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Modernizing public health data systems and workforce capacity: The Centers for Disease Control and Prevention's Public Health Informatics Fellowship Program (PHIFP)

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Abstract

Context: The COVID-19 pandemic exposed governmental public health's outdated information technology and insufficient data science and informatics workforce capacity. The Centers for Disease Control and Prevention (CDC) Public Health Informatics Fellowship Program (PHIFP) is well positioned to strengthen public health data science and informatics workforce capacity.

Program: Established in 1996, PHIFP is a two-year, full-time, on-the-job training program. PHIFP includes a didactic curriculum, applied learning through informatics projects completed at the assigned host site, short-term technical assistance projects, and a final capstone project.

Evaluation: Fellows have learned from and bolstered host site informatics capacity through development or enhancement of information systems, evaluations, data integration, data visualization, and analysis. Among recent graduates, 54% are employed at CDC and 16% are employed at other public health organizations, including local health departments.

Discussion: Fellowships such as PHIFP, which recruit and train promising scientists in public health informatics, are important components of efforts to strengthen public health workforce capacity.

Keywords

CDC; informatics; public health; fellowship; workforce

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INTRODUCTION

The vision for Public Health 3.0, a framework for public health in the 21st century, is supported by a foundation of adept collection and management of timely and actionable data.¹ The COVID-19 pandemic starkly exposed the importance of this foundation and the need for public health professionals to capture, evaluate, manage, analyze, and apply existing and novel — and increasingly complex — data for public health action.² However, largely attributable to chronic underinvestment, public health agencies often rely on outdated information technology, might have brittle and siloed data systems, and can have insufficient data science and informatics capacity.^{3,4} Data modernization that ensures interoperability among data systems, promotes seamless data reporting, enables bi-directional data sharing, and supports advanced analytics^{5,6} is urgently needed.

The U.S. Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC), and Council of State and Territorial Epidemiologists (CSTE) have recognized that data modernization relies on a public health workforce that is well trained in data-related disciplines.^{3,5–7} However, substantial workforce capacity gaps exist. As of 2021, approximately 30% of public health department staff reported data-based training needs, including identifying appropriate data sources and collecting valid data.⁸ Among needed data-related disciplines, public health informatics is particularly important. Public health informatics is the systematic application of information, computer science, and technology to public health practice, research, and learning.⁹ Availability of training in applied public health informatics is crucial for development of a public health workforce capable of data modernization.

For nearly 30 years, CDC has hosted a competitive, on-the-job, applied fellowship in public health informatics. To share this training model with others who are invested in public health informatics workforce development, we describe CDC's Public Health Informatics Fellowship Program (PHIFP) and summarize fellows' characteristics, projects, and contributions to pressing public health problems, with a focus on the past five years.

Program Description

Established in 1996, PHIFP provides fellows with two years of applied on-the-job training to build informatics skills. As federal employees in temporary training roles, fellows are placed in learning assignments (referred to as host sites) across CDC, other federal agencies, or state and local public health departments. Supervisors and mentors at host sites play a crucial role in the fellows' experiences and provide project-based experiential learning opportunities. PHIFP fellows, informally referred to as CDC's Data Detectives, train using a competency- and performance-based curriculum that emphasizes a holistic and systems-thinking approach to solve high-priority public health informatics challenges.

Through an annual, competitive application process, PHIFP accepts early- to mid-career candidates with master's or doctoral degrees in disciplines such as public health informatics, biomedical informatics, information sciences, data and computer science, statistics, and epidemiology. Candidates are selected for interviews with participating host sites. Candidates are then matched with host sites based on candidates' and host site supervisors'

preferences and to meet the informatics and data science needs of participating host sites and CDC. Application process details are available at <https://www.cdc.gov/phifp>.

PHIFP consists of four core components as follows: a classroom- and webinar-based didactic curriculum; informatics and data science projects completed at the host site; short-term technical assistance projects completed outside of the host site (i.e., Informatics-Aids or Info-Aids); and a fellow-led capstone project in the final year of the fellowship.

Didactic curriculum

During orientation and bi-weekly didactic sessions, PHIFP program staff and subject matter experts teach informatics, data science, and public health topics. These topics include (but are not limited to) data analysis and visualization, information system evaluation, written communication and scientific writing, health data interoperability standards, and project management. Fellows learn the programming languages R and Python, and also learn Health Level 7 (HL7) Fast Healthcare Interoperability Resource (FHIR) interoperability specifications for exchanging electronic health data among clinical and public health entities. Those who wish to deepen their knowledge can pursue additional courses and just-in-time self-study through massive open online course platforms. In addition, fellows are enrolled in CDC's Data Science Upskilling (DSU) program. DSU provides tailored project-based performance support and access to additional intensive data science and computing training.¹⁰

The curriculum is competency based. To define the competencies, PHIFP staff identified applied knowledge and skills required for public health informaticians. Applying defined competencies in the curriculum design facilitates career growth in areas identified as crucial to the field.¹¹ Core PHIFP competency domains include: analysis, assessment, and evaluation; communication; public health informatics sciences; and health systems change. The PHIFP team and education specialist also incorporate broader models, such as HHS competencies and the Public Health Foundation Core Competencies for Public Health Professionals,^{12,13} and principles of health equity, diversity, equity, and inclusion. Curricula planning is guided by the Dreyfus Model of Skill Acquisition and integrated with the fellowship using the Introduce-Reinforce-Master-Assess (IRMA) model.^{14,15}

Role of host sites and host site projects

Fellows spend most of their time engaged in applied learning on projects assigned by their host site supervisors and mentors. Host site supervisors and mentors apply to participate in PHIFP as a host site for a fellow. Within their application, prospective host sites propose one or more projects that address their informatics needs. At host sites that are matched with a fellow, the fellows work on these projects and additional host site projects during PHIFP. Projects often require creative solutions to complex public health data and information system challenges. By completing host site projects, fellows learn and directly apply their expertise and bolster the informatics capacity at the host site. Host site projects provide opportunities for fellows to learn to work effectively in multidisciplinary public health settings. Host site supervisors and mentors provide mentorship, guidance, and support to the fellows, and fellows function as integral host site team members. Not only do fellows

learn to collaborate with colleagues in other disciplines (e.g., laboratorians, epidemiologists, program evaluators, public health advisors, policy analysts, computer scientists, and health communications specialists) but often have opportunities to be in the crucial public health informatics role of interpreter or translator between different disciplines.

As part of host site projects, fellows often develop and implement new public health information systems, enhance existing information systems, and conduct informatics evaluations. Specific recent examples of fellows' host site projects include building and refining a data pipeline, establishing a central code repository within a CDC Division to enhance collaboration and reduce duplication of efforts, and developing a real-time country-level data collection system to allow program staff to assess national-level laboratory capacity and readiness to respond to global disease outbreaks.

Informatics-Aids (Info-Aids)

Info-Aids are short-term technical assistance projects that fellows complete for a requesting site that is outside of their host site. Fellows are required to complete at least one Info-Aid during PHIFP. PHIFP staff match fellows to an Info-Aid based on the needs of the requesting site and the fellow's skills. Info-Aids may be requested from within CDC, or by other federal agencies, state or local health departments, nonprofit public health organizations, or international health organizations. During Info-Aids, fellows may collaborate with the requesting organization to evaluate and diagnose informatics problems, identify new and feasible approaches, and support implementation of sustainable solutions. Fellows can practice and apply problem solving and critical thinking skills while collaborating with colleagues from multiple public health disciplines to enhance the requesting organization's informatics and data science capacity.

Recent Info-Aid projects supported CDC's COVID-19 and Mpox emergency responses and other high-priority public health work. Fellows developed informatics applications or data systems to enhance monitoring (e.g., of COVID-19 vaccine distribution), developed automated processes for data matching and identifying patients at risk for poor clinical outcomes (e.g., maternal morbidity), and established technical specifications and requirements for a data collection system.

Capstone Projects

During their second year of PHIFP, fellows complete a capstone project at their host site. From their work on a capstone project, fellows apply the breadth and depth of their informatics knowledge, skills, and abilities in the design, development, implementation, or evaluation of a complex public health information system or artifact. Although the nature of capstone projects share similarities with academic theses or dissertations, PHIFP capstone projects are largely intended to address and be applied to practical public health challenges encountered by the fellows or host sites.

Capstone projects have increased data systems interoperability, automated data visualization to enhance surveillance, increased data access, promoted data reporting among public health partners with the public, and supported public health and clinical decision-making. Recent examples of capstone projects have included improving public access to CDC's foodborne,

waterborne, and environmental disease data by integrating disparate data into an interactive dashboard and notifying providers of older patient's fall risk by using automated analysis and reporting of data from a health information exchange.

To allow fellows to improve their communication skills and share their contributions to data modernization with a broader audience, graduating fellows give a presentation about their Info-Aids and capstone projects to a CDC-wide audience during well attended internal scientific symposia.

Fellow characteristics and post-PHIFP employment

Since its inception in 1996, PHIFP has graduated 204 fellows (Figure). Through 2020, the annual number of incoming fellows ranged from 4 to 12. Attributable to additional financial resources from CDC's Data Modernization Initiative⁶ and the American Rescue Plan, the number of incoming fellows more than doubled during 2019–2022. In the following sections, we focus specifically on fellows' data during 2019–2023. Because informatics, data science, and public health data needs are rapidly evolving areas, these recent PHIFP data are expected to more accurately reflect current public health informatics needs and challenges at CDC and partnering agencies.

Among the 80 fellows who started the program during 2019–2023 (representing 5 cohorts), 59% had a master's degree as their highest degree and 19% had a PhD or DrPH (Table). Approximately half of the fellows were not U.S. citizens; 26 (58%) of these 45 fellows were citizens of African nations and 13 (29%) were citizens of Asian nations. Overall, 72 fellows were assigned to host sites across CDC, three were assigned to other federal agencies (e.g., the U.S. Food and Drug Administration), and three were assigned to local or state health departments.

Fellows from the 2019–2023 cohorts contributed to 26 peer-reviewed papers related to their CDC activities. The wide-ranging focus of these papers included descriptions or evaluations of informatics solutions, descriptions of outbreak responses, data analyses and cohort studies to support outbreak responses or address public health concerns, program evaluations, and literature reviews of clinical electronic record systems.^{16–41}

Forty fellows started the program during 2022–2023 and are still fellows as of May 1, 2024. Of the 40 fellows who started PHIFP during 2019–2021, 37 (93%) graduated. Of these graduates, 20 (54%) are employed at CDC, six (16%) are employed at other public health organizations, including local health departments, and three (8%) are employed with healthcare organizations. Employment data were not available for eight graduates.

DISCUSSION

For approximately 30 years, CDC's PHIFP has provided public health informatics training and supported public health workforce development. The urgency to modernize public health data has increased the importance of PHIFP and public health informatics training.^{2,3} Not only have PHIFP fellows advanced informatics projects, but many recent graduates are employed at CDC and public health settings. They are strengthening and advancing

diversity of the public health workforce. PHIFP fellows and graduates are well positioned to apply informatics knowledge, innovative solutions, and interdisciplinary approaches to public health challenges.

Applied training is foundational to PHIFP's value. The host site experience, Info-Aids, and capstone projects allow fellows to learn and directly apply knowledge to their projects, apply systems thinking, and develop sophisticated problem-solving skills. This hands-on approach is consistent with evidence-based adult learning principles.⁴² Additionally, host sites and Info-Aid requestors benefit from completion of fellows' projects and increased informatics capacity. This mutually beneficial model might be applicable elsewhere. For instance, academic degree programs in informatics might consider placement of students within local or state health departments for short-term technical assistance. CDC further advances workforce development through support of CSTE's Data Science Team Training (DSTT). DSTT provides opportunities for state and local health departments to address their informatics and data science workforce gaps.⁴³

Public health urgently needs a broad-based enterprise approach to data modernization and interoperable data systems for data exchange.³ Accomplishment of these complex goals will require technical expertise. However, accomplishment of these goals will also likely require cross-discipline collaboration and an informatics workforce trained to collaborate effectively with multidisciplinary and cross-sectoral teams. PHIFP's emphasis on interdisciplinary approaches, multidisciplinary collaborations, and communication is anticipated to prepare fellows and graduates to solve complex informatics challenges within a broader public health context.

The rapidly evolving data landscape necessitates the need to strengthen the data capabilities of the public health workforce.^{2,3} Notably, approximately half of recent PHIFP graduates have remained at CDC and a substantial proportion of other graduates are employed within public health. This retention in public health is particularly important because public health departments are often unable to recruit data scientists and informaticians because of competition from higher-paying jobs in the private sector.³ Public health fellowships, including PHIFP, can serve as robust pathways for recruitment, training, and retention of diverse cadres of highly trained public health professionals. For informaticians, PHIFP provides experiential opportunities to apply their skills to protect health on a population level, improve lives, and prepare for the health threats of tomorrow.

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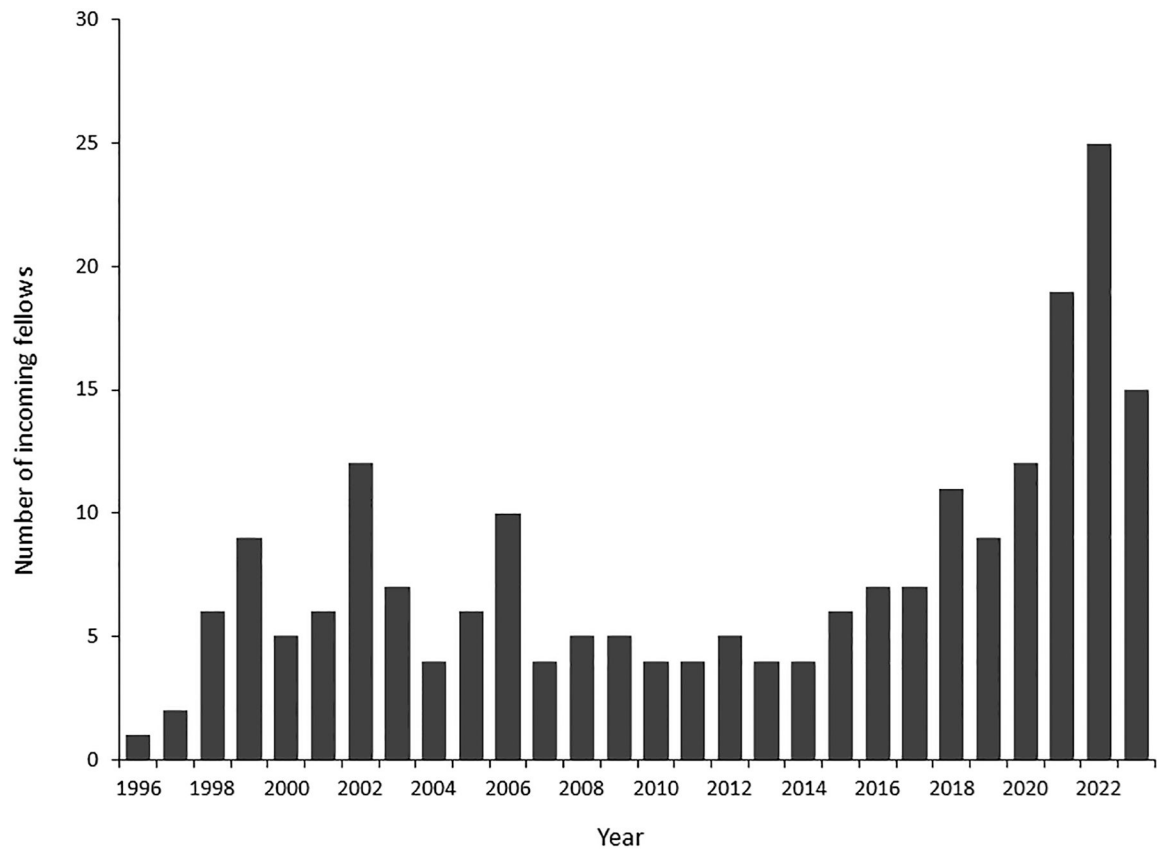
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IMPLICATIONS FOR POLICY & PRACTICE

- PHIFP fellows contribute to public health data modernization; PHIFP graduates are well-poised to advance informatics and data science capacity at CDC and other public health agencies.
- Health informatics training programs and governmental public health agencies can consider PHIFP's applied, practical, and host-site-based approach as a useful model for public health informatics training and capacity building.

**Figure.**

Number of incoming CDC Public Health Informatics Fellowship Program (PHIFP) fellows each year, 1996–2023.

Bar graph of the number of fellows who started each year from 1996 to 2023, where the number of fellows per year increased from approximately 5 to 10 during 1998–2020 to 19 in 2021 and 25 in 2022.

Table.

Characteristics of CDC Public Health Informatics Fellowship Program (PHIFP) fellows at the time of application, 2019–2023.

Overall (N = 80)	
Highest Degree	
Master's ^a	47 (59%)
PhD or DrPH	15 (19%)
PharmD	5 (6%)
MD or other medical degree ^b	13 (16%)
Citizenship	
United States	35 (44%)
Non-United States	45 (56%)
Nigeria	12
Ghana	3
India	3
Cameroon	2
Ethiopia	2
Lebanon	2
Pakistan	2
Philippines	2
South Korea	2
Sri Lanka	2
Uganda	2
Other ^c	11

^a Master's degree includes MPH (n = 20), MSc (n = 15), MS (n = 8), MHE (n = 1), MPA (n = 1), MSPH (n = 1), and ScM (n = 1).

^b MD or other medical degree includes MD (n = 8), MBBS (n = 2), MBChB (n = 2), and DVM (n = 1).

^c Other includes Benin (n = 1), Haiti (n = 1), Honduras (n = 1), Ireland (n = 1), Kazakhstan (n = 1), Kenya (n = 1), Malawi (n = 1), Morocco (n = 1), Nepal (n = 1), Thailand (n = 1), and Zimbabwe (n = 1).