostics	42.6	41.0	58.6	45.6
Epidemiology	30.0	38.5	46.6	34.5
Clinical/medical/pathogenic bacteriology	56.8	64.1	79.3	62.4
Immunology	58.9	46.2	75.9	60.6
Virology	40.0	43.6	72.4	47.0
Environmental/water microbiology	30.5	35.9	37.9	32.8
Environmental science/environmental health	42.6	41.0	51.7	44.3
Biochemistry	77.9	64.1	93.1	79.1
Statistics/biostatistics	43.2	56.4	70.7	50.5
Laboratory instrumentation/instrumental analysis	56.3	56.4	55.2	56.1
Bacteriology laboratory	70.0	48.7	86.2	70.4
Virology laboratory	31.6	35.9	60.3	38.0
Total scientific core courses completed, *N* (percent)	1,013 (44.4)	223 (47.6)	457 (65.7)	1,783 (51.8)
Average number of 12 scientific courses completed per person	5.3	5.7	7.9	6.2
Average number of 25 courses (13 leadership/managerial + 12 scientific) completed per person	9.7	11.2	14.1	11.1

PHEAL = public health, environmental, and agricultural laboratory

APHL = Association of Public Health Laboratories

DISCUSSION

Directors of PHEALs must provide leadership in public health emergencies, address resource shortages, formulate and evaluate policy, and actively engage in the politics of governmental bureaucracies. These varied demands are fully reflected in the 31 core courses identified in this article.

The dual set of qualifications, being an active scientist and leader/manager, can be a barrier to ensuring an adequate pool of qualified PHEAL scientist-managers and directors. Individuals seeking these dual qualifications must be encouraged through insuring their access to the 31 core courses identified in this article, which will help maximize return on investment given limited educational resources. Consequently, the findings of low completion rates for many of these core courses by scientist-managers and directors is disconcerting and may call for major new emphases in training current and future PHEAL leaders.

Core courses

The 2006 survey showed that sitting PHEAL directors placed more importance on courses, skills, and experience related to management and leadership than on scientific knowledge and experience. This finding is supported by earlier reports that the average directors of governmental laboratories spend most of their time leading and managing a scientific organization rather than acting as a laboratory scientist.[4,14] This finding is especially true in large PHEALs in which leadership and managerial responsibilities are paramount to a director's success, and doctoral-level scientist-managers answering to the director serve as chief scientists in various scientific specialties.

However, data from the 2006 survey also show that laboratory directors must continue to possess a strong background in laboratory science as a basic qualification for their positions. PHEAL scientist-managers and directors still view themselves first as scientists and have advanced to their current positions by being productive and successful in that realm. This perception is important because they must be seen and respected as scientifically competent by both their employees and the communities they serve before they can provide the leadership and managerial expertise associated with operating a complex scientific organization.

The continuing need for this scientific background is reflected in high rankings of importance given to molecular biology, epidemiology, bacteriology, immunology, and virology. The list of useful courses identified from the 2006 survey revealed that while state laboratory directors believe that knowledge of other fields (e.g., toxicology, mycology, and medical genetics) may be useful to individuals in their positions, they were seldom important in those positions. At the same time, a list of unnecessary courses, also identified from the 2006 survey, revealed that PHEAL directors were least willing to complete advanced coursework in fields in which they were not personally involved on a routine basis.[9]

Course importance and completion rate

The 2011 survey showed that most current PHEAL scientist-managers and directors have not completed a majority of the 25 core courses, which runs contrary to these same leaders' belief in the importance of these subjects. This dissonance is supported by the moderately negative rank correlation (-0.58) between the completion rankings of 25 core courses and their importance rankings. While this finding may be due in part to individuals not appreciating some core courses until they are needed, we believe most of this dissonance is related to course availability and access. Most scientific doctoral degrees obtained by PHEAL scientist-managers and directors emphasize science and allow for core courses such as biochemistry, bacteriology, or immunology to be easily accessed and taken. However, these doctoral programs may provide little time or opportunity to pursue such core courses as public health law, surveillance systems in public health, or laboratory management. In addition, mid-career laboratory leaders, when balancing the day-to-day demands of both professional and personal responsibilities, may find it very difficult to pursue additional coursework.

The finding that the average number of core courses completed generally increased with higher-level job classification and education level was expected. However, the two exceptions must be interpreted with caution due to the small numbers of employees in these subgroups who completed the 2011 survey.

The decreasing core course completion rates by laboratory type, when going from local laboratories to state, federal, environmental, and university laboratories, may reflect a need by the smaller laboratories to employ more broadly and highly cross-trained employees. As laboratories become larger with more employees, as positions become more specialized, and as organizational structures become more hierarchical, it also may become less important for a large laboratory to support having nonscientist-managers and non-directors take many courses core to functioning effectively as a laboratory scientist-manager or director.

The significant difference in core course completion rates between laboratorians aged ≤ 50 years and those aged ≥ 51 years may be attributed to two factors. One factor may be that core courses become more accessible to individuals as they age and climb the career ladder because both the individuals and their laboratories see greater value in supporting the completion of more core courses. Another factor may be that the older age cohort may have obtained a broader graduate education that included more core courses than did the younger cohort.

A similar core course completion rate for laboratorians with a master's degree compared with those with a scientific doctorate may be related to the type of master's degree earned. For example, a professional master's degree (e.g., master of public health, master of business adminstration, or master of public administration) may provide graduates with a greater boost to completion rates for core courses than a master of science or PhD in a scientific specialty. Likewise, the higher core course completion rate for laboratorians with a professional doctorate compared with those with a scientific doctorate may mean the former group had greater access to more core courses during or after their formal education and training.

Educational and training program needs

From 2000 through 2010, only 1.8% (1,341/75,203) of students earned degrees from U.S. schools of public health in the program area of biomedicine (e.g., biomedical and laboratory sciences, microbiology, parasitology, immunology, cancer biology, biochemistry, and pathobiology). In 2010, only 1.3% (77/6,109) of students earned master's degrees in biomedicine.[15]

Within the past 10–15 years, a number of master's-level programs have been established in which students can choose to emphasize public health microbiology or epidemiology with a practicum or capstone project that involves partnering with a PHL in a state or local health department. However, with rare exception,[16] these programs do not provide a primary emphasis on PHL science and practice.

The pool of future PHEAL scientist-managers and directors consists of approximately 5,000 existing scientific and technical PHEAL workers without doctoral degrees and an unknown number of students pursuing doctoral degrees in the biological and chemical sciences. Historically, many PHEAL scientist-managers and directors earned a DrPH or ScD in biomedicine. However, in 2009–2010, only 53 biomedicine students graduated from schools of public health with doctoral degrees,[15] and in 2010, only one of these 53 students earned a DrPH, and none earned an ScD.[14] More specifically, there is currently no doctoral program in PHL science and practice in the U.S., which makes it very difficult to recruit and maintain, let alone expand, the current PHEAL workforce of 529[1] PHEAL scientists with doctoral degrees. To do so, PHEALs must recruit and retain 21 new employees each year with appropriate doctorates in or applicable to PHL science and practice.[17]

Today's limited educational resources and relatively small size of the student population for this specialty area call for only one or two institutions to establish a program in PHL science and practice. Furthermore, currently employed PHEAL scientists are unable or unwilling to leave work for two to four years to pursue a campus-based doctoral degree. These limitations can best be overcome by establishing a doctoral program employing Internet-based distance learning with research performed in the laboratory of the student's current employer. Such a program could fully support the pipeline needs of the entire PHEAL workforce in the U.S. at minimum cost without requiring students to leave jobs and uproot families. Distance learning also would allow such a program to readily employ PHEAL leaders from across the country to prepare the best training materials and serve as part-time faculty and mentors for students. There is currently an effort under the aegis of the APHL to identify a willing academic entity to establish such a joint academic and PHL doctoral program (Personal communication, Brock Neil, APHL Workforce Development Committee, February 2013).

We recognize that the list of core courses presented in this article represents a comprehensive range of scientific, managerial, and leadership knowledge, and it is unlikely that any one individual would complete all of them. However, scientist-managers and directors must have a broad working knowledge and be capable of applying that knowledge if they are to be successful leaders in today's public health climate. The U.S. needs academic institutions that offer master's and doctoral degrees in PHEAL science and practice that maximize return on educational investment by successfully merging PHEAL science, management, and leadership components. These core courses also should be emphasized in predoctoral traineeships and postdoctoral fellowships in PHEAL science and practice. However, existing pre- and postdoctoral training opportuinities for PHL scientists have emphasized the laboratory sciences while mostly excluding management and leadership.

In addition, these same core courses will prove useful when looking for vehicles to help laboratorians acquire workplace competencies. The ongoing national project to develop workplace competencies for public health laboratorians is developing a dozen domains.[9] The 31 core courses identified in this article align closely with 10 of the 12 competency domains. Four of these 10 domains cover scientific discipline-specific laboratory practices (i.e., general laboratory science, chemical sciences, microbiological sciences, and bioinformatics), and six domains cover discipline cross-cutting laboratory practices (i.e., communications, informatics, management and leadership, research, safety and security, and surveillance).

Core courses and competencies also provide important building blocks for creating PHEAL career paths or ladders. As presented elsewhere,[3] PHEAL career ladders should be based on levels of education (i.e., high school diploma or general educational diploma through doctoral degree), supervision requirements, experience, and other promotional criteria that depend in large part on core coursework and workplace competencies.

Bringing academic institutions, PHEAL competency-based core courses, workplace competencies, and field-based PHEAL scientist-managers and directors together should be an important objective if academic and fellowship programs are to prove effective in recruiting, educating, and training an adequate pool of competent future leaders in the field of PHEAL science and practice.

Study limitations

The findings in this study were subject to several limitations. First, the data on course importance and course completions were self-assessed and, therefore, subject to personal bias. Second, the response rate for the 2006 survey was 80%, and it's possible that responding laboratory directors differed in a systematic way from nonresponding laboratory directors. Likewise, the response rate to the 2011 survey was 29%, and responding PHEAL workers may have differed in a systematic way from nonresponding workers. For example, 22 of 105 laboratories that did not provide respondents in the 2011 survey were mostly local public health (n=11), environmental (n=4), or agricultural (n=4) laboratories. Data may have been skewed toward state PHLs, as those laboratories' employees comprised a majority of respondents in both surveys. Although response rates for survey populations involving thousands of possible respondents often achieve response rates of 25%–40%, such low response rates reduce the ability to fully generalize or accurately interpret survey results. Third, because no statistical weights were developed to account for nonresponding laboratorians, the results of the Chi-square tests performed on comparisons of course completion rates among various age cohorts must be reviewed with caution. Data obtained from the small numbers of agricultural and university laboratories must be interpreted with particular caution.

CONCLUSIONS

Thirty-one scientific and leadership/managerial core courses were identified that may provide current and future PHEAL scientist-managers and directors with the knowledge and training needed to function effectively in their positions. PHEAL directors did not identify advanced specialty courses as important if the knowledge they provided was not routinely used by those directors. There was a moderately negative correlation between the rankings of 25 core courses by importance and completion rates. Although completion rates for these core courses generally increased with higher-level job classification, higher academic degree, and employee age, a notable educational weakness among current laboratorians with leadership roles in PHEALs is that they completed, on average, fewer than half of 25 core courses.

There is currently no doctoral program in PHL science and practice in the U.S. In addition, PhD programs in the biological and chemical sciences provide little or no access to management/leadership courses and training needed by PHEAL scientist-managers and directors. These limitations make it difficult to maintain or expand this workforce. Strategies are needed to encourage current and future PHEAL leaders to complete more of these core courses, to encourage academic institutions offering programs and degrees in PHL science and practice to adopt curricula that emphasize these core courses, and to encourage the use of these core courses as vehicles for laboratorians at PHEALs to acquire a wide range of workplace competencies.

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