Commentary

Surveillance of Occupational Health Disparities: Challenges and Opportunities

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Increasingly, the occupational health community is turning its attention to the effects of work on previously underserved populations, and researchers have identified many examples of disparities in occupational health outcomes. However, the occupational health status of some underserved worker populations is not described due to limitations in existing surveillance systems. As such, the occupational health community has identified the need to enhance and improve occupational health surveillance to describe the nature and extent of disparities in occupational illnesses and injuries (including fatalities), identify priorities for research and intervention, and evaluate trends. This report summarizes the data sources and methods discussed at an April 2008 workshop organized by NIOSH on the topic of improving surveillance for occupational health disparities. We discuss the capability of existing occupational health surveillance systems to document occupational health disparities and to provide surveillance data on minority and other underserved communities. Use of administrative data, secondary data analysis, and the development of targeted surveillance systems for occupational health surveillance are also discussed. Identifying and reducing occupational health disparities is one of NIOSH's priority areas under the National Occupational Research Agenda (NORA). Am. J. Ind. Med. 53:84–94 2010. *Published 2010 Wiley-Liss, Inc.*[†]

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INTRODUCTION

The United States workforce has changed significantly over the past several decades, gaining more women working outside the home, becoming more ethnically diverse (in particular experiencing an increase of Hispanics in the workforce), and growing older [Toossi, 2007, 2002]. These demographic changes have been accompanied by a shift away from an economy based on manufacturing jobs to one dominated by the services sector. To compete in the marketplace, many companies have restructured, downsized their workforces, increased their reliance on temporary workers and contractor-supplied labor, and adopted more flexible and lean production technologies [National Institute for Occupational Safety and Health (NIOSH), 2002]. These changes bear implications for the occupational health

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status of the workforce, and raise new challenges for researchers interested in tracking patterns of occupational injury and illness and developing appropriate and effective intervention strategies.

The existence of health disparities (or inequalities) in the United States across demographic and socioeconomic strata has been well described [Brondolo et al., 2009; Williams and Mohammed, 2009]. These disparities have been tied to a variety of inequalities in social determinants of health including easy access to healthy foods, neighborhoods that are safe and free from environmental contamination, and access to high quality and affordable healthcare services [Adler et al., 2007]. Work, where individuals spend a large portion of their waking hours, is also an important social determinant of health (see Krieger [2010] in this issue). The employment of some demographic groups in high-risk jobs can lead to disparities in work-related exposures and rates of illnesses and injuries, including fatalities [Murray, 2003; Lipscomb et al., 2006]. Factors such as workplace discrimination, ineffective training, or inadequate communication due to literacy or language barriers, and pressures to accept risky work assignments due to economic insecurity can also lead to health disparities, even among workers in similar jobs. Unequal access to healthcare providers trained in occupational health can result in disparities in the quality of care received for work-related conditions [Dembe, 2001]. Work is also often the source of health insurance, and increasingly, wellness and health promotion resources, representing additional linkages between employment and worker health.

At the same time that changes in our workforce and economy would point to the generation of disparities across worker groups, the occupational health of American workers is incompletely characterized. A variety of factors including occupational mobility, economic insecurity, and lack of training about the possible work-relatedness of health problems present barriers to reporting into occupational health surveillance systems, especially among those populations that may be most at risk. Gaps in the occupational health surveillance systems themselves present further challenges. Many researchers have commented on overall undercounting in occupational health surveillance systems [Leigh et al., 2004]. Most recently, the Committee on Education and Labor of the US House of Representatives published the majority report, *Hidden Tragedy: Underreporting of Workplace Injuries and Illnesses*, cataloging the evidence that the official Bureau of Labor Statistics (BLS) reports on work-related injuries and illnesses do not capture the true scope of illnesses and injuries that occur in the US workforce, potentially missing up to 69% of illnesses and injuries [Committee on Education and Labor, 2008]. Further, mechanisms that lead to differential undercounting of occupational outcomes among underserved worker groups have been well described [Azaroff et al., 2002].

NIOSH, through its National Occupational Research Agenda (NORA), has recognized the need to develop appropriate research strategies to reduce occupational health disparities. In creating a research agenda to reduce disparities, NIOSH researchers and external stakeholders identified improving surveillance systems as a top goal towards better targeting intervention programs. To better address these challenges, NIOSH, together with the Council of State and Territorial Epidemiologists (CSTE), sponsored a workshop on improving surveillance for occupational health disparities in April 2008. The goal of this workshop was to explore untapped sources and innovative approaches to collecting occupational surveillance data to better identify disparities in rates of occupational injuries and illnesses, especially among populations most likely to be disproportionately undercounted. Participants discussed the strengths and limitations of existing surveillance including the Bureau of Labor Statistics' data systems and workers' compensation statistics, and explored innovative approaches to supplementing these data such as through household surveys, medical claims data, and major non-workplace-based longitudinal epidemiological studies.

This article provides an overview of the existing systems for occupational health surveillance and a discussion of their suitability for characterizing disparities in occupational outcomes. We also describe ad hoc analyses that have been used to fill gaps in knowledge, and provide examples of creative and innovative approaches to the collection of data on worker groups about whom little has been documented. The discussion of data sources is followed by methodological considerations in the surveillance of occupational health disparities. Participants in the April 2008 workshop provided recommendations for continuing and new directions, and their ideas are also briefly summarized here (Table I). Though the scope of this special issue of the American Journal of Industrial Medicine goes beyond surveillance, many of the articles in this issue exemplify the opportunities and challenges discussed at this workshop. We describe how the work presented in this special issue fits within the broader context of surveillance for occupational health disparities.

DATA SOURCES USED FOR OCCUPATIONAL HEALTH DISPARITIES SURVEILLANCE

Occupational Health Surveillance Systems

There are two primary national surveillance systems dedicated to occupational health outcomes: the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illness (SOII, often referred to as the ''annual survey''), both run by the US Department of

TABLE I. Workshop Participants' Recommendations for the Surveillance of Occupational Health Disparities

Recommendation	Specific actions
1. Encourage the improvement of U.S. occupational illness and injury surveillance to capture disparities	Improve completeness of demographic data in SOII
	Support U.S. Department of Labor Bureau of Labor Statistics' efforts to improve surveillance systems
2. Continue to support state-based work as a critical component of occupational health surveillance	Support states' work to utilize local public health infrastructure and work with community partners to obtain valuable data not otherwise available
3. Conduct secondary analyses of non-occupational datasets	Assess availability and quality of occupation information
	Consider linking external sources for exposure data
	Develop meta-dataset of secondary sources for occupational health analysis
4. Consider alternative means of surveillance	Consider population-specific surveillance/surveys when needed
	Explore community-based surveillance with non-governmental organizations, community clinics, and other local organizations to capture hard to reach populations
5. Improve and expand sources of external exposure data	Validate external sources of exposure data (e.g., O*NET)
	Expand available external exposure data
6. Develop/utilize theoretical models	Apply theoretical models to clarify research hypotheses about the role of occupational exposures in health disparities
	Disentangle the role of occupational exposures from the contribution of occupation to socioeconomic position and class
7. Expand on NIOSH's current research agenda	Support the expansion of the surveillance, intervention, and research agenda to eliminate occupational health disparities, within the National Occupational Research Agenda

Labor's Bureau of Labor Statistics (BLS). CFOI represents a detailed accounting of work-related fatal injuries in the United States. Data gathering from 25 different sources ensures a high rate of capture of work-related fatalities to workers in all sectors, including workers on small farms, self-employed and family workers, and public sector workers [Ruser, 1998]. (BLS acknowledges that a small percentage of work-related fatalities, especially those that occur on farms, on the sea, or on highways may escape capture by the system [BLS, 2008].) CFOI records information on work arrangements (e.g., self-employed, family business employee, salaried or hourly), sex, age, race, and ethnic origin, foreign birthplace, and data on the industry and type of workplace, exposure that led to the injury, source of injury, activity, and location of the worker at the time of the incident. CFOI data can also be linked to other data sources, such as the Current Population Survey (CPS); such linkage is necessary to obtain a denominator to calculate rates.

Because worker fatalities are so well documented and CFOI includes both demographic information as well as occupational characteristics, it is an excellent source of data with which to track disparities in occupational fatalities. Researchers have made extensive use of CFOI data, to include the demonstration of disparities in work-related fatalities by ethnicity and foreign-born status. In the published literature are reports such as those by Mulloy et al. [2007] documenting disproportionate rates of work-related fatalities among Hispanic and foreign-born workers in New Mexico, and Loh and Richardson's [2004] article that helped direct attention to occupational fatality rates among foreign-born workers [Loh and Richardson, 2004].

SOII, which relies on reporting of data from the Occupational Safety and Health Administration records (i.e., OSHA 300 logs) kept by a nationwide sample of employers, is a widely cited source of occupational injury data for the U.S. The use of this data to demonstrate disparities in occupational outcomes is limited by missing race/ethnicity information for approximately one-third of the records [National Research Council, 2003; Committee on Education and Labor, 2008], since reporting race/ethnicity is voluntary. In addition, information on country of origin and foreign-born status is not included in SOII records. However, SOII data are capable of revealing other disparities, such as the dramatic difference between the types of events that injure younger versus older workers [see BLS, 2007].

More fundamental shortcomings of SOII data also hamper the description of occupational health disparities, namely the ''undercount'' or the finding that SOII represents an underestimate of the burden of occupational injuries in the U.S. [Ruser, 2008]. If underreporting of injuries to this BLS system occurred without regard to the demographics of workers, the estimation of *relative* measures would not be biased. However, as with other sources of occupational health data that rely on reporting, evidence for the systematic exclusion of data from minority and immigrant worker has been presented, and underserved workers are likely underrepresented in this data source [Azaroff et al., 2002].

A failure to report or capture a work-related outcome can occur at one of several sequential steps including the recognition and diagnosis of a work-related problem, the reporting of a health problem to a worker's supervisor, or recording of the health problem in employer logs, in what

has been referred to as the ''filtering effect'' [Webb et al., 1989; Azaroff et al., 2002]. SOII data are particularly vulnerable to this effect, as a worker's condition must not only be recognized and diagnosed, but must be recorded by an employer on the OSHA log in order to appear in the SOII system—a drawback of ''establishment-based'' survey systems. BLS is currently conducting investigations into undercounting in the SOII system [Ruser, 2008]. Those and others' efforts to assess and improve national surveillance systems are crucial to ensure that disparities in occupational health can be accurately described.

Occupational health researchers also go directly to OSHA logs (often accessing OSHA logs with assistance from employees' unions) to assess and describe the burden of occupational injury, at times comparing OSHA log data to another source of occupational data [e.g., Welch and Hunting, 2003]. In this issue, Buchanan et al. [2010] use OSHA 300 logs from five large unionized hotel companies to estimate injury rates in non-supervisory hotel workers and document disparities by Hispanic ethnicity, sex, job title, and by hotel chain. Through linking and matching OSHA log data with an employee roster, the investigators were able to disaggregate OSHA recordable outcomes by race and ethnicity. Their report demonstrates the value of administrative records, and arguably, also makes a case for the inclusion of worker race and ethnicity in occupational injury records (such as OSHA logs and workers' compensation records), as linkage with union rosters or personnel files is not always possible.

Workers' compensation data, though not formal surveillance systems, have been extensively used for surveillance and research [Levy et al., 2006; Markowitz, 2007]. Workers' compensation data sets usually contain information on costs (a major focus of these systems), some data on cause of or type of injury, demographic information including age, occupation, and address, and are most complete for insured (vs. self-employed self-insured) employers. For researchers, obtaining access to and working with these state-based datasets can be challenging. A major barrier to using workers' compensation data for identification and tracking of disparities is the lack of race, ethnicity, and place of birth information in these datasets [Hunt et al., 2005]. Commonly available variables that might be used to examine disparities include age at injury, occupational class (codes for occupational class are available for claims from insured employers), and pre-injury wage. Other variables may be available on a state-by-state basis. For example, in this issue, Bonauto et al. used data on claimants' language preference from Washington state compensable claims data to assess the experience of non-English speaking workers. Using this data, Bonauto et al. [2009] found associations between language proficiency and delays in claims adjudication and administration (including approval for medical treatment) for work-related conditions.

Also in this issue, Smith et al. [2010] used Washington state workers' compensation data including the ''Report of Industrial Injury for Occupational Disease'' (RIIOD) completed by the healthcare professional, to compare the experience of workers employed by temporary agencies to workers in standard arrangements based on North American Industrial Classification System (NAICS) codes. Disparities driven by contingent employment are an emerging focus among researchers in the U.S. and around the world [Quinlan et al., 2001; Landsbergis, 2003; Quinlan and Bohle, 2009]. Approaches such as Smith et al.'s creative use of workers' compensation data are needed to describe the occupational health status of contingent workers.

State-Based Surveillance

NIOSH funding activities include support of state-based occupational health surveillance activities. Fifteen states are currently funded to collect data on a variety of conditions and working populations [NIOSH, 2008a; Davis and Souza, 2009]. State-based activities not only assist NIOSH in determining needs and priorities, but also generate data to describe local variations in occupational health and provide links to intervention activities. In addition, state-based surveillance systems, though not currently funded to provide ''coverage'' of the entire country, provide needed information on occupational illness. It is widely recognized that SOII provides poor estimates of the incidence of occupational illness (vs. injury), and is particularly poor at surveillance of chronic illnesses.

Funding to states supports ''fundamental'' surveillance activities, including the preparation of occupational health indicators [Centers for Disease Control and Prevention, 2007] as well as focused projects based on local needs and available data sources [NIOSH, 2004]. The analysis of hospital discharge data by Lefkowitz [2010] in this issue is an example of a fundamental state surveillance activity that can be repeated over time to monitor trends, and may be compared with other states, within limitations.

Focused projects variously involve surveillance on priority health conditions, populations, or exposures of interest at the state level, and usually include intervention components. Such state-based projects include Fatality Assessment Control and Evaluation (FACE) programs (nine states) and surveillance of serious work-related injuries to teens (one state). States tailor these programs to local needs, including adding special emphases on disparities when indicated [see NIOSH, 2007]. For example, Massachusetts' FACE (MA FACE) program recently identified a rise in fatal work-related injuries among immigrants from Brazil. Though Hispanic workers have been identified as a group experiencing disproportionately high rates of work-related fatalities (both in Massachusetts and nationally [CDC, 2008]), data on workers of Brazilian origin had not

previously been reported. Because Brazilian workers may be identified within several racial and ethnic categories, aggregated statistics can obscure the experience of this group. MA FACE worked to identify all victims of Brazilian origin and described and publicized 15 cases of work-related fatal injuries to Brazilian workers [Massachusetts Department of Public Health (MDPH), 2009]. The MA FACE program worked closely with leaders in the local Brazilian community to provide workers with information about the causes of these fatalities and workers' health and safety rights on the job.

NIOSH's state-based Sentinel Event Notification System for Occupational Risk (SENSOR) includes surveillance of respiratory diseases such as work-related asthma (five states [Rosenman et al., 1997; NIOSH, 2008b]), silicosis (two states), and injury and illness from pesticide exposure (five states [NIOSH, 2009a]). Some state-based surveillance projects include a de facto focus on populations of minority or immigrant workers, such as pesticide injury and illness surveillance in agricultural states. Farm work is typically performed by migrant and immigrant workers, who may have low education and literacy levels and low English skill [Villarejo, 2003; Villarejo and McCurdy, 2008].

In this issue Calvert and Higgins describe how a NIOSH-funded state-based SENSOR pesticides program identified a cluster of birth defects cases among babies of female farmworkers that were linked to pesticide exposure [Calvert and Higgins, 2010]. Calvert and Higgins' report illustrates the importance of state occupational health surveillance activities to not only developing systems for monitoring and tracking of health outcomes but for guiding policies and practices that are determined at the state level.

Targeted Surveillance Systems

When occupational health information about a population is particularly elusive, NIOSH may institute a targeted surveillance program. One such program is NIOSH's collaboration with the U.S. Department of Labor's National Agricultural Workers Survey (NAWS) [Steege et al., 2009; U.S. Department of Labor Employment and Training Administration, 2009a]. NAWS, initiated in 1988, is a probability survey of a sample of U.S. hired crop workers. Between 1,500 and 4,000 workers are interviewed each year to produce the most extensive source of information on farmworkers. The NAWS survey is tailored to the characteristics of much of this workforce including: low English language skills, mobility, seasonal and geographically variable employment, lack of personal telephones, etc. The primary limitation to the NAWS involves achieving a truly representative sample. Enumeration of farm employers relies primarily on the Department of Labor's Quarterly Census of Employment and Wages (QCEW) file—a limited source for farm employers that lists few small farms. Farmworker turnover, employer refusal rate, and other selection and participation issues threaten generalizability and potential validity. Despite these drawbacks, the NAWS can serve as an example of targeted surveillance on a population of workers who would otherwise go undescribed.

Analysis of Secondary (Research) Data

Data collected for purposes *not* specific to occupational health studies can be of great value to occupational health researchers. National or large health surveys may be used to document and study occupational health disparities. For example, occupational health researchers have used both the National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES). A particular advantage in using secondary data is that populations not often well captured by occupational health surveillance systems, such as minority and immigrant populations, may be the focus of or may be oversampled by those non-occupational data collection programs.

Perhaps the first researchers to explicitly demonstrate the utility of general surveillance data for occupational health studies were Kaminski and Spirtas, who used NHIS to calculate morbidity, disability and reported healthcare use patterns by industry and occupation. Those authors recommended exploring NHIS for extensive surveillance of occupational diseases. NHIS, as with other sources that were not collected with occupational studies in mind, has limitations [Kaminski and Spirtas, 1980]. For example, detailed occupation and industry codes are available for many years of data (excluding the most recent years), however occupation information concerns current job only, and workplace exposure information is not available. On the other hand, NHIS does offer an advantage in that the nationally representative sampling frame includes oversampling of minority populations.

Several analyses of NHIS data have produced information on occupational health disparities. Fleming et al. [2003] used NHIS to describe the mortality experience of pesticide-exposed workers (i.e., farmers and pesticide applicators), finding an elevated age-adjusted risk of accidental death and death from certain cancers, when compared to other U.S. workers. Caban-Martinez et al. [2007] used NHIS to demonstrate disparities in healthcare access across worker populations and found that unmet dental needs were highest in health service workers (males) and construction and extraction workers (females). Monographs of occupational health studies conducted using NHIS have been compiled by the University of Miami's Miller School of Medicine [University of Miami Occupational Research Group, 2009].

In this issue, McCollister et al. [2010] analyzed NHIS data and found that Hispanics were at least four times more likely than whites or blacks to lose their health insurance during the 1997–2007 study period. This study and the findings of Caban-Martinez demonstrate an important

mechanism through which work fundamentally interacts to affect workers' health and drive health disparities: through the provision (or lack thereof) of access to medical care.

NHANES, another nationally representative sample of the U.S. civilian, non-institutionalized population, also provides useful data for occupational health surveillance. For example, Tak et al. [2009] used NHANES data to identify high noise exposure occupations and industries, and high exposure settings in which workers reported lower than average use of protective devices. While NHANES offers exposure data (such as noise) not typically collected by NHIS, NHANES generally contains less detailed occupational information, allowing for analysis only by broader occupational groupings.

Other national surveillance systems, recurring and longitudinal surveys, and one-time surveys may also be used to gain information about the distribution of health conditions related to work. The Health and Retirement Study is a biennial longitudinal study of middle-aged and older adults focusing on issues of health and retirement and how aging adults and their families deal with declining health in later life. HRS includes a series of questions about work; therefore, researchers may probe the relationship between work and the numerous health outcomes in the dataset [e.g., NIOSH, 2009b; University of Michigan Institute for Social Research, 2009]. The survey is nationally representative and oversamples African-Americans, Hispanics, and Florida residents, allowing for the possibility of studies of disparities by race among older Americans.

Public use datasets from federally funded studies can be identified through the Computer Retrieval of Information on Scientific Projects (CRISP) database, or through a federal agency's webpage, for example, the National Heart Lung and Blood Institute (NHLBI). These datasets derive from federally funded, usually longitudinal, data collection systems that may be amenable to add-on data collection and special studies. An assessment of the utility of existing data must be done, including ascertaining the presence and quality of occupation/industry and demographic variables. MacDonald et al. [2009] recently reviewed 30 population-based epidemiology and surveillance datasets (19 of which were public-use sets), collected to identify risk factors for cardiovascular disease. Their review found that 26 of the 30 datasets reviewed contained occupation and industry information, though these variables were often not used or were utilized solely as indicators of socioeconomic position.

In this issue De Castro et al. report on their use of the National Latino and Asian American Study [Center for Multicultural Mental Health Research, 2009], a 2002–2003 survey of 2,554 Latino and 2,095 Asian American respondents that aimed to gather data on the similarities and differences in mental illness and service use. De Castro et al. [2010] found that among employed persons, smoking prevalence is highest in male blue-collar Asian American workers. The authors point out the confluence of disproportionate exposures these workers may experience: not only smoking, but also the chemical exposures that are more abundant in blue-collar jobs. This study corroborates evidence from previous studies that point to blue-collar workers as a focal point for intervention activities that address workers' health.

Health Claims and Healthcare System Data

Healthcare system and health claims data are collected primarily for medical and administrative (e.g., billing) purposes. Researchers have pointed to the value of administrative data for occupational health research and surveillance, acknowledging that the need for data on occupational health outcomes is not met by existing surveillance systems [e.g., Pollack et al., 2007]. Such data include workers' compensation files (discussed previously), health insurance claims, union health and welfare fund data, hospital discharge (HDD) and emergency department data, and records from other healthcare settings such as community-based clinics and health centers.

Hospital data have previously been used to estimate rates of occupational outcomes [Sorock et al., 1993; Earle-Richardson et al., 2003; Alamgir et al., 2006] including identifying disparities [Hunt et al., 2005]. In this issue, Lefkowitz et al. report race- and ethnicity-specific rates of work-related injuries. Their analysis of HDD data revealed higher rates of certain work-related injuries for Hispanic workers, compared to non-Hispanic workers. The investigators concluded that HDD are a viable source of data for monitoring of disparities in occupational injury experience in NJ, and may possibly serve as a source of feedback regarding interventions with targeted groups of workers [Lefkowitz, 2010].

Administrative claims data, collected for purposes other than research, can be limited by a lack of variables of interest (e.g., race and ethnicity in workers' compensation data) and can present challenges to researchers (e.g., complexity of diagnosis codes in hospitalization records). Using health claims data for the purpose of identifying occupational health disparities is further hampered by the underrepresentation of minority populations among the insured. The very workers of interest to those aiming to document and track occupational health disparities will often be underrepresented in claims datasets. In this issue, Lowry et al. [2010] described such a limitation, in their assessment of the utility of hospital-based trauma registry data as a source of information on traumatic injury to contingent workers. Studies such as Lowry et al.'s, that reveal weaknesses and biases in our data sources, may help to stimulate efforts toward finding solutions.

Another challenge associated with using health claims data is identifying the population at risk. Appropriate

denominator information for the cases in claims datasets will usually not be available. Overcoming the lack of data on the base population is particularly challenging, though there are examples in the literature. For example, a research group that included the Carpenters' Trust of Western Washington built a cohort data set from union work records and outcome data obtained from both health insurance (health and welfare fund) and workers' compensation records (for description of cohort, see Lipscomb et al. [1997]). Using a similar approach, Duke University researchers studied occupational outcomes among the university workforce by employing human resources data and, similar to the Carpenters' Trust, identified incident health events through the use of both workers' compensation records and health insurance claims data. The Duke researchers used this linked data not only to identify trends in occupational injuries but also to look for potential sources of bias. The investigators' finding that nurses' aides were less likely than RNs to be represented among the insured workers indicates that estimates of health outcomes among the nurses aides were likely to be undercounts, relative to RNs ([Pompeii et al., 2008], for cohort description see Dement et al. [2004]).

Combining and linking such data represents an opportunity to examine the interplay between the workers' compensation and private insurance claims and to improve capture of occupational health outcomes. Some investigators have used multiple data sources to attempt to capture more incidents than may be captured by any one data source alone. Walters [2009] used hospitalized claims from workers' compensation and records from a regional burn center to characterize occupational burns in Oregon. Researchers in Kentucky [Bunn et al., 2007] linked hospital discharge and WC data to describe work-related injuries in that state.

Novel sources of health data are also being explored, such as from community health centers (CHCs) whose outreach and services are often focused on underserved populations. The Massachusetts Department of Public Health's Occupational Health Surveillance Program (OHSP) has undertaken two projects aimed at surveillance of low-income minority and immigrant workers—populations for whom little data were available at the state level. First, with an enhanced surveillance project funded under NIOSH's state-based funding program, OHSP surveyed working CHC patients about their occupational health experience and began to assess the feasibility of conducting occupational health surveillance through CHCs. The survey provided rare information on the occupational health experience of low-income minority and immigrant workers in Massachusetts. OHSP identified CHCs as potential partners for meeting the occupational health needs of those workers [MDPH Occupational Health Surveillance Program, 2007].

The second demonstration project, currently underway, is partnering with four CHCs to systematically collect patients' occupational information, and establish methods to identify work-related injuries and illnesses in the medical data system. Electronic medical records (EMRs) are quickly being instituted in medical settings including CHCs, and present a possibility for occupational data fields to be programmed into electronic health systems. A broader effort by the public health community to address occupational health surveillance through EMRs and more generally, electronic health records (EHRs), is needed [Filios et al., 2008].

METHODOLOGICAL CONSIDERATIONS IN OCCUPATIONAL HEALTH DISPARITIES SURVEILLANCE

Measuring Occupational Health Disparities

In addition to identifying an appropriate data source for the surveillance of occupational health disparities, several methodological issues should be considered. These include defining the disparity, obtaining adequate data on exposures, correctly estimating denominators, and avoiding bias in the use of an occupation variable.

Surveillance of a health disparity necessarily involves defining the disparity and deciding how progress toward reducing it will be measured. The National Center for Health Statistics (NCHS), mandated with tracking progress toward eliminating health disparities, has produced considerable guidance on defining and measuring disparities. Researchers at NCHS have enumerated some of the major decisions involved in reporting health disparities in their report *Methodological Issues in Measuring Health Disparities* [Keppel et al., 2005]. They include: choice of a reference point from which to measure disparities, the choice of a comparison population, whether the disparity is reported in terms of favorable or adverse events (e.g., personal protective equipment is available vs. not available), whether the disparity focuses on pairs or summary measures over all of the groups (i.e., African-American, Asian, American Indian, Pacific Islander, White) within a domain (i.e., race), and choice of summary statistics to be reported (absolute measure such as the difference in rates vs. relative measures such as relative risk). All of these factors affect the conclusions that will be reached regarding the existence and size of a disparity [Keppel et al., 2005].

Sources of Denominator Data for Occupational Health Disparities Surveillance

For the calculation of incidence rates, data on the size of the population at risk (denominator data) are needed.

There are several sources of denominator data for the U.S. workforce, though each has limitations for the surveillance of disparities. The CPS, administered by BLS and the Census Bureau, is the most extensive source of denominator information on the U.S. workforce. CPS samples non-military, non-institutionalized members of approximately 57,000 households through personal and phone interviews. Characteristics of employment are collected, as are a limited set of demographics (age, sex, race and ethnicity, education, marital status). Special studies (with supplemental questions) have been conducted with the CPS including data collections on foreign-born workers, union members and people who work at home. The Census Bureau also administers the American Community Survey (ACS), a survey of more than three million addresses that contains similar industry and occupation information to the CPS, plus some additional demographics. Differential undercounting has been documented in the U.S. Census Bureau samples [U.S. Census Bureau, 2002]. To the extent that minority and/or immigrant workers participate in the workforce yet are undercounted by these surveys, the accurate estimation of occupational injury and illness incidence rates will not be possible. In 2009, the US Census Bureau announced an increase in the administration of Spanish-language surveys in the hopes of maximizing the participation of Spanish speakers.

The Current Employment Statistics (CES) survey, administered by BLS, surveys approximately 390,000 businesses and government agencies for payroll information on employment, including wages, hours, and geographic detail. However, aside from sex, the CES does not contain demographic variables. BLS also administers the Quarterly Census of Employment and Wages (QCEW), which collects workforce data on only those workers covered by state unemployment compensation plans and federal workforce unemployment compensation. This dataset has extensive industry detail (as does the CES), and geographic detail, however, among other limitations, it does not include demographic characteristics. The Occupational Employment Statistics (OES), administered by BLS, is a semi-annual mail survey of 1.2 million establishments over 3 years. The OES contains detailed employment, wage, industry and geographic information according to occupation; however, as with the CES and QCEW, the dataset cannot be used for the preparation of denominators because it lacks demographic information.

Comparing denominator information across surveys of the same population group can point to problems in ascertaining the base population for a survey or study. For example, the availability of appropriate denominator/comparison data presents a challenge to farm labor researchers. Comparison of the 2006 (crop-only) NAWS (described previously) sample with the 2006 CPS (crop and livestock) reveals significant baseline demographic differences between the two samples [Kandel, 2008], calling into question the ability to draw valid conclusions when comparing those two samples. The availability of accurate denominator information on worker groups such as farmworkers is especially important to describe the occupational health status of those workers, and importantly, to our ability to compare their health status to that of other workers.

Exposure Assessment

A challenge to accomplishing meaningful occupational health surveillance (and etiologic research), especially when using secondary data sets, can be the lack of information that has been collected on worker exposure. Data sets not originally collected for occupational investigations may lack include information on workplace exposures. For example, in the previously discussed review by MacDonald et al. [2009], only 17 of the 30 datasets examined contained information on workplace exposures. At times it may be possible to link datasets missing exposure data to external sources of exposure information, usually through common variables such as occupation/industry combinations.

One such source of external exposure data is the Occupational Information Network (O*NET) data [U.S. Department of Labor Employment and Training Administration, 2009b]. O*NET, developed and maintained by the Department of Labor, is a comprehensive source of data including the skills, abilities, knowledge, tasks, work activities, work context, experience levels, job interests, and work values/needs required by a given occupation. Though limitations in the use of linked exposure information, such as variation within occupations that is obscured by an average O*NET rating, are a reality, the use of exposure databases may enhance the utility of non-occupational health datasets for occupational health analyses, including surveillance.

O*NET has recently been used in etiologic investigations into disparities. d'Errico et al. [2007] and Boyer et al. [2009] have used O*NET as a source of information on work exposures, in an effort to disentangle the role of socioeconomic status (SES) from that of working conditions. d'Errico et al. observed a strong gradient by SES in rates of work-related injuries among hospital workers. By linking occupations to psychosocial, ergonomic, and organizational exposure data through O*NET, the authors found the gradient was reduced significantly, indicating that occupational exposures made a substantial contribution to injury rates [d'Errico et al., 2007].

In this issue, Meyer et al. used O*NET as a source of information on the ''substantive complexity'' of mothers' work, and linked that information to maternal occupation on birth certificates. Exploring the dual roles of work and educational attainment in rates of low birth weight (LBW) among white, black, and Hispanic infants, Meyer et al. [2010] found that a mismatch between maternal educational attainment and work substantive complexity was associated with

LBW only in babies born to black mothers. Though d'Errico et al.'s and Meyer et al.'s studies did not produce surveillance-type estimates, they demonstrate the potential to use an external source of exposure data to help clarify the role of occupation in health.

Modeling Occupation

The preceding discussion of the various meanings of occupation alludes to the fundamental complexity involved in modeling an occupation variable. As mentioned previously, care should be taken when using occupation collected only for the purposes of assigning SES. However, methodological challenges in the use of occupation variables go far beyond issues of data quality or misclassification. Though occupation alone, or as a component of a composite variable, is sometimes considered a proxy for SES, it may also serve as a proxy for work exposures in relation to health, as illustrated by d'Errico et al.'s finding. Socioeconomic gradients in health have been observed to various extents. Many European studies using occupational categories as indicators of SES have found consistent associations with health indicators [Rose and Marmot, 1981; Marmot et al., 1991]. In the U.S. this relationship has been less clear, possibly due to the heterogeneity of prestige, skills, power, and earning potential within U.S. occupational classification.

As argued by Landsbergis [2010] in this issue, all component measures should be examined individually with attention to possible explanatory pathways; the multiple potential roles for occupation must be considered. When a potentially relevant variable, for example, a workplace exposure, is unmeasured, the implications of its absence should be discussed in relation to the conclusions reached about the role of work [Braveman et al., 2005]. When not considered the main exposure, working conditions may be on the causal pathway between SES and health or they may be confounders of the relationship between occupation and health outcomes. The use of more appropriate statistical methods such as causal diagrams, structural equation modeling, and multilevel regression is needed to disentangle the role of work in these complex relationships [Landsbergis, 2010].

The April 2008 workshop that initiated this discussion of data sources and methods for the surveillance of occupational health disparities enabled participants to pinpoint some of the most significant challenges to their work. Meeting participants also made recommendation and suggestions for the continued improvement of the systems that track occupational outcomes in this country; those are briefly summarized in Table I. While accomplishing surveillance for occupational health disparities involves many challenges, the potential to explore untapped data sources and bring creative approaches presents opportunities to interested researchers.

Our data systems cannot be considered successful until we have demonstrated proven capability to identify and track disparities, even (and especially) among the hardest-to-reach, most precariously employed worker groups. This will necessarily involve the enhancement of current systems, the development of new data collections, and the integration of our work with other public health practitioners and researchers who also reach out to underserved groups in the population with other health studies and interventions in mind. An increasing interest in the social determinants of health and a surge in workplace-based wellness and health promotion activities present opportunities for occupational health researchers to combine efforts with social epidemiologists and health promotion practitioners. This should result in more holistic public health programming that collects improved data on our underserved populations, and returns with effective health and safety interventions.

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