

Heather L Krasna (Orcid ID: 0000-0002-4820-9773)

Katarzyna Czabanowska (Orcid ID: 0000-0002-3934-5589)

Author Biographies

Heather Krasna, MS, is Assistant Dean, Career Services, at Columbia University Mailman School of Public Health, and PhD Candidate, Maastricht University. She has 22 years' experience in career development and her doctoral research focuses on employment outcomes of public health graduates.

Katarzyna Czabanowska, PhD, is Associate professor at the International Health Department, Maastricht University, the Netherlands. She directs the Governance and Leadership in European Public Health programme. Her research focus is on public health workforce development, public health leadership, competence-based education and training, identification of skill gaps between the job market and taught curricula.

Angela Beck, PhD, MPH, is Clinical Assistant Professor in the Department of Health Behavioral and Health Education and Associate Dean of Student Engagement and Practice at the University of Michigan School of Public Health (UMSPH). She is Director of the Region V Public Health Training Center and Behavioral Health Workforce Research Center.

Linda F. Cushman, PhD, Professor of Population and Family Health at Columbia University Mailman School of Public Health, is a sociologist and health researcher with expertise in research design and implementation in underserved, minority communities.

Jonathon P. Leider, PhD, is Senior Lecturer at Division of Health Policy and Management, School of Public Health at the University of Minnesota, Minneapolis MN, and is Director of Evaluation for the Region V Public Health Training Center, and Associate Faculty at the Johns Hopkins Bloomberg School of Public Health.

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Labor Market Competition for Public Health Graduates in the United States: A Comparison of Workforce Taxonomies with Job Postings Before and During the COVID-19 Pandemic

AUTHOR NAMES:

Heather Krasna, MS^{1,2}, hk2778@cumc.columbia.edu, 722 W. 168 St. 1003, New York, NY 10024 USA, +1-212-305-1548

Katarzyna Czabanowska^{2,3}, PhD

Angela Beck⁴, PhD

Linda F. Cushman¹, PhD

Jonathon P. Leider⁵, PhD

Affiliations:

1. Columbia University Mailman School of Public Health, New York, NY USA
2. Department of International Health, School CAPHRI Care and Public Health Research Institute, Faculty of Health Medicine and Life Sciences, Maastricht University, Maastricht, The Netherlands
3. Department of Health Policy Management, Institute of Public Health, Faculty of Health Care, Jagiellonian University, Krakow, Poland
4. Department of Health Behavior and Health Education, University of Michigan School of Public Health, Ann Arbor, MI, USA
5. Division of Health Policy and Management, School of Public Health at the University of Minnesota, Minneapolis MN

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ABSTRACT

A strong public health workforce (PHW) is needed to respond to COVID-19 and public health issues worldwide. However, classifying, enumerating, and planning the PHW is challenging. Existing PHW taxonomies and enumerations focus on the existing workforce, and largely ignore workforce competition for public health graduates (PHGs). Such efforts also do not utilize real time data to assess rapid changes to the employment landscape, like those caused by COVID-19. A job postings analysis can inform workforce planning and educational program design alike. To identify occupations and industries currently seeking PHGs and contrast them with existing taxonomies, authors matched existing PHW taxonomies to standardized occupational classification codes, then compared this with 38,533 coded, US job postings from employers seeking Master's level PHGs from July 1 2019-June 30, 2020. Authors also analyzed 24,516 postings from March 2019-Oct. 2019 and compared them with 24,845 postings from March 2020-Oct. 2020 to assess changing employer demands associated with COVID-19. We also performed schema matching to align various occupational classification systems. Job postings pre-COVID and during COVID show considerable but changing demand for PHGs in the US, with 16-28% of postings outside existing PHW taxonomies, suggesting labor market competition which may compound PHW recruitment and retention challenges.

Keywords: Public health workforce, taxonomy, public health education, job postings, labor market competition

Introduction

Well before the onset of the COVID-19 pandemic, there was a well-documented healthcare workforce shortage.¹ The World Health Organization (WHO) estimated a shortage of 18 million health workers by 2030 to meet the requirements of the Sustainable Development Goals and universal health coverage targets set by the WHO. Several other direction-setting policy documents have been published including the European Action Plan for Strengthening Public Health Capacities and Services,² the WHO's "Comprehensive health labour market framework for universal health coverage"³ and the WHO Global Strategy on Human Resources for Health.⁴ Concerns regarding workforce shortages due to the migration of healthcare professionals,⁵ retirements or attrition of public health (PH) workers,^{6,7} and lack of information

regarding worker supply based on the postgraduate employment outcomes of public health graduates (PHGs)⁸ have become even more urgent due to the COVID-19 pandemic. The WHO Global Strategy recommends gathering workforce data as “global public good to be shared in the public domain.”⁴

Due to the crucial role of disease prevention in responding to and recovering from the COVID-19 pandemic, assessing the public health workforce (PHW) remains critically important. Categorizing and enumerating clinical health professionals such as physicians, nurses, midwives, etc.^{9,10}, while challenging, is generally made simpler by the licensing and registration for these occupations. The PHW is more difficult to define, classify, and enumerate due to a lack of a consistent definition of PH professionals; lack of licensure or certification of PH professionals in most cases; and lack of central registries of these professionals in most countries, with the exception of the United Kingdom¹¹ and Poland, where registration is optional¹².

Even achieving consensus definitions for the PHW is difficult. PH professionals have been defined as “people who are involved in protecting and promoting the collective health of whole or specific populations,”¹³ or those contributing to the Essential Public Health Operations (EPHOs)¹⁴, Essential Public Health Services¹⁵, or Foundational Public Health Services (FPHS)¹⁶, which are different, but related, models describing core functions of public health systems. The workforce is “characterized by its diversity and its complexity and includes people from a wide range of occupational backgrounds.”¹⁷ Not only is this workforce diverse in its occupations, it is diverse in its employment settings or sectors. While the “core” PHW has often been defined as existing within government agencies,^{18,19} it has also been acknowledged that PH work takes place in academia, the voluntary/nongovernmental organization sector (i.e. charities, non-for-profit organizations), healthcare, and corporations (for-profit companies), and that many people contribute to the “wider” PHW, which can include people whose work indirectly contributes to public health efforts^{20,21}

The PHW is undergoing particular strain in the COVID-19 context. Especially in the US, PHW and leadership are being subject to harassment in a highly politicized and polarized COVID-19 response environment. COVID-19 associated burnout is compounding an already-stressed and chronically underfunded workforce that has decreased by approximately 20% since the onset of the Great Recession in 2008^{22,23}. When employers from outside the PHW, who seek to hire candidates with the skills provided by a public health education, offer higher wages or a

better work environment for PHGs, this can entice PHGs away from finding employment in the PHW and can compound PHW shortages, resulting in a workforce crisis.

Existing taxonomies and enumerations use a needs-based approach

Several attempts have been made to define and enumerate the PHW, often beginning with creating PHW taxonomies which include categories of occupations—including job functions or titles—which contribute to EPHOs. In workforce research, occupations are categorized or classified, described and quantified using standardized metrics and surveys designed by expert industrial psychologists or labor market researchers. For example, the International Labour Organization (ILO) uses International Standard Classification of Occupations (ISCO-08) codes^{24(p)}, the US Bureau of Labor Statistics (BLS) uses Standard Occupational Classification (SOC) codes²⁵, and the UK uses its own SOC codes²⁶ to classify occupations. Although such codes can be imperfect—the WHO global strategy advocates that the ILO revise the ISCO “for greater clarity on delineation of health workers and health professions”⁴—mapping the occupations in a workforce taxonomy to these codes allows researchers to use consistent, standard definitions of workers’ roles, and is important for labor market projections and assessment of educational requirements.⁴

To create a PHW taxonomy, many researchers use a needs-based framework—focusing first on the EPHOs and the staff needed to provide them—or use surveys of the existing PHW to determine which occupations exist therein. A recent systematic review article synthesized articles focused on enumerations and definitions of the PHW over a nearly two-decade period.²⁷ This article includes a new proposed taxonomy based on a synthesis of occupation-specific terms and job titles collected from the reviewed articles, which researchers matched to ISCO-08 codes based on their judgements of job titles. Additionally, while several articles within the systematic review list occupations by name, only two sources highlighted in the review specifically focus on PHW occupational taxonomies, one by the University of Michigan/Centers for Disease Control and Prevention (referred to here as “UM”)¹⁹ and one by the Centre for Workforce Intelligence (CfWI) in the United Kingdom.^{18,20}

These workforce taxonomies have primarily been created through a multi-step, “top-down” process, beginning with the high-level definition of EPHOs,^{15,28} followed by a literature review (often including a “job analysis” of job descriptions provided by current PH

professionals), followed by data extraction or qualitative coding, review of key terms by experts, focus groups, and finally pilot testing/surveys of the PHW²⁹; or scoping, literature review, data collection, and stakeholder engagement.¹⁸ The taxonomies generally only include occupations that the researchers defined as contributing to EPHOs, and sometimes define PHW even more narrowly; for example, the UM taxonomy emphasizes occupations in the governmental PHW.

Insufficiencies of current PHW taxonomies

While these taxonomies are an important step in PHW categorization and enumeration, they may leave out relevant occupations due to their focus on the existing PHW and how it is defined. These taxonomies, themselves, also may not be sufficiently robust in describing the landscape of PHW employment because they do not take supply of PHG into account, nor the labor market competition³⁰ for PHG: “partial health workforce policies...designed on the basis of needs-based estimates and focused on training more health workers” are “not sufficient in addressing health worker shortages.”³

New research in the United States indicates that PHG may be increasingly finding employment in the for-profit sector and other fields which may not contribute to EPHOs; assessment of the current PHW and its need for PHG is not enough if it ignores this “leaky pipeline”³¹⁻³⁴ or loss of PHGs to occupations and sections that do not contribute to the EPHOs.

Additionally, the existing taxonomies do not clearly delineate the occupations which require formal education in PH versus those that do not. Workers included in PHW taxonomies can include everyone from medical doctors and scientists, to nurses, to sanitarians, to typists and office clerks because they are involved in, or support, the delivery of public health services and protections. To ensure we can assure “a competent public health workforce,”³⁵ it is essential to know how many individuals with formal education in PH (PHGs) are needed in the PHW, and for which specific occupations, then contrast with PHG employment outcomes and detailed data on labor market competition. This manuscript employs a theoretical framework which includes an analysis of both the existing PHW, the supply of PHGs, and employer competition to hire them, adapted from prior healthcare workforce research³⁰ for this article (Appendix Figure 1).

< FIGURE 1: Diagram of Labor Market Dynamics for PHGs >

Utility of job postings analysis to classify PHW

One method of determining the labor market demand for PHGs is to analyze job postings/advertisements for these graduates, and compare them with the existing definitions and taxonomies for the PHW. Job postings typically include the job title, a description of the employing organization, an overview of job tasks or functions, and a list of required or desired skills, experience, education, or other credentials. Because job descriptions are designed to clearly describe the skills and qualifications needed to perform a job, they are a useful source of insight into current hiring needs. Although job postings are not created for the purposes of workforce research, many studies have been conducted which leverage the rich, text-based information from job postings—approximately 85% of which are posted on the internet³⁶—to infer employer needs and workforce trends. Several research studies on PHW have utilized job descriptions analysis to discern employer demands.^{37–41}

New technologies and methodologies allow for ISCO-08 and SOC coding of large-scale job postings data, thereby creating a list of occupations for which employers are currently seeking PHGs. Utilizing job postings data, to contrast with existing taxonomies, also provides data-driven, “real time” insights more quickly than periodic surveys or expert opinion.

This article seeks to more consistently map the occupations identified in existing PHW taxonomies to ISCO-08 and US SOC codes, then contrast them with job postings data which illustrate occupations and sectors currently seeking to hire PHGs. By identifying the job postings targeting PHGs which are not part of existing taxonomies, we can reveal new occupations or sectors which may be drawing PHGs away from the occupations that past researchers have defined as contributing to the EPHOs, thus assessing the labor market competition for PHGs. This research can also identify possible workforce gaps, and provide insights to academia to innovate their curricula. Finally, through an analysis of job postings in two time frames, before COVID-19 and during the COVID-19 pandemic, we can assess whether demand for PHGs has changed during the COVID-19 pandemic.

Methods

To assess which jobs seek PHGs aside from those in existing PHW taxonomies, researchers first matched PHW taxonomies with ISCO-08 codes, then contrasted job postings with the codes; and assessed differences in proportions of postings before and during the COVID-19 pandemic.

Mapping existing taxonomies to Standardized Occupational Classifications

The ILO's ISCO-08 codes classify occupations into 441 categories, while the US Department of Labor's Standard Occupation Classification (referred to here as "USSOC") codes, revised in 2018, include 867 different detailed occupations.²⁵ The US Department of Labor offers a SOC to ISCO-08 "crosswalk" to match the codes to one another.⁴² The UK's Office for National Statistics (ONS) has its own SOC codes (referred to here as "UKSOC"), with 583 unique codes matching to 28,749 job titles and subtypes²⁶; and a UKSOC to ISCO-08 SOC crosswalk exists.

Two of the existing taxonomies, UM⁴³ and the CfWI Core workforce report^{18,20} did not include matches to SOC codes in their descriptions. Therefore, the lead researcher matched the job titles, or, when available, job descriptions, to their respective SOC codes, and then to ISCO-08 codes. For UM, the researcher referenced earlier studies which matched the titles which were later used for the taxonomy with USSOC codes⁴⁴⁻⁴⁶ and verified the proposed taxonomy with one of the authors of the original taxonomy. We also utilized a SOC-matching system developed by the US National Institutes of Health to match the available descriptions of the jobs in the UM taxonomy with USSOC codes.⁴⁷ In cases where more than one USSOC code matched a job from the UM taxonomy, or where more than one job title from UM matched the same USSOC code, both are included in the table (Appendix Table 1). In cases where no USSOC code match could be found, this is indicated in the table.

For the CfWI taxonomy of the Core PHW in the UK, the lead researcher referred to the detailed descriptions of each occupation in the report and attempted to match them to UKSOC 2010 codes using a qualitative approach, and further, utilized the UK ONS Occupation Coding Tool, which matches job titles to UKSOC 2010 codes⁴⁸, which then match to ISCO-08. Additionally, CfWI included a report on the "wider" PHW, which utilized discussions with various professional association members to determine which other occupations were considered "engaged" in PH. CfWI mapped these to UKSOC 2010 code, which the researcher cross-matched to ISCO-08 codes using the UK's ONS crosswalk⁴⁹. For the purpose of this study, we included only those occupations listed as "active" in their engagement ("public health was explicitly part of their job").

The taxonomy proposed in the systematic review article²⁷ was already matched to ISCO-08 codes by the article's authors.

Utilizing a job postings database

This manuscript utilizes a commercially-available job postings database, maintained by Burning Glass Technologies (BG). BG is a data vendor which compiles millions of job postings every year using “bots” which search more than 40,000 different sources, tracking 3.4 million job postings at any time.³⁶ Data from this site has been used in many other workforce studies,^{40,50-52} including analysis of COVID-19's impact on the labor market.⁴⁰

BG utilizes machine learning and natural language processing technology to match job postings data with the employer's required or desired Classification of Instructional Program (CIP) codes⁵³, which are developed by the US Department of Education to categorize areas of academic study; to allow searchability by the level of education required; and to match jobs with industries/sectors and USSOC codes.

We conducted three BG queries. We delimited all queries to job openings posted in the United States, for which, according to the BG algorithms, the employer desired or required a Master's level degree, with any of the CIP codes which match PH degrees, including 51.22 (including General Public Health, Environmental Health, Health/Medical Physics, Occupational Health/Industrial Hygiene, Public Health Education/Promotion, Community Health/Preventive Medicine, Maternal and Child Health, International PH/International Health, Health Services Administration, Behavioral Aspects of Health); 26.1309, Epidemiology; and 26.1102, Biostatistics.

One query was for 40,707 job postings from Jul. 1, 2019 - Jun. 30, 2020, of which 38,533 were USSOC-coded. The second and third queries were designed to compare jobs across all sectors before and during COVID-19, including jobs posted March 1, 2020 through Oct. 31, 2020 (n=24,845, the “COVID-19 era”), and March 1, 2019 through Oct. 31, 2019 (n=24,516 the “pre-COVID-19 era”). We compared occupations and sectors from the COVID-19 using two-proportion independent sample z tests with $\alpha=.05$.

Results

Mapping existing taxonomies to ISCO-08 and SOC codes

The three main taxonomies had varying levels of specificity (Appendix Table 1). The most detailed was the UM taxonomy, with a total of 69 job titles (three titles not originally in the taxonomy, “Pharmacist,” “Emergency Medical Services Worker,” and “Other Business Support Services” were added, because they were included in a US PHW survey based on the taxonomy)⁵⁴. Matching the UM codes to USSOC and ISCO-08 codes revealed some discrepancies. There were three titles for which a USSOC code could not be found: “Population Health Specialist,” “Implementation Specialist,” and “Adult protective services/Community worker.” Several titles could map to multiple USSOC codes, and in some cases, several UM codes could map to one SOC code, for example, “Health officer,” “Subagency-level director: Bureau, department, division, or branch,” and “Deputy director (agency or subagency level)” all match to the USSOC “Chief Executives.”

The CfWI “Mapping the Core” taxonomy encompassed 11 job titles, each of which could include a large number of sub-titles. When matching the titles to ISCO-08 codes using the ONS Occupation Coding Tool⁴⁸ and subsequently matching UK SOC codes to ISCO-08 codes, however, multiple titles matched to the same ISCO-08 codes (e.g., “Public health consultants and specialists,” “Directors of Public Health (DsPH),” “Public health managers,” and “Public health practitioners” all matched to ISCO-08 2269, “Health professionals not elsewhere classified”).

Some of the CfWI titles were too broad to clearly match to a particular SOC or ISCO-08 code—for example, “Information workers” could refer to individuals who analyze data, but could also mean communications specialists. CfWI also excluded several occupations which appear in other taxonomies, including “midwives, general practitioners (GPs), community pharmacists...staff across the NHS and local government fulfilling a public health function as part of their job...staff supporting public health teams (e.g. business support staff, administration staff...)”¹⁸ The CfWI “Understanding the wider public health workforce” report, in contrast, lists 75 different UKSOC occupations for which the workers were seen as engaged actively in PH, encompassing 56 ISCO-08s, but 34 (such as “prison guards,” “butchers,” and “athletes”) matched no occupations in the other taxonomies nor the BG postings and were excluded to reduce confusion.

The taxonomy by Watts et. al.²⁷ included 103 titles, the majority of which were mapped to ISCO-08 codes by the authors using job titles alone, but multiple titles were matched to the

same ISCO-08 code; removing duplicates, there were 33 unique ISCO-08 codes, and 7 job titles which were not matched to an ISCO-08 code. Two titles, “Emergency Preparedness” and “Quality Improvement Specialist” were not matched to ISCO-08 codes, but could be matched to USSOC codes due to their greater specificity.

A few “consensus” occupations could be clearly identified across the UM, CfWI, and Watts taxonomies. These included “Health Services Managers” (ISCO-08 1342); “Environmental and occupational health inspectors” (3257); “Environmental and occupational health and hygiene professionals” (2263, including health educators); “Social work and counselling professionals” (2635); “Biologists, botanists, zoologists and related professionals” (2131, including Epidemiologists, Microbiologists); “Statisticians” (2120); “Community health workers” (3253); “Nurses” (2221); “Systems analysts” (2511); and “Medical and pathology laboratory technicians” (3212), illustrating the interprofessionalism of the PHW.

Contrasting existing taxonomies with Burning Glass Data

There were a total of 38,533 SOC-coded job postings in the US, where a Master’s level PHG was sought, in the BG data from July 1, 2019-June 30, 2020, within 315 different USSOC occupations. We excluded those occupations with 50 or fewer job postings in the data collection, thus analyzing 92 unique SOC coded-occupations, representing a total of 36,225 postings from the sample. The jobs postings data also included postings by industry/sector.

Overall, there were 32 unique USSOC coded occupations in BG (corresponding to 29 unique ISCO-08 occupations) which were not included in the UM, CfWI “Core” or “Wider” taxonomies, or Watts taxonomies, representing 10,089 jobs, or 28% of the BG postings. Of these jobs, 4,335 were for “Managers, All Other” (ISCO-08 1114/USSOC 11-9199). When these are excluded, 16% of the BG jobs did not match existing taxonomies (See Table 1 and Appendix Table 1). Table 1 compares job titles/occupation naming used in the occupational taxonomies and contrasts them with the number of job postings within each US SOC code/ISCO-08 code, from the BG data from 2019-2020, with the list sorted by number of job postings in BG.

In the July, 1 2019-June 30, 2020 BG data, 33,563 were coded by industry/sector; the top industries were Health Care and Social Assistance (n=10,476 postings or 31.2%); Educational Services (7,606, 22.7%); Public Administration/Government (4,127, 12.3%); Finance and Insurance (3,312, 9.9%), Professional, Scientific, and Technical Services (3,507, 10.4%), Manufacturing (2,251, 6.7%), Other Services (except Public Administration) (1,089, 3.2%),

Information (282, 0.8%), Administrative and Support and Waste Management and Remediation Services (264, 0.8%), and Retail Trade (261, 0.8%).

<TABLE 1: Comparison of Top 10 Most Sought Jobs for Public Health Graduates, By Public Health Taxonomy, SOC, AND ISCO-08 Codes >

<APPENDIX TABLE 1: Full Comparison of Public Health Taxonomies and BG Postings, Linked to ISCO-08 and USSOC Codes>

Comparing pre-COVID and “COVID Era” jobs

There were 24,845 job postings from March 1, 2020 through Oct. 1, 2020 (the “COVID era”), and 24,516 postings from March 1, 2019 and Oct. 1, 2019 (“pre-COVID”).

Significant differences were observed in the proportion of job postings by industry or sector comparing the two time frames, including a decrease in positions in Colleges, Universities, and Professional Schools ($p<.0001$) and General Medical and Surgical Hospitals ($p<.0001$), and increases in Insurance Carriers ($p<.0001$), and Pharmaceutical and Medicine Manufacturing ($p<.0001$). (Appendix Table 2).

Comparing COVID-era and pre-COVID postings, there were significant increases in postings for Epidemiologists and Statisticians, Medical and Health Services Managers, Natural Sciences Managers (including research managers), Sales Managers, Chief Executives, Computer Occupations, Private Detectives (a USSOC occupation mapping Contact Tracers, which does not yet have a USSOC code), Architecture and Engineering Managers (including project managers), Biologists, Compliance Officers, and Community Health Workers. General management occupations, and roles in education and social services declined. (See Appendix Table 2).

< TABLE 2: Comparison of COVID VS pre-COVID Era Industries/Sectors and Jobs>

<APPENDIX TABLE 2: Comparison of COVID VS pre-COVID Era Occupations>

Discussion

This article has sought to consistently map PHW occupations with SOCs, contrast them with jobs requiring PHGs, and finally, illuminate labor market competition for PHGs, while offering insights into COVID-19's impact on hiring of PHGs. While competition for PHGs has been hinted at in past research, it is more clearly illuminated here, and these findings can be used to both create policies to reduce workforce gaps, and also innovate educational curricula.

Mapping taxonomies to ISCO-08 and SOC codes, while challenging, provides key insights into PHW labor market dynamics; but these codes do not always clearly align with public health occupations, making it more difficult to gain a complete picture of the PHW. There is clear competition for PHGs outside the PHW as it has been traditionally defined; for example, though the US PHW has often been defined as governmental, government comprised only 12% of job postings for PHGs.

Mapping to Standardized Occupational Classifications: using new tools

Job analysis—a specific method in industrial psychology—is a critical element in taxonomy creation. New tools exist, which can ensure taxonomies match accurately to SOCs based on complete job descriptions. These include machine learning tools such as the US National Institutes of Health “SOCcer” tool⁴⁷, large-scale, coded datasets such as BG, or even direct inquiries with the BLS or ONS. The existing taxonomies were mainly created both through discussions with experts in the field and with surveys, by using lists of job titles without complete job descriptions for each occupation, or using job categories which are too broad to match to specific occupations.

The suggestion by Watts and colleagues that differences in taxonomies reflect differences in PH systems is reconfirmed by this investigation. For example, there are several occupations absent from the UM taxonomy, but which appear in other taxonomies or in BG. These include roles in academia, such as “Postsecondary Teachers” and “Social Science Research Assistants.” Conversely, CfWI includes academia as a core part of the PHW. However, while different countries have different taxonomies, we observe there is still some consensus between different taxonomies regarding which occupations are a core part of the PHW.

Evidence of labor market competition for PHGs

It is notable that there were 24,845 job postings in the “COVID era”, and 24,516 postings “pre-COVID era.” The BLS’s monthly Job Openings and Labor Turnover Survey (JOLTS), which tracks the number of monthly job postings in the US, indicates that there were consistently fewer job postings in 2020 than 2019 each month (e.g., 15.9% fewer job openings in March 2020 compared with March 2019; 30.7% fewer in April, and 26% fewer in May)⁵⁵, which suggests that the job market for master’s level PHGs has not been as negatively impacted by the COVID-19 pandemic as compared with the broader job market.

The fact that 4,127 positions in Public Administration (government) were posted in the 2019-2020 BG data set is notable because there were 17,948 Master’s-level PHGs in 2019 in the US. New data show approximately 19% of Master’s level PHGs enter into government after graduation, giving approximately 3,410 PHGs entering government, a shortfall of approximately 717 PHGs, and preliminary evidence of a long-suspected labor market mismatch.^{32,33,56} This mismatch—in which not enough PHGs are entering government to fill critical PHW shortages—may have serious repercussions for the ability of the governmental PHW to respond to public health crises including COVID-19.

The occupations from BG that do not exist in current taxonomies provide researchers with insight into labor market competition. The large percentage of computer-related occupations in BG outside the taxonomies may reflect employers seeking epidemiology or biostatistics students, such as corporations seeking data scientists. There are also several business-related occupations (sales, marketing, operations research) which appear in BG but not existing taxonomies, reflecting occupations in the for-profit sector seeking PHGs—an indicator of job market competition which could negatively impact the ability of PHG to fill a PHW shortage. Conversely, several occupations in PHW taxonomies had very few BG postings, reflecting occupations in the PHW not requiring a PHG.

COVID-19 and changes in industry/sector

In addition to ongoing labor market competition, COVID-19 appears to have impacted the job market for PHGs, and there are several possible explanations for these changes. The insurance industry markedly increased hiring in the COVID era. In the United States, health insurance firms were one of the few sectors to experience fewer financial challenges due to COVID-19, because elective medical procedures were halted during lockdowns, reducing

insurance claims. Hospitals had the opposite challenge; significant revenue comes from elective procedures, cancelled due to COVID-19. Education sector hiring has declined, reflecting financial challenges. Pharmaceutical firms are growing due to investments in COVID-19 treatments and vaccines. Finally, hiring in government stayed quite similar, pre-COVID vs. COVID-era—possibly reflecting funding priorities made by policymakers in the US during the time period being analyzed.

Recommendations and future PHW research

In order to improve PHW research, we suggest advocacy efforts to BLS and ILO ensure inclusion of codes that encompass critical PH occupations, since several occupations in PH do not match to ISCO-08 or SOC codes. And while the use of SOCs, by themselves, to enumerate the PHW is controversial due to the “ill-defined” nature of the workforce^{44,57} and the fact that simply counting the number of people in an occupation does not illuminate the PHW because many work outside PH (e.g., the vast majority of nurses are not PH nurses), these codes are still helpful in gathering in-depth occupational information.

To truly assess labor market competition for PHGs, this analysis should be combined with efforts to enumerate the current PHW, assess what proportion of the workforce work in occupations which require PH education (according to SOC-based educational benchmarks⁵⁸), compare the current level of PH education within each occupation, and determine expected attrition,⁷ then contrast the current PHW with population needs based on EPHOs, and finally determine employment outcomes of PHGs. Such an assessment can allow workforce planners to determine whether there are enough PHGs contributing to EPHOs; this article’s analysis can clarify which industries are “poaching” PHGs from EPHO-related jobs. This can guide policy levers to alter the job market by ensuring competitive wages, reducing barriers to entry into the traditional PHW³⁴, and creating more effective recruitment programs for PHGs to compete with new sectors. Additionally, in order to ensure PHGs understand and are committed to their role in contributing to the EPHOs, there can be stronger efforts to connect PHGs to a professional identity which is directly connected to the EPHOs; a professional identity or ethos is also important for the existing PHW. This study illustrates that PHW is comprised of a very diverse range of different occupations, making it more difficult to create a unified professional identity. Efforts towards professionalization, including credentialing, registration, consistent

competencies, and a strong professional board or association, can help connect PHGs to a stronger, more unified PHW²¹. Simultaneously, PHGs who do decide to enter the “wider” PHW can advocate for better PH principles wherever they go, bringing the voice of public health to settings beyond traditional PH.

Uses by academia

Higher education institutions may not wish to see themselves as “vocational preparation” programs whose only role is to respond to employer demands, but if they ignore *current* employer demand, their curricula may be seen as outdated by their graduates’ employers. Universities preparing PHGs can utilize this analysis to discern real-time job market requirements of employers. The jobs with the fastest increases in hiring during the COVID-19 era focus on statistics and epidemiology, program management, computer-related positions, community health workers, and individuals managing clinical trials or research programs. An increased need for Chief Executives highlights the need for leadership training to meet the COVID-19 pandemic’s management challenges or replace retiring PH executives; and “private detectives” may reflect the hiring of contact tracers/disease investigators. Social workers and physicians are needed to provide direct services and to help with prevention efforts for COVID-19; the increase in market research and compliance may reflect new research around behavior change communication or enforcement of COVID-19-related regulations. The increase in Engineering Managers might reflect the need to bring PH expertise to the design of buildings to ensure healthy airflow and reduce the transmission of an airborne virus. Ensuing curriculum meets employer demands for leadership, statistics, market research, program and research management, computer programming/data science, business skills, and operations research can ensure PHGs have relevant skills for today’s job market.

Career advising for PH students can also be enhanced by referring students to information on the occupations referenced in this taxonomy; each USSOC occupation is described in detail on a comprehensive career guidance website, O*Net Online⁵⁹, which includes alternative job titles, job descriptions, lists of job tasks, technology and tools used, knowledge, skills and abilities, detailed work activities, work context, level of required education or training, credentials or certifications, work styles and values, related occupations, salary ranges, and projected labor market growth, providing one of the richest and most accurate sources of occupational data available. A new career guidance intervention could be designed, similar to the

UK's PHORCaST program,⁶⁰ based on the occupations listed here, which in turn could help encourage students to consider PH studies and contribute to the EPHOs. Universities can also utilize these results to portray to prospective students why a PH degree can offer career satisfaction.⁵⁶

Limitations

The BG data was gathered from the United States. BG does have data collections from Europe, which may help future researchers. BG's coding algorithms are proprietary. It is possible that the jobs in the dataset are not truly reflective of who is hiring PHGs. More research is necessary, including hand-searching actual job posting samples from BG to validate their methodology. It is possible BG might undercount certain sectors due to the way the jobs are posted online. Jobs posted through government contractors may be miscategorized or undercounted. Also, large-scale/mass hiring efforts may take place through only a single job posting, which could undercount surge hiring efforts.

BG leaves out qualitative information which might be gleaned by hand-coding or using a text-based analysis to discern current skills needed by employers. This can be especially critical for the COVID-19 era jobs, which may reflect new and emerging occupations without ISCO or SOC codes. Further research, including qualitative analysis or employer surveys, would further illuminate skills requirements. Also, occupations are only one of multiple elements which should be considered when researching the workforce; sector, mission/subject area, and funding source are all factors to consider.

Several occupations, including policy analyst, advocacy, and contact tracing do not map clearly to ISCO-08 or SOC codes. Some taxonomy occupations are not clearly defined such as "population health specialist," and without a job description, may be impossible to match to a code. More research to finalize the mapping should be conducted, using full job analysis.

This "demand side" approach may illustrate workforce gaps, but should be used in combination with needs-based workforce and funding assessments for PHW hiring, to gather a more complete picture of PHW gaps.

Conclusions

A complete analysis of the PHW should include the supply of PHGs and labor market competition for them. By understanding who is hiring PHGs, we can intentionally design

policies and recruitment initiatives to fill workforce gaps. And while universities offering PH degrees design them to prepare students to contribute to EPHOs, the competencies gained by their students are clearly in demand in fields which may or may not contribute to EPHOs³².

COVID-19 has altered the labor market for millions of people, including PHGs. illuminated the critical role of a trained PHW. By more fully understanding this workforce, leaders can advocate to effectively harness the energy and commitment of new PHGs to contribute to EPHOs to heal our world.

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TABLE 1: Comparison of Top 10 Most Sought Jobs for Public Health Graduates, By Public Health Taxonomy, SOC, AND ISCO-08 Codes

ISCO-08 CODE	ISCO-08 TITLE	USSOC CODE	USSOC TITLE	"No Two Workforces" Titles ²⁷	UM Title ¹⁹	CfWI CORE Title ¹⁸	CfWI "Wider" WF Title ²⁰	BG jobs # 2019 - 2020
1342	Health services managers	11-9111	Medical and Health Services Managers	Agency Leadership, Coordinators, Directors Of Public Health, Health Care Administrators, Health Management, Health Planners, Health Policy Makers, Health Promotion Managers, Managers, Public Health Manager	1.1.5. Program director	Public health consultants and specialists		4,636
1114	Senior officials of special-interest organizations	11-9199	Managers, All Other					4,335
2120	Mathematicians, actuaries and statisticians	15-2041	Biostatisticians (15-2041.01)/Statisticians (15-2014)	Biostatisticians, Statisticians	1.2.23. Statistician	Intelligence and knowledge professionals		3,241
2221	Nursing professionals	29-1141	Registered Nurses (including Public Health Nurse)	Health Visitors, Licensed Practical Or Vocational Nurse, Nurses, Nursing Home Health Aide, Nursing Technicians, Primary Healthcare Registered Nurses, Public Health Nurse, Registered Nurses, School Nurses, Social Nursing, Community Health Nurses	1.2.14.1.1. Public health or community health nurse	Public health nurses; Health Visitors; School Nurses		1,956
2519	Software and applications developers and analysts not elsewhere classified	15-1199	Computer Occupations, All Other			Intelligence and knowledge professionals		1,833
2120	Mathematicians, actuaries and statisticians	15-2031	Operations Research Analysts	Biostatisticians, Statisticians				1,340

2131	Biologists, botanists, zoologists and related professionals	19-1041	Epidemiologists	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers	1.2.6. Epidemiologist	Public health scientists		1,237
2310	University and higher education teachers	25-1199	Postsecondary Teachers, All Other	Academic Public Health Specialists		Public health academics	Higher education teaching professionals	1,223
2421	Management and organization analysts	13-1111	Management Analysts					835
2263	Environmental and occupational health and hygiene professionals	21-1091	Health educators	Environmental Health Experts, Environmental Public Health Workers, Occupational And Environmental Health Specialists	1.2.8. Health educator	Environmental health professionals		810

TABLE 2: Comparison of COVID VS pre-COVID Era Industries/Sectors and Jobs

NAICS Code	Industry	COVID (March 1, 2020- Oct. 31, 2020)		Pre COVID (March 1, 2019-Oct. 31, 2019)		
		Job Postings	%	Job Postings	%	
6113	Colleges, Universities, and Professional Schools	3,757	19.9%	4,986	25.51%	***
6221	General Medical and Surgical Hospitals	3,229	17.1%	3,889	19.90%	***
5241	Insurance Carriers	2,854	15.1%	2,040	10.44%	***
9211	Executive, Legislative, and Other General Government Support	1,478	7.8%	1,528	7.82%	
3254	Pharmaceutical and Medicine Manufacturing	1,353	7.2%	917	4.69%	***
5417	Scientific Research and Development Services	1,258	6.7%	1,113	5.69%	**
6211	Offices of Physicians	574	3.0%	793	4.06%	***
6241	Individual and Family Services	381	2.0%	357	1.83%	
5416	Management, Scientific, and Technical Consulting Services	298	1.6%	347	1.78%	
8133	Social Advocacy Organizations	290	1.5%	299	1.53%	
	All other	3,407	18%	3,276	17%	**
	Total	18,879	100%	19,546	100%	

Notes: *** p<.0001, ** p<.01, *p<.05

Note: A total of 18,879 jobs from March 1, 2020 to Oct. 31, 2020, and 19,546 jobs from March 1, 2019 to Oct. 31, 2019, were assigned NAICS codes in Burning Glass. 764 postings from the COVID era, and 644 from the pre-COVID era are excluded from the table, but not from the statistical analysis, because they existed in industries with 30 or fewer postings in one of the time points.

FIGURE 1: Diagram of Labor Market Dynamics for PHGs

**APPENDIX TABLE 1: Full Comparison of Public Health Taxonomies and BG Postings,
Linked to ISCO-08 and USSOC Codes**

APPENDIX TABLE 2: Comparison of COVID VS pre-COVID Era Occupations

Appendix Table 1: Full Comparison of Public Health Taxonomies and BG Postings, Linked to ISCO-08 and USSOC Codes

ISCO-08 CODE	ISCO-08 TITLE	USSOC CODE	USSOC TITLE	No Two Workforces Titles	UM Title	CfWI "Core" Title	CfWI "Wider" WF Title	BG jobs # 2019-2020
1112	Senior government officials	11-1011	Chief Executives		1.1.1. Public health agency director	Directors of Public Health (DsPH)		310
1112	Senior government officials	11-1011	Chief Executives		1.1.2. Health officer	Directors of Public Health (DsPH)		Duplicate
1112	Senior government officials	11-1011	Chief Executives		1.1.3. Subagency-level director: Bureau, department, division, or branch	Directors of Public Health (DsPH)		Duplicate
1112	Senior government officials	11-1011	Chief Executives		1.1.4. Deputy director (agency or subagency level)	Directors of Public Health (DsPH)		Duplicate
1112	Senior government officials	11-9161	Emergency Management Directors	Emergency Preparedness Staff	1.2.4. Emergency preparedness/Management worker			85
1112	Senior government officials	11-1021	General and Operations Managers		1.4.2.2. Facilities or operations worker			677
1114	Senior officials of special-interest organizations	11-9199	Managers, All Other					4335
1114	Senior officials of special-interest organizations	11-2031	Public Relations and Fundraising Managers					303
1211	Finance managers	11-3031	Financial Managers	Financial Operations				150
1212	Human resource managers	11-3131	Training and Development Managers		1.4.2.4.1. Training/Workforce development personnel			52
1212	Human resource managers	11-3111	Compensation and Benefits Managers					72
1219	Business services and administration managers not elsewhere classified	11-3011	N/A Multiple possible matches (11-3011.00 Administrative Services Managers, etc.)	Business Operations	1.4.1. Administrator /1.4.2. Business support			287
1219	Business services and administration managers not elsewhere classified	11-3061	N/A No clear match (11-3061.00 Purchasing Managers)	Business Operations	1.4.2.3. Grants or contracts specialist			5
1221	Sales and marketing managers	11-2022	Sales Managers					400
1221	Sales and marketing managers	11-2021	Marketing Managers					219
1223	Research and development managers	11-9121	Natural Sciences Managers					739
1223	Research and development managers	11-9041	Architectural and Engineering Managers					182

1321	Manufacturing managers	11-3051	Industrial Production Managers					301
1330	Information and communications technology service managers	11-3021	Computer and Information Systems Managers		1.2.10. Information systems manager/1.2.10.2. Information technology specialist	Intelligence and knowledge professionals		50
1341	Child care services managers	11-9031	Education Administrators, Preschool and Childcare Center/Program					58
1342	Health services managers	11-9111	Medical and Health Services Managers	Agency Leadership, Coordinators, Directors Of Public Health, Health Care Administrators, Health Management, Health Planners, Health Policy Makers, Health Promotion Managers, Managers, Public Health Manager	1.1.5. Program director	Public health consultants and specialists		4636
1344	Social welfare managers	11-9151	Social and community services managers		1.1.6. Public health manager or program manager	Public health consultants and specialists	Social services managers and directors	340
1345	Education managers	11-9033	Education Administrators, Postsecondary			Public health academics	Senior professionals of educational establishments	476
1345	Education managers	11-9032	Education Administrators, Elementary and Secondary School			Public health academics		81
1345	Education managers	11-9039	Education Administrators, All Other					78
2113	Chemists	19-2031	Chemists	Chemists				40
2120	Mathematicians, actuaries and statisticians	15-2041	Statisticians (15-2014), including Biostatisticians (15-2041.01)	Biostatisticians, Statisticians	1.2.23. Statistician	Intelligence and knowledge professionals		3241
2120	Mathematicians, actuaries and statisticians	15-2031	Operations Research Analysts	Biostatisticians, Statisticians				1340
2120	Mathematicians, actuaries and statisticians	15-2011	Actuaries	Biostatisticians, Statisticians				4
2120	Mathematicians, actuaries and statisticians	15-2041.02	Clinical Data Managers		1.2.10.3. Data manager	Intelligence and knowledge professionals		Duplicate

2131	Biologists, botanists, zoologists and related professionals	19-1042	Medical Scientists, Except Epidemiologists	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers	1.2.11.4. Scientist or medical technologist	Public health scientists		479
2131	Biologists, botanists, zoologists and related professionals	19-1022	Microbiologists (including Public health laboratory scientist)	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers	1.2.11.4. Scientist or medical technologist ("Laboratory Scientist/Medical Technologist")	Public health scientists		33
2131	Biologists, botanists, zoologists and related professionals	19-1041	Epidemiologists	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers	1.2.6. Epidemiologist	Public health scientists		1237
2131	Biologists, botanists, zoologists and related professionals	19-1020	Biologists	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers		Public health scientists		165
2131	Biologists, botanists, zoologists and related professionals	19-1029	Biological Scientists, All Other	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers		Public health scientists		94

2131	Biologists, botanists, zoologists and related professionals	19-1011	Animal Scientists	Biologists, Epidemiologists, Food Safety Epidemiologists, Health Services Researchers, Microbiology, Parasitology, Public Health Scientists, Researchers		Public health scientists		3
2133	Environmental protection professionals	19-2041	Environmental Scientists and Specialists, Including Health		1.2.5. Environmental health worker	Environmental health professionals		94
2143	Environmental engineers	17-2081	Environmental Engineers	Engineers, Health Engineers, Sanitary Engineers	1.2.5.2. Engineer			44
2149	Engineering professionals not elsewhere classified	17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors					54
2164	Town and traffic planners	19-3051	Urban and Regional Planners				Town planning officers	73
2211	Generalist medical practitioners	29-1063	Internists, General	Family Doctors, Physician Assistants, Physicians, Social Medicine	1.2.17. Physician	Medical practitioners		0
2211	Generalist medical practitioners	29-1069	Physicians and Surgeons, All Other, including Preventive medicine physicians 29-1069.09	Family Doctors, Physician Assistants, Physicians, Social Medicine	1.2.17.1. Public health or preventive medicine physician			58
2211	Generalist medical practitioners	29-1069	Physicians and Surgeons, All Other, including Preventive medicine physicians 29-1069.09	Family Doctors, Physician Assistants, Physicians, Social Medicine				Duplicate
2212	Specialist medical practitioners	29-1069	Physicians and Surgeons, All Other, including Preventive medicine physicians 29-1069.09	Doctor, Public Health Consultants, Public Health Physicians, Public Health Practitioners, Public Health Specialists, Specialist Doctors				Duplicate
2221	Nursing professionals	29-1141	Registered Nurses (including Public Health Nurse)	Health Visitors, Licensed Practical Or Vocational Nurse, Nurses, Nursing Home Health Aide, Nursing Technicians, Primary Healthcare Registered Nurses, Public Health Nurse, Registered Nurses, School Nurses,	1.2.14.1. Registered nurse	Public health nurses; Health Visitors; School Nurses	Nurses	Duplicate

				Social Nursing, Community Health Nurses				
2221	Nursing professionals	29-1141	Registered Nurses (including Public Health Nurse)	Health Visitors, Licensed Practical Or Vocational Nurse, Nurses, Nursing Home Health Aide, Nursing Technicians, Primary Healthcare Registered Nurses, Public Health Nurse, Registered Nurses, School Nurses, Social Nursing, Community Health Nurses	1.2.14.1.1. Public health or community health nurse	Public health nurses; Health Visitors; School Nurses		1956
2221	Nursing professionals	29-1141.04	Registered Nurses, specifically Clinical Nurse Specialists (29-1141.04)	Health Visitors, Licensed Practical Or Vocational Nurse, Nurses, Nursing Home Health Aide, Nursing Technicians, Primary Healthcare Registered Nurses, Public Health Nurse, Registered Nurses, School Nurses, Social Nursing, Community Health Nurses	1.2.14.1.2. Clinical services registered nurse (in PH WINS, "Other Registered Nurse – Clinical Services")	Public health nurses; Health Visitors; School Nurses		Duplicate
2221	Nursing professionals	29-1171	Nurse Practitioners	Health Visitors, Licensed Practical Or Vocational Nurse, Nurses, Nursing Home Health Aide, Nursing Technicians, Primary Healthcare Registered Nurses, Public Health Nurse, Registered Nurses, School Nurses, Social Nursing, Community Health Nurses	1.2.14.1.3. Advanced practice nurse	Public health nurses; Health Visitors; School Nurses		84
2222	Midwifery professionals	29-1161	Nurse Midwives	Midwives			Midwives	7

2230	Traditional and complementary medicine professionals	29-1199	Health Diagnosing and Treating Practitioners, All Other					Duplicate USSOC code but different ISCO-08 code
2240	Paramedical practitioners	29-1071	Physician Assistants		1.2.18. Physician assistant			37
2250	Veterinarians	29-1131	Veterinarians (including Public health veterinarian)	Animal Control	1.2.25.1. Public health veterinarian		Veterinarians	0
2261	Dentists	29-1029	Dentists, all other (including Public health dentist)	Dental Therapists, Dentist, Oral Health Care, Public Health Dental Worker	1.2.16.1. Public health dentist			0
2261	Dentists	29-1029	Dentists, all other (including Public health dentist)	Dental Therapists, Dentist, Oral Health Care, Public Health Dental Worker			Dental practitioners	Duplicate
2262	Pharmacists	29-1051	Pharmacist	Pharmacists	Pharmacist		Pharmacists	22
2263	Environmental and occupational health and hygiene professionals	21-1091	Health educators	Environmental Health Experts, Environmental Public Health Workers, Occupational And Environmental Health Specialists	1.2.8. Health educator	Environmental health professionals		810
2263	Environmental and occupational health and hygiene professionals	29-9011	Occupational Health and Safety Specialists--NOTE, SOC CODED AS 29-9011 or as 19-5011	Environmental Health Experts, Environmental Public Health Workers, Occupational And Environmental Health Specialists,		Environmental health professionals		581
2265	Dieticians and nutritionists	29-1031	Dietitians and nutritionists	Dieticians, Nutritionists, Public Health Dieticians, Public Health Nutritionists	1.2.15. Nutritionist or dietitian			239
2269	Health professionals not elsewhere classified	29-1199	Health Diagnosing and Treating Practitioners, All Other	Allied Health Professional			Podiatrists; Health professionals n.e.c.; Occupational therapists	93
2269	Health professionals not elsewhere classified					Public health consultants and specialists; Directors of Public Health (DsPH); Public health managers; Public health practitioners		

2310	University and higher education teachers	25-1199	Postsecondary Teachers, All Other	Academic Public Health Specialists		Public health academics	Higher education teaching professionals	1223
2310	University and higher education teachers	25-1072	Nursing Instructors and Teachers, Postsecondary	Academic Public Health Specialists		Public health academics		317
2310	University and higher education teachers	25-1071	Health Specialties Teachers, Postsecondary	Academic Public Health Specialists		Public health academics		201
2310	University and higher education teachers	25-1054	Physics Teachers, Postsecondary	Academic Public Health Specialists		Public health academics		0
2320	Vocational education teachers	25-1194	Vocational Education Teachers, Postsecondary				Further education teaching professionals	51
2351	Education methods specialists	25-9031	Instructional Coordinators				Education advisers and school inspectors	144
2356	Information technology trainers	13-1151	Training and Development Specialists					106
2359	Teaching professionals not elsewhere classified	25-3099	Teachers And Instructors, All Other, Except Substitute Teachers				Teaching and other educational professionals n.e.c.	284
2359	Teaching professionals not elsewhere classified	21-1012	Educational, Guidance, School, and Vocational Counselors					216
2411	Accountants	13-2011	Accountants		1.4.2.1. Accountant or fiscal worker			113
2412	Financial and investment advisers	13-2051	Financial Analysts					89
2412	Financial and investment advisers	13-2052	Personal Financial Advisors					51
2421	Management and organization analysts	13-1111	Management Analysts					835
2422	Policy administration professionals	13-1199	Business Operations Specialists, All Other (NOTE: USSOC does not have a clear code for this)	Policy Analysts		Intelligence and knowledge professionals		53
2423	Personnel and careers professionals	13-1071	N/A Multiple possible matches 13-1071.00 Human Resources Specialists, 11-3121.00 Human Resources Managers, 43-4161.00 Human Resources Assistants, Except Payroll and Timekeeping		1.4.2.4. Human resources personnel			372

2423	Personnel and careers professionals	13-1141	Compensation, Benefits, and Job Analysis Specialists					62
2431	Advertising and marketing professionals	13-1161	Market Research Analysts and Marketing Specialists					82
2432	Public relations professionals	27-3031	Public Relations specialists		1.2.7. Health communicator/1.2.7.1. Public information specialist	Public health managers		179
2511	Systems analysts	15-1111	Computer & Information Research Scientists	IT Workers	1.2.10.1. Public health informatics specialist	Intelligence and knowledge professionals		670
2511	Systems analysts	15-1121	Computer Systems Analysts	IT Workers		Intelligence and knowledge professionals		210
2512	Software developers	15-1132	Software Developers, Applications					119
2514	Applications programmers	15-1131	Computer Programmers			Intelligence and knowledge professionals		223
2519	Software and applications developers and analysts not elsewhere classified	15-1199	Computer Occupations, All Other			Intelligence and knowledge professionals		1833
2521	Database designers and administrators	15-1141	Database Administrators		1.2.10.3. Data manager	Intelligence and knowledge professionals		114
2529	Database and network professionals not elsewhere classified	15-1122	Information Security Analysts					80
2611	Lawyers	23-1011	Lawyer		1.4.3. Attorney or legal counsel			0
2631	Economists	19-3011	Economists	Economists, Health Economist	1.2.2. Economist			124
2632	Sociologists, anthropologists and related professionals	19-3041	Sociologists			Public health consultants and specialists; Public health scientists		13
2633	Philosophers, historians and political scientists	19-3094	Political Scientist (includes Policy Analyst)		1.2.19. Policy analyst	Public health managers		323
2633	Philosophers, historians and political scientists	19-3099	Social scientists and related workers		1.2.21. Program evaluator	Public health managers		331

2635	Social work and counselling professionals	21-1011	N/A multiple possible SOC codes/titles fit taxonomy: SOCs 21-1011, Substance Abuse and Behavioral Disorder Counselors; 21-1022, Healthcare Social Workers; 21-1019, Counselors, All Other; and OPM occupational categories 0185–Social Work, 0186–Social Services Aid and Assistant, 0187–Social Services, 0180–Psychology, and 0181–Psychology Aid and Technician	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.1. Behavioral health professional		Social workers; Probation officers; Welfare professionals n.e.c.; Counsellors	24
2635	Social work and counselling professionals	21-1014	Mental Health Counselors	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.1.1. Behavioral counselor			76
2635	Social work and counselling professionals	21-1022	Healthcare Social workers	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.22. Social worker/Social services professional			73
2635	Social work and counselling professionals	21-1023	Mental Health and Substance Abuse Social Workers (S/I/A);	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.22. Social worker/Social services professional			26
2635	Social work and counselling professionals	21-1021	Child, Family, and School Social Workers	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.22.1. Social services counselor	Public health practitioners		52
2635	Social work and counselling professionals	21-1011	Substance Abuse and Behavioral Disorder Counselors	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.22.1. Social services counselor	Public health practitioners		Duplicate
2635	Social work and counselling professionals		N/A NO SOC MATCH FOUND	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.2.22.2. Adult protective services/Community worker	Public health practitioners		
2635	Social work and counselling professionals	21-1019	Counselors, All Other	Behavioral Health Professional, Behavioral Health Staff, Social Workers	1.3.6. Peer counselor			10
2635	Social work and counselling professionals	21-1099	Community and Social Service Specialists, All Other	Behavioral Health Professional, Behavioral Health Staff, Social Workers				80

2635	Social work and counselling professionals	21-1029	Social Workers, All Other	Behavioral Health Professional, Behavioral Health Staff, Social Workers				62
2641	Authors and related writers	27-3042	Technical Writers					83
3111	Chemical and physical science technicians	19-4099	Life, Physical, and Social Science Technicians, All Other; Including Quality Control Analysts (19-4099.01)	Quality Improvement Specialist	1.4.2.5. Quality improvement worker			105
3111	Chemical and physical science technicians	19-4099	Quality Control Analysts (note: 19-4099.01)		1.2.11.3. Quality control worker	Public health managers		Duplicate
3141	Life science technicians (excluding medical)	19-4091	Environmental Science and Protection Technicians, Including Health; Multiple titles: Sanitarian/Environmental Science and Protection Technician		1.2.5.1. Sanitarian or inspector/1.2.5.3. Technician	Environmental health professionals		42
3212	Medical and pathology laboratory technicians	29-2011	Medical and Clinical Laboratory Technologists	Lab Technicians, Laboratory Assistant, Laboratory Worker, Scientific Laboratory Staff	1.2.11. Laboratory worker	Public health scientists		7
3212	Medical and pathology laboratory technicians	29-2012	Medical and Clinical Laboratory Technicians	Lab Technicians, Laboratory Assistant, Laboratory Worker, Scientific Laboratory Staff	1.2.11.2. Technician (in PH WINS, "Laboratory Aide or Assistant")			72
3221	Nursing associate professionals	29-2061	Licensed Practical and Licensed Vocational Nurses		1.2.14.2. Licensed practical or vocational nurse	Public health practitioners		0
3252	Medical records and health information technicians	29-2071	Medical Records and Health Information Technicians	Public Health Informatics, Public Health Information Specialist				0
3253	Community health workers	21-1094	Community Health Workers	Community Health Workers, Health Care Educators, Health Prevention Workers, Health Promotion, Health Promotion Specialists, Public Health Workers, Village Doctors	1.3.2. Community health worker	Public health practitioners		106

3253	Community health workers	21-1094	Community Health Workers	Community Health Workers, Health Care Educators, Health Prevention Workers, Health Promotion, Health Promotion Specialists, Public Health Workers, Village Doctors	1.3.3. Disease intervention specialist	Public health practitioners		Duplicate
3253	Community health workers	21-1094	Community Health Workers	Community Health Workers, Health Care Educators, Health Prevention Workers, Health Promotion, Health Promotion Specialists, Public Health Workers, Village Doctors	1.3.4. Health navigator			Duplicate
3257	Environmental and occupational health inspectors and associates	29-9012	Occupational Health and Safety Technicians	Assistant Health Inspector, Food Inspectors, Health Inspector, Hygienists	1.2.5.1. Sanitarian or inspector	Environmental health professionals		84
3258	Ambulance workers	29-2041	Emergency Medical Technicians and Paramedics		1.2.3. Emergency medical technician/Emergency medical services worker (note--there are 2 categories for this in PN-WINS)		Paramedics; Ambulance staff (excluding paramedics)	0
3258	Ambulance workers	29-2041	N/A Multiple matches Emergency Medical Services Worker		Emergency Medical Services Worker: in PH WINS but not taxonomy			Duplicate
3259	Health associate professionals not elsewhere classified	29-2099	Health Technologists and Technicians, All Other					149
3314	Statistical, mathematical and related associate professionals	19-4061	Social Science Research Assistants					604
3322	Commercial sales representatives	41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products					185
3334	Real estate agents and property managers	11-9141	Property, Real Estate, and Community Association Managers					147
3339	Business services agents not elsewhere classified	13-2099	Financial Specialists, All Other					52

3341	Office supervisors	43-1011	N/A Multiple possible matches: First-Line Supervisors of Office and Administrative Support Workers (43-1011.00), Clinical Research Coordinator (11-9121.01), Community Health Worker (21-1094.00)					199
3343	Administrative and executive secretaries	43-6011	Executive Secretaries and Executive Administrative Assistants	Administrators, Office Support Staff		1.4.4.1. Administrative assistant		33
3351	Customs and border inspectors	13-1041	Compliance Officers/Environmental Compliance Inspectors (13-1041.01)			1.2.12. Licensure/Regulation/Enforcement worker		178
3351	Customs and border inspectors	13-1041.07	Regulatory Affairs Specialists			1.2.12. Licensure/Regulation/Enforcement worker		Duplicate
3351	Customs and border inspectors	13-1041.06	Coroners			1.2.13. Medical examiner		Duplicate
3411	Legal and related associate professionals	33-9021	Private Detectives and Investigators (Note: This is likely a code for Contact Tracers)					94
3412	Social work associate professionals	21-1093	Social and Human Service Assistants	Preventive Youth Healthcare			Youth and community workers; Child and early years officers; Housing Officers; Welfare and housing associate professionals n.e.c.	153
3422	Sports coaches, instructors and officials	27-2022	Coaches and Scouts				Sports coaches, instructors and officials	55
3423	Fitness and recreation instructors and program leaders	29-9091	Athletic Trainers	Fitness Instructors			Fitness instructors	7
3512	Information and communications technology user support technicians	15-1151	Computer User Support Specialists					99

							Local government administrative occupations; 4114 Officers of non-governmental organisations	
4110	General office clerks	43-9061	Office Clerks, General					78
4120	Secretaries (general)	43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive		1.4.4.2. Secretary (43-6014.00 Secretaries and Administrative Assistants, Except Legal, Medical, and Executive; 43-6013.00 Medical Secretaries)			189
4131	Typists and word processing operators	43-9022	Word Processors and Typists	Typists				0
4222	Contact centre information clerks	43-4051	Customer Service Representatives (Including Patient representatives, 43-4051.03)		1.3.4. Health navigator	Health visitors		121
4227	Survey and market research interviewers	43-4111	Interviewers, Except Eligibility and Loan					83
5153	Building caretakers	37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	Disinfectors	1.4.2.2.1. Custodian			0
5222	Shop supervisors	41-1011	First-Line Supervisors of Retail Sales Workers					55
5322	Home-based personal care workers	31-1011	Home Health Aides		1.3.5. Nursing and home health aide	Health visitors	Care workers and home carers; Senior care workers	0
5414	Security guards	33-1099	First-Line Supervisors of Protective Service Workers, All Other					69
5419	Protective services workers not elsewhere classified	33-9011	Animal Control Workers		1.3.1. Animal control worker		Protective service associate professionals n.e.c.	1
7543	Product graders and testers (excluding foods and beverages)	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers					88
9112	Cleaners and helpers in offices, hotels and other establishments	37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	Disinfectors				Duplicate
uncoded		uncoded		Employees At Local Health Agencies				
uncoded		uncoded		Health Assistant				

uncoded		uncoded		Health Protection Officer				
uncoded		uncoded		Health Technicians				
uncoded		uncoded		Sociomedical Assistants				
#N/A	#N/A		N/A NO SOC MATCH FOUND		1.2.20. Population health specialist	Public health consultants and specialists		
#N/A	#N/A		N/A NO SOC MATCH FOUND		1.2.9. Implementation specialist	Public health managers		
#N/A	#N/A		Other Business Support Services		Other Business Support Services: in PH WINS but not taxonomy			

NOTE: Table compares job titles/occupation naming used in “No Two Workforces are the Same: A Systematic Review of Enumerations and Definitions of Public Health Workforces,” the University of Michigan Public Health Workforce Taxonomy (UM), CfWI “Mapping the Core Public Health Workforce,” and “Understanding the wider public health workforce in England,” matched to ISCO-08 codes and USSOC codes; and contrasts with the number of job postings within each US SOC code/ISCO-08 code in Burning Glass from 2019-2020. List is sorted by ISCO-08 code. Where more than one taxonomy name matches to the same ISCO-08 or SOC code, the number of postings in the “BG jobs #2019-2020” column is marked “Duplicate” to prevent over-counting; USSOC codes in BG were given at the six-digit level of detail; where a sub-occupation (8 digits) was mentioned in a taxonomy, it is included but the BG jobs # is listed as “duplicate.” Positions which exist in Burning Glass but not in any public health workforce taxonomy are shaded in gray. “PH-WINS” refers to the Public Health Workforce Interests and Needs Survey, which draws upon the UM taxonomy.

Appendix Table 2: Comparison of COVID VS pre-COVID Era Occupations

Analysis of 24,845 job postings from March 1, 2020 through Oct. 1, 2020 (the “COVID era”), and 24,516 postings from March 1, 2019 and Oct. 1, 2019 (“pre-COVID”), from US employers seeking Master’s level public health graduates, from Burning Glass, SOC-coded; comparison between time periods using independent sample z-tests. Notes: *** p<.0001,** p<.01, *p<.05

COVID Era		Number of Job Postings, COVID	% Postings, COVID	Pre-Covid Era Number of Job Postings Pre-Covid	% Postings, Pre-Covid	
11-9111	Medical and Health Services Managers	3132	12.6%	2949	12.0%	
11-9199	Managers, All Other	2638	10.6%	2965	12.1%	***
15-2041	Statisticians	2274	9.2%	1794	7.3%	***
29-1141	Registered Nurses	1274	5.1%	1272	5.2%	
19-1041	Epidemiologists	1260	5.1%	663	2.7%	***
15-1199	Computer Occupations, All Other	978	3.9%	1105	4.5%	**
15-2031	Operations Research Analysts	898	3.6%	874	3.6%	
25-1199	Postsecondary Teachers, All Other	683	2.7%	730	3.0%	
15-1111	Computer and Information Research Scientists	668	2.7%	664	2.7%	
21-1091	Health Educators	562	2.3%	570	2.3%	
11-9121	Natural Sciences Managers	499	2.0%	416	1.7%	*
13-1111	Management Analysts	462	1.9%	584	2.4%	**
11-1021	General and Operations Managers	443	1.8%	422	1.7%	
29-9011	Occupational Health and Safety Specialists	348	1.4%	337	1.4%	
11-2022	Sales Managers	339	1.4%	285	1.2%	*
19-4061	Social Science Research Assistants	323	1.3%	424	1.7%	**
19-1042	Medical Scientists, Except Epidemiologists	288	1.2%	301	1.2%	
11-9033	Education Administrators, Postsecondary	263	1.1%	395	1.6%	***
11-1011	Chief Executives	242	1.0%	190	0.8%	*
19-3099	Social Scientists and Related Workers, All Other	190	0.8%	228	0.9%	*
11-3011	Administrative Services Managers	186	0.7%	179	0.7%	
21-1094	Community Health Workers	183	0.7%	19	0.1%	***
11-9151	Social and Community Service Managers	181	0.7%	285	1.2%	***
11-2031	Public Relations and Fundraising Managers	179	0.7%	199	0.8%	
15-1131	Computer Programmers	167	0.7%	131	0.5%	*
11-9041	Architectural and Engineering Managers	162	0.7%	46	0.2%	***
29-1031	Dietitians and Nutritionists	162	0.7%	207	0.8%	*
19-3094	Political Scientists	160	0.6%	222	0.9%	**
15-1121	Computer Systems Analysts	159	0.6%	162	0.7%	
11-2021	Marketing Managers	152	0.6%	191	0.8%	*
11-3051	Industrial Production Managers	146	0.6%	188	0.8%	*
25-1072	Nursing Instructors and Teachers, Postsecondary	144	0.6%	166	0.7%	
33-9021	Private Detectives and Investigators	139	0.6%	39	0.2%	***
25-3099	Teachers And Instructors, All Other, Except	138	0.6%	199	0.8%	**

	Substitute Teachers					
43-1011	First-Line Supervisors of Office and Administrative Support Workers	135	0.5%	175	0.7%	*
19-1020	Biologists	127	0.5%	68	0.3%	***
11-9141	Property, Real Estate, and Community Association Managers	127	0.5%	106	0.4%	
29-2099	Health Technologists and Technicians, All Other Secretaries and Administrative Assistants, Except	112	0.5%	65	0.3%	**
43-6014	Legal, Medical, and Executive	111	0.4%	173	0.7%	**
27-3031	Public Relations Specialists	110	0.4%	118	0.5%	
13-1041	Compliance Officers	109	0.4%	81	0.3%	
11-3031	Financial Managers	109	0.4%	119	0.5%	
21-1012	Educational, Guidance, School, and Vocational Counselors	103	0.4%	163	0.7%	**
25-1071	Health Specialties Teachers, Postsecondary Compensation, Benefits, and Job Analysis Specialists	100	0.4%	102	0.4%	
13-1141	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	97	0.4%	39	0.2%	***
41-4012	Economists	97	0.4%	127	0.5%	*
19-3011	Economists	83	0.3%	71	0.3%	
21-1093	Social and Human Service Assistants	79	0.3%	112	0.5%	*
15-1132	Software Developers, Applications	78	0.3%	89	0.4%	
21-1029	Social Workers, All Other	73	0.3%	30	0.1%	***
29-1199	Health Diagnosing and Treating Practitioners, All Other	73	0.3%	57	0.2%	
29-1171	Nurse Practitioners	72	0.3%	55	0.2%	
13-1151	Training and Development Specialists	72	0.3%	62	0.3%	
13-2099	Financial Specialists, All Other	70	0.3%	35	0.1%	**
29-1069	Physicians and Surgeons, All Other	69	0.3%	44	0.2%	*
13-1161	Market Research Analysts and Marketing Specialists	67	0.3%	43	0.2%	*
15-1141	Database Administrators	65	0.3%	58	0.2%	
19-4099	Life, Physical, and Social Science Technicians, All Other	64	0.3%	88	0.4%	*
25-9031	Instructional Coordinators	63	0.3%	102	0.4%	**
19-1029	Biological Scientists, All Other	58	0.2%	62	0.3%	
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	57	0.2%	55	0.2%	
19-2041	Environmental Scientists and Specialists, Including Health	56	0.2%	66	0.3%	
11-9161	Emergency Management Directors	55	0.2%	48	0.2%	
19-3051	Urban and Regional Planners	53	0.2%	50	0.2%	
27-3042	Technical Writers	53	0.2%	59	0.2%	
21-1022	Healthcare Social Workers	52	0.2%	35	0.1%	
25-2022	Middle School Teachers, Except Special and Career/Technical Education	51	0.2%	44	0.2%	
13-2051	Financial Analysts	51	0.2%	55	0.2%	
11-9032	Education Administrators, Elementary and	50	0.2%	67	0.3%	

Secondary School						
11-3111	Compensation and Benefits Managers	7	0.0%	131	0.5%	***
11-9039	Education Administrators, All Other	25	0.1%	84	0.3%	***
21-1014	Mental Health Counselors*	46	0.2%	75	0.3%	**
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	23	0.1%	74	0.3%	***
15-1151	Computer User Support Specialists	40	0.2%	67	0.3%	**
29-2012	Medical and Clinical Laboratory Technicians*	23	0.1%	62	0.3%	***
43-4051	Customer Service Representatives	41	0.2%	57	0.2%	
43-4111	Interviewers, Except Eligibility and Loan Community and Social Service Specialists, All Other	38	0.2%	56	0.2%	
21-1099	Other	46	0.2%	52	0.2%	
21-1021	Child, Family, and School Social Workers	22	0.1%	51	0.2%	**

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FIGURE 1: Diagram of Labor Market Dynamics for PHGs

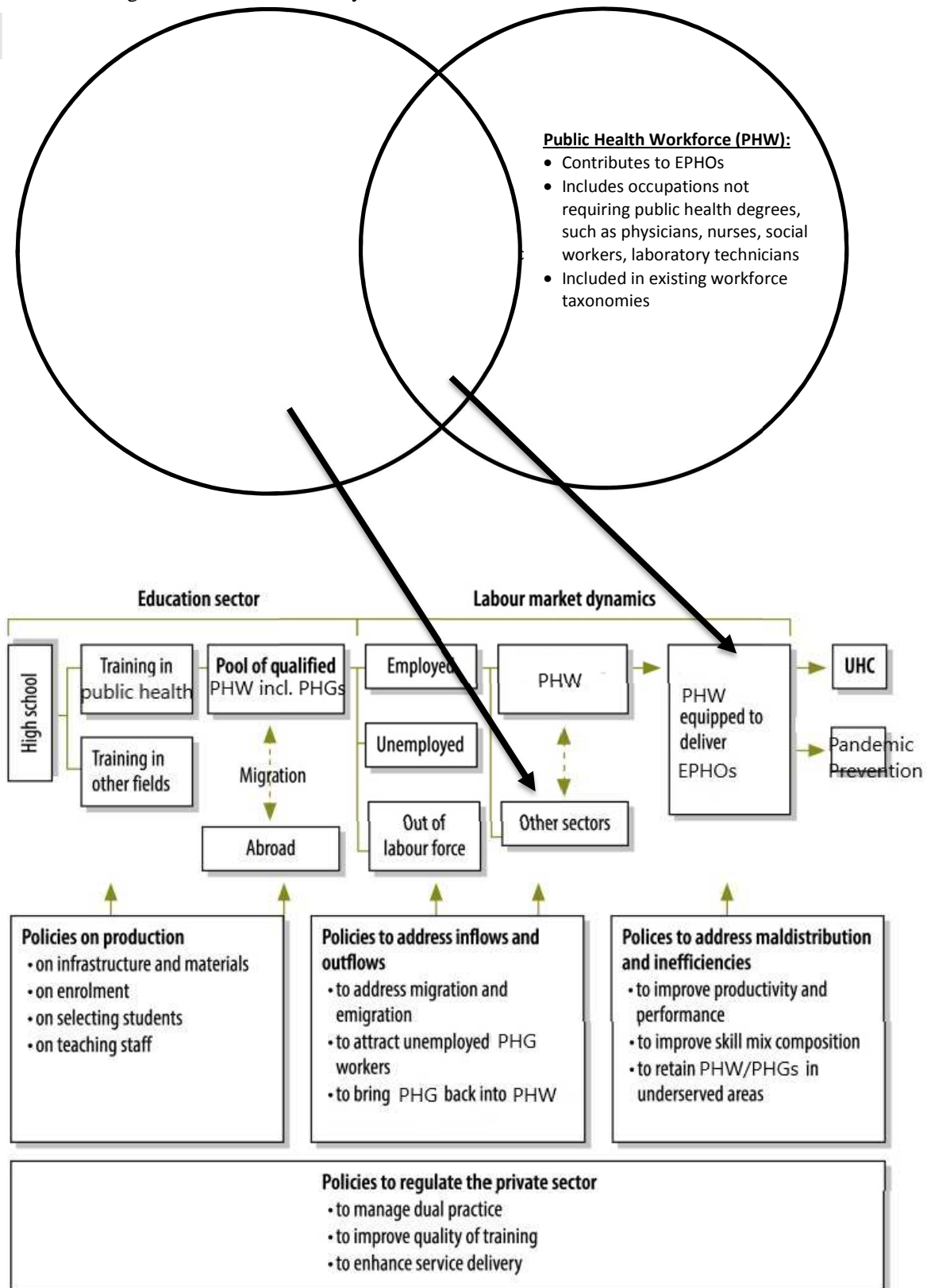


Diagram adapted from Vujicic M, Zurn P. The dynamics of the health labour market. Int J Health Plann Manage 2006; 21: 101-15
<http://dx.doi.org/10.1002/hpm.834> PMID: 16846103.