AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 57:596–604 (2014)

Occupational Health Disparities: A State Public Health-Based Approach

Martha Stanbury, MSPH[1]* and Kenneth D. Rosenman, MD[2]

Background *This report used employment and public health surveillance data in Michigan to characterize work-related race/ethnic health disparities.*
Methods *U.S. Census data were used to calculate the percent by race/Hispanic ethnicity in occupational groups ranked by three measures for potential work-related health risks. Disparities by race/ethnicity were generated from occupational health surveillance data.*
Results *Blacks and Hispanics were over-represented in lower wage–higher manual–labor occupations and in highest risk occupations. Blacks were at greater risk of silicosis, work-related asthma, and work-related burns than whites, and Hispanics had higher rates of work-related acute fatal injuries and pesticide injury than non-Hispanics.*
Conclusions *Michigan employment data indicated that blacks and Hispanics were overly represented in lower paid and more hazardous jobs. Occupational health surveillance data confirmed disparate risks for some illnesses and injuries. This approach can be used in other states to bring awareness to policy makers and direct interventions.* Am. J. Ind. Med. 57:596–604, 2014. © *2013 Wiley Periodicals, Inc.*

KEY WORDS: health disparities; occupational health surveillance; work-related injury/illness

INTRODUCTION

It has been proposed that work-related health disparities arise in part from over-representation of racial and ethnic minority workers in the most hazardous occupations and industries and from the incomplete penetration of occupational health and safety interventions to certain worker populations due to barriers created by social, cultural, and economic issues including language, literacy, and marginal economic status [Murray, 2003; Lipscomb et al., 2006; Landsbergis, 2010; NIOSH, 2012a]. Monitoring the magnitude and characteristics of work-related health disparities by race and Hispanic ethnicity over time is critical for identifying priorities for interventions to address the causes of these disparities and assessing the impacts of interventions.

The history of labor in the United States abounds with stories of death and disease among minority and immigrant workers. For example, in 1911, 146 mostly female immigrant textile workers died at the Triangle shirtwaist factory fire in New York City [Berman, 1978]; and, in the 1930s over 1,500 African American workers digging a water tunnel in Gauley Bridge West Virginia died of acute and accelerated silicosis from inhaling high concentrations of silica dust [Rosner and Markowitz, 1991]. Studies have identified the increased burden of lung cancer among African Americans compared to whites, who worked in chromate and bichromate production [U.S. Public Health Service, 1953], rubber production [McMichael et al., 1976], and foundries [DeCoufle and Wood, 1979]. Hispanic and African American workers have been found to be at increased risk for all injuries and illnesses compared to whites [Robinson, 1989]. Within two occupational groups, black hospital workers have been found to be at increased risk for all injuries [Simpson and Severson, 2000]

[1]Division of Environmental Health, Michigan Department of Community Health, Lansing, Michigan
[2]Department of Medicine, College of Human Medicine, Michigan State University, Lansing, Michigan
Contract grant sponsor: National Institute for Occupational Safety and Health; Contract grant number: U60 OH008466.
Disclosure Statement: The authors report no conflicts of interests.
*Correspondence to: M. Stanbury, MSPH, State Administrative Manager, Division of Environmental Health, Michigan Department of Community Health, P.O. Box 30195, Lansing, MI 48909. E-mail: stanburym@michigan.gov

Accepted 5 December 2013
DOI 10.1002/ajim.22292. Published online 30 December 2013 in Wiley Online Library (wileyonlinelibrary.com).

compared to white hospital workers, and black textile workers have been found to be at increased risk of byssinosis compared to whites [Martin and Higgins, 1976]. A high percentage of the migrant agricultural work force is Hispanic; workers in the agricultural industry are at risk of pesticides poisonings [Kutz et al., 1977] and acute injuries such as heat stroke [Luginbuhl et al., 2008; Fleischer et al., 2013]. The work-related traumatic injury death rate for Hispanics has exceeded the rate for non-Hispanics in most of the past 20 years [Cierpich et al., 2008; Byler, 2013].

Although work-related health disparities have been identified by high profile events and research studies, there is no nationwide surveillance system that is tracking work-related health disparities [Souza et al., 2010]. Data on race (white, black or African-American, Asian, other and multiple race) and Hispanic ethnicity from the official national system that tracks occupational injuries and illnesses (the annual Survey of Occupational Injuries and Illnesses (SOII) conducted by the Bureau of Labor Statistics) is very limited because reporting of these data elements is voluntary and is missing in 37% of the records [Bureau of Labor Statistics, 2012]. Most workers compensation data systems are not useful for tracking work-related disparities by race and Hispanic ethnicity because the national standard for claims reporting that is used by 80% of state workers compensation systems does not have data elements that cover race or ethnicity.[1]

State-based occupational health surveillance systems, on the other hand, often do have information on race and Hispanic ethnicity because of their access to patient data in hospital discharge records, healthcare provider reports, death certificates, poison center data, and other state health data sources. State occupational health surveillance programs have legal access to these data under the public health exclusion in the Health Insurance Portability and Accountability Act, which permits sharing of protected health information for public health purposes as long as the agency to which the information is provided is legally authorized to collect and receive that information [CDC, 2003]. Funding from the National Institute for Occupational Safety and Health (NIOSH) over the past 30 years has supported case-based occupational health surveillance systems in states, and these state data systems have been effective in linking data with interventions including workplace investigations, industry-wide activities and educational outreach [NIOSH, undated].

The objective of this report is to illustrate the value of using state demographic and employment data from the U.S. Census and data from a state-based occupational health surveillance program for identifying and addressing health disparities associated with work.

[1] Howe F. International Association of Industrial Accident Boards and Commissions. Personal communication 9/4/2013.

MATERIALS AND METHODS

Employment Demographics in Michigan

Data on the distribution of workers by race and Hispanic ethnicity in occupations and industries in Michigan was extracted from the U.S. Census Current Population Survey (CPS) using the U.S. Census' on-line data mining tool "Dataferrett" [U.S. Census Bureau, undated]. CPS is a monthly statistical survey conducted by the United States Census Bureau for the Bureau of Labor Statistics (BLS). It includes state-level data on the numbers employed by occupation and industry groups categorized using the U.S. Census coding system for race (white, black or African American, Asian, American Indian, and various smaller racial groups) and ethnic (Hispanic/non-Hispanic) groups. Note that the U.S. Census collects information on race and Hispanic ethnicity as separate categories for each person, thus these categories are not mutually exclusive.

Data were extracted in three ways to explore the supposition that minorities were over-represented in more hazardous jobs and thus were at higher risk of work-related illnesses and injuries. The first two ways were based on the proposition that low wage, non-professional work is higher risk because it generally involves more manual labor and more exposure to physical and chemical hazards [Lipscomb et al., 2006]. Accordingly, first, the percent employed by race and Hispanic ethnicity in Michigan was compared for each of the 21 major occupational categories and ranked by median hourly wage published by the Bureau of Labor Statistics [Bureau of Labor Statistics, undated]. Second, the percent within each race/ethnic group employed in specific occupations among all employed in that occupational group was obtained; the ten most common occupations within each race/ethnic group were selected and categorized by whether they were professional/managerial, clerical/service, or trades/operators/manual labor based on the major occupational grouping of the International Standard Classification of Occupations [International Labor Office, 2012]. The third way used data on occupational injury/illnesses by occupation: the percent by race and Hispanic ethnicity employed in Michigan was determined in each of the eleven private sector occupations with highest incidence rates of occupational injuries and illnesses nationally [Bureau of Labor Statistics, 2007].

Michigan Occupational Health Surveillance Data

Michigan has been conducting work-related public health surveillance since 1988 with support from NIOSH. Work-related surveillance activities have been a collaboration between Michigan State University, the Michigan Occupational Safety and Health Administration (MIOSHA) housed

in the Michigan Department of Licensing and Regulation, and the Michigan Department of Community Health. Michigan State University has been designated the bona fide agent of the state to lead the occupational health surveillance activities of Michigan.

Occupational diseases and all injuries are legally reportable conditions under Michigan's Public Health Code (Act 368 of 1978) and its associated administrative rules. They require reporting of personal identifiers, demographic information and clinical data by healthcare providers, clinical laboratories, healthcare institutions, and employers. Although all occupational conditions are reportable, surveillance activities have focused on a limited number of conditions, including work-related asthma, silicosis, fatal occupational injuries, work-related burns, and acute pesticide-related injury and illness. Years when these conditions were placed under surveillance varied depending on funding. When information from individuals reported to the surveillance system indicated ongoing unsafe conditions at their worksites, additional follow-up was conducted by MIOSHA to identify and ameliorate health and safety hazards. Detailed descriptions of the surveillance systems' data and intervention activities are provided in annual reports (http://www.oem.msu.edu/AnnualReports.aspx).

Each condition-specific surveillance system includes demographic information, including race and Hispanic ethnicity, information about the person's occupation and industry where they were exposed, and clinical information to determine if the case meets the surveillance case definition for that condition. This information was abstracted from medical records and case interviews that were obtained after receipt of initial case reports. It should be noted that the data definitions for race and Hispanic ethnicity have depended on the condition under surveillance. In some, one data element included both race and Hispanic ethnicity as mutually exclusive categories, and for others, as is done in Census data, there were two data elements where race and Hispanic ethnicity were not mutually exclusive.

Analysis of race and Hispanic ethnicity data for silicosis, fatal occupational injuries, acute work-related pesticide illness/injury, occupational asthma, and work-related burns surveillance systems in Michigan are presented here. Analysis of the race/Hispanic ethnicity data in each surveillance system included comparisons of rates by each race group and by Hispanic/non-Hispanic ethnicity. Cases in each surveillance system with missing race/ethnicity information were excluded from the analysis. Denominators for rates were from the Current Population Survey [U.S. Census Bureau, undated]. The denominator for silicosis was the average annual male population in each race group over age 40 for 1985–2010, the years of surveillance data. This denominator was used because of the long latency of the condition from time of exposure to onset of disease and because silicosis occurred almost always in men. The denominators for the other conditions were the annual employed population for each race/ethnic group averaged over the years of each surveillance system. Statistical significance of the comparisons of rates between racial and ethnic groups were calculated using OpenEpi 2.3.1 [Dean et al., 2011].

The Institutional Review Boards of Michigan State University and the Michigan Department of Community Health reviewed and approved the occupational health surveillance programs from which the data for this study were derived.

RESULTS

Employment Demographics

The Michigan workforce in 2011 was estimated to be 4,202,653, in the following race categories: 84.7% white, 10.4% black, 3.1% Asian, and 1.8% other including multiple races. The workforce included 3.8% of Hispanic origin (Hispanics may be included in all race categories).

Compared to whites, blacks were over-represented in five of the seven lowest paid occupational groups (bottom tertile), and underrepresented in six of the seven highest paid groups (top tertile) (Table Ia). Hispanics were underrepresented in six of the seven highest paying occupations and over-represented in four of the seven lowest (Table Ib). The 10 most common occupations where individuals in each race/ethnicity group were employed are shown in Table II. All of the top 10 occupations among blacks and 9 of the 10 occupations of Hispanics were service or manual labor; in contrast only 1 among Asians and 7 of the 10 top occupations of whites and were service or manual labor.

Blacks were over-represented in 3 of the 11 occupations with highest work-related injury/illness rates nationally (nurses aides: 27%, laborers: 22%, and truck drivers: 22.1%; compared to 10.4% overall). Hispanics were over-represented in three of the 11 highest risk occupations (construction laborers: 7.9%; truck drivers: 13.2%; and food servers, non-restaurant: 13.6%; compared to 3.8% overall) (Table III).

Michigan Occupational Health Surveillance Data

Silicosis

Silicosis is a chronic disease with scarring of the lung, which is caused by inhalation of silica dust. In addition, individuals with silicosis are at increased risk of developing, connective tissue disease, kidney disease, lung cancer, and tuberculosis. Industries with historically high levels of exposure to silica include foundries, mining, and ceramics and glass manufacturing. Of the 1,109 persons confirmed

TABLE IA. Percent Employed in Michigan in 2011 in Major Occupational Groups* by Race, Ranked by Median Hourly Compensation Rate for Each Occupational Group**

			Race			
Occupational groups	**Median hourly rate**	**Michigan # employed**	**% White**	**% Black**	**% Asian**	**% other**
All occupations	$16.71	4,202,653	84.7	10.4	3.1	1.8
Management	$45.15	448,268	88.1	5.7	4.4	1.8
Computer and math	$36.67	83,179	75.2	6.8	15.3	2.7
Legal	$36.19	40,824	95.2	3.6	1.2	0
Architecture and engineering	$35.35	122,791	80.2	4.8	12.5	2.5
Business and financial	$30.05	151,630	82.5	11.4	4.5	1.6
Healthcare practitioners	$28.95	287,413	83.8	8.4	5.7	2.1
Life, physical, and social sciences	$28.89	32,126	82.1	3.1	12.4	2.4
Production	$25.98	352,176	83	12.1	3.6	1.3
Education	$22.13	236,573	87	9	3.8	0.2
Arts, design, entertainment, sports	$21.12	73,790	93.4	3	0	3.6
Installation maintenance and repair	$19.72	135,209	89.9	6	1.1	3
Community and social services	$19.42	60,273	74.1	23.8	2.1	0
Construction and extraction	$19.29	155,550	92.5	6	0	1.5
Protective services	$17.60	74,769	84.5	13.1	0	2.4
Office/administrative support	$15.05	522,843	87.7	10.4	1.1	0.8
Transportation	$13.92	245,355	81.6	16.2	0.5	1.7
Healthcare support	$12.28	114,038	77.1	20.9	1.6	0.4
Sales	$12.09	446,182	88.6	8.5	1.2	1.7
Building and grounds cleaning and maintenance	$10.91	144,716	71.7	18.3	2.9	7.1
Personal care and service	$10.02	169,704	76.3	18.7	2.8	2.2
Farming/fishing	$9.31	35,426	93.2	0	0	6.8
Food preparation and serving	$9.10	269,819	82.7	11.8	2.1	3.4

Source: 2011 *Current Population Survey*, U.S. Bureau of Census.

**Source*: 2012 National Occupational Employment and Wage Estimates. United States Bureau of Labor Statistics.

with silicosis in Michigan between 1985 and 2010, race was available on all but 8 individuals. Of those with known race, 40% were black. The incidence rate of silicosis among black men over age 40 was 8.5 per 100,000 versus 1.6 per 100,000 for white men over age 40 (rate ratio 5.5; 95% CL 4.9–6.2; $P < 0.001$).

Acute fatal occupational injuries

These are defined as acute trauma to the body resulting from an acute exposure to energy or from the absence of such essentials as heat or oxygen caused by a specific event, incident or series of events within a single workday or shift [Bureau of Labor Statistics, 2013a]. The number of work-related acute fatal injuries in Michigan ranged from 95 to 174 per year between 2001 and 2011 for a total of 1,497 fatalities. Race and Hispanic ethnicity information were available in 100% of the fatalities. By ethnicity, 72 (4.8%) were Hispanic. Hispanics had a significantly higher fatality rate than non-Hispanics: 4.4/100,000, compared to a rate of 3.4/100,000 for non-Hispanics (Rate ratio 1.49; 95% CL 1.18–1.89; $P < 0.001$).

Pesticides

Exposure to pesticides can cause a variety of acute health effects depending on the type of pesticide and the type and duration of exposure, ranging from skin irritation to major neurological effects. Michigan's surveillance system for work-related acute pesticide illness confirmed that 845 workers became ill from pesticide exposure from 2001 through 2011. Overall, the data did not show health disparities by race but did by Hispanic ethnicity. Ethnicity was available for 401 (47.5%) of the 845 confirmed cases. The Hispanic rate of 2.9/100,000 was significantly higher than the rate for non-Hispanics of 0.7/100,000 (Rate ratio 4.1; 95% CL 3.06–5.55; $P < 0.001$).

Work-Related Burns

A burn is an injury caused by heat, electricity, chemicals, friction, or radiation. Michigan's surveillance system identified 5,942 work-related burns between 2009 and 2011; race was determined for 3,542 (59.6%). Although the rates of burns comparing whites and blacks overall were not

TABLE IB. Percent Employed in Michigan in Major Occupational Groups* by Hispanic Ethnicity Ranked by Median Hourly Compensation Rate for Each Occupational Group**

Occupational groups	Median hourly rate	Michigan # employed	Ethnicity	
			% Hispanic	% Non-Hispanic
All occupations	$16.71	4,202,653	3.8	96.2
Management	$45.15	448,268	1.7	98.3
Computer and math	$36.67	83,179	2.2	97.8
Legal	$36.19	40,824	8.2	91.8
Architecture and engineering	$35.35	122,791	0.8	99.2
Business and Financial	$30.05	151,630	2.9	97.1
Healthcare practitioners	$28.95	287,413	1.5	98.5
Life, physical, and social sciences	$28.89	32,126	2.4	97.6
Production	$25.98	352,176	6.5	93.5
Education	$22.13	236,573	2.1	97.9
Arts, design, entertainment, sports	$21.12	73,790	4	96
Installation maintenance and repair	$19.72	135,209	3.5	96.5
Community and social services	$19.42	60,273	3.2	96.8
Construction and extraction	$19.29	155,550	4.2	95.8
Protective services	$17.60	74,769	6.3	93.7
Office/administrative support	$15.05	522,843	3.2	96.8
Transportation	$13.92	245,355	4.7	95.3
Healthcare support	$12.28	114,038	1.7	98.3
Sales	$12.09	446,182	2.5	97.5
Building and grounds cleaning and maintenance	$10.91	144,716	9.3	90.7
Personal care and service	$10.02	169,704	2.6	97.4
Farming/fishing	$9.31	35,426	45.4	54.6
Food preparation and serving	$9.10	269,819	5.2	94.8

*Source: 2011 *Current Population Survey*, U.S. Bureau of Census.
**Source: 2012 National Occupational Employment and Wage Estimates. United States Bureau of Labor Statistics.

significantly different, the risk of blacks having more severe burns (2nd or 3rd degree) was significantly increased compared to whites (19.1/100,000 in blacks and 15.3/100,000 in whites; rate ratio 1.25; CL 1.1–1.4; $P < 0.001$).

Work-Related Asthma

Between 1988 and 2011, 3,102 individuals were confirmed in Michigan with work-related asthma. Race was available on 3,025 (96%) individuals. Among the 3,025 cases with race, 571 (18.8%) were black and 60 (2%) were Hispanic. The annual incidence rate of work-related asthma for blacks of 4.8/100,000 was 1.9 times greater than that of whites (2.5/100,000) (RR: 1.9; 95% CL 1.7–2.1; $P < 0.001$).

Table IV summarizes the significant race/Hispanic ethnicity disparity rates in each of these five surveillance systems.

DISCUSSION

Work-related health disparities by race and Hispanic ethnicity in Michigan are evident in public health surveillance data and suggested by employment data in Michigan. Surveillance findings are consistent with published data [Hunt et al., 2005; Cierpich et al., 2008; CDC, 2012; Byler, 2013]. In states with more comprehensive occupational health surveillance programs like Michigan, results of data analysis and specific case reports to the surveillance systems have been used by the program to direct and support public health interventions that address identified disparities. For example, the finding in Michigan of a disproportionate numbers of Hispanics among work-related fatal injuries supported national data [Richardson, 2005], and because of this concern, MIOSHA has funded a variety of safety training programs directed at Spanish, non-English speaking workers. In another example, the Michigan Department of Agriculture and Rural Development investigated an incident involving 12 Hispanic farmworkers reported with acute pesticide illness from the drift of an organophosphate pesticide from a nearby field, and found multiple violations of pesticide safety requirements [Schwartz and Stanbury, 2007].

The best example of an occupational health disparity in Michigan surveillance data is the preponderance of blacks among those with silicosis. Because 80% of cases of silicosis

TABLE II. Ten Most Common Occupations for Whites, Blacks, Asians and Hispanics* in Michigan, 2011: Grouped by Categories—Manager/Professional, Clerical/Sales/Service, and Trades/Operators/Manual Laborers**

White/non-Hispanic (# employed: white—3,558,662; non-Hispanic—4,041,165)[a]
- Manager/professional
  - Managers, all other (2.1%)
  - Nurses (2.1%)
  - Elementary/middle school teachers (2.1%)
- Clerical/sales/service
  - Cashiers (2.4%)
  - Retail salespersons (2.4%)
  - Secretaries (2.3%)
  - Supervisors of retail sales workers (1.9%)
  - Waiters/waitresses (1.6%)
- Trades/operators/manual laborers
  - Driver/sales workers and truck drivers (2.3%)

Black (#employed: 435,105)
- Clerical/sales/service
  - Nursing/home health aides (4.7%)
  - Personal and home care aides (2.8%)
  - Cashiers (2.8%)
  - Customers service reps (2.4%)
  - Retail salespersons (2.3%)
  - Cooks (2.2%)
- Trades/operators/manual labor
  - Janitors (3.1%)
  - Assemblers and fabricators (3.1%)
  - Laborers (2.5%)
  - Bus drivers (2.1%)

Asian (# employed: 129,414)
- Manager/professional
  - Mechanical engineers (9%)
  - Software developers (7.5%)
  - Postsecondary teachers (4.2)
  - Computer/information systems managers (3.9%)
  - Physical therapists (3.6%)
  - Managers (3.4%)
  - Nurses (3.2%)
  - Accountants (2.9%)
  - Physicians (2.7%)
- Clerical/sales/service
  - Maids and housekeeping clearers (2.7)

Hispanic (# employed 161,489)*
- Manager/professional
  - Accountant (2%)
- Clerical/sales/service
  - Janitors (3.9%)
  - Retail salespersons (2.7%)
  - Waiters/waitresses (2.7%)
  - Cooks (2.3%)
  - Food preparation workers (2.1%)
- Trades/operators/manual labor
  - Agricultural workers (9.8%)
  - Assemblers and fabricators (4%)
  - Grounds maintenance workers (2.9%)
  - Packers and packagers, hand (2%)

[a]Ranking and percent in each occupation same for "white" and "non-Hispanic."
*Category of Hispanic is not exclusive of race.
**Categories from International Labor Organization, 2012.

TABLE III. Number and Percent Employed by Race and Hispanic Ethnicity in Michigan,* 2011, in the 11 Highest Risk Occupations Nationally**

Occupation/incidence rate per 10,000	National incidence rate per 10,000*	Total employed, Michigan	% White	% Black	Other %	% Hispanic	% Non-Hispanic
All occupations combined	128	4,202,653	84.7	10.4	4.9	3.8	96.2
Nursing aides	526	74,105	70.1	27.4	2.5	1.9	98.1
Construction laborers	488	23,774	87.4	10.2	2.4	7.9	92.1
Laborers and freight, stock and material movers	466	49,609	74.0	22.0	4.0	3.7	96.3
Emergency medical technicians and paramedics	454	4,834	100	0	0	0	100
Heavy and tractor-trailer truck drivers	411	16,080	75.7	22.1	2.2	13.2	86.8
Roofers	410	3,393	100	0	0	0	100
Welders, cutters, solderers and braziers	363	18,196	85.7	5.0	9.3	3.5	96.5
Carpenters	335	30,817	94.0	5.1	0.9	0.9	99.1
Food servers, non-restaurant	333	1,443	100	0	0	13.6	86.4
Mobile heavy equipment mechanics	317	5,976	100	0	0	0	100
Industrial machinery mechanics	316	10,010	82.9	8.3	8.8	0	100

*From 2011 Current Population Survey.
**Eleven occupations with highest incidence rates for non-fatal injuries and illnesses in 2006 from Bureau of Labor Statistics [2007].

TABLE IV. Significant Disparities by Race/Hispanic Ethnicity: Michigan Surveillance Systems for Silicosis, Acute Fatal Occupational Injuries, Acute Pesticide Illness/Injury, Work-Related Burns Occupational Asthma, With White as Referent

Condition under surveillance	Years of surveillance data	# Cases	% With race/ethnicity available	White rate per 100,000	Statistically significant disparity		
					Rate	Rate ratio	95% CL
Silicosis	1985–2010	1,109	99	1.6	Black: 8.5/100,000	5.5	4.9–6.2; $P < 0.001$
Fatal injuries	2001–2011	1,497	100	3.4	Hispanic: 4.4/100,000	1.49	1.18–1.9; $P < 0.001$
Pesticide injury	2001–2011	845	47.5	0.7	Hispanic: 2.9/100,000	4.1	3.06–5.55; $P < 0.001$
Work-related burns	2009–2011	5,942	59.6	15.3[a]	Black: 19.1/100,000[a]	1.25	1.1–1.4; $P < 0.001$
Work-related asthma	1988–2011	3,102	96	2.5	Black: 4.8/100,000	1.9	1.7–2.1; $P < 0.001$

[a]Significant for burn cases with 2nd and 3rd degree burns only.

came from exposure to silica in Michigan's foundries, to prevent future cases MIOSHA targeted enforcement inspections to ensure that foundries were in compliance with the MIOSHA silica air standard [Rosenman et al., 2012].

Access to personal identifiers and contact information in the surveillance systems has allowed the surveillance program to obtain a depth of information on occupational health disparities that is not available in national data. For example, a historian at MSU conducted in-depth interviews of the work experiences of four individuals reported to the silicosis surveillance system. These four individuals were blacks who had come up from the South to work in Michigan foundries. Discrimination in the workplace and resulting impact on exposure to silica were best illustrated in one of these individuals' own words: "Bein' black was restrictin' … that's why you took the worst jobs. They was the hardest ones … The white guys they walk back out when [they see] the shake-out [removal of the metal casting from the sand mold, where the highest silica dust exposures occur] and all that hot stuff—they go back out … I could shake out more than any guys and I could take the heat 'cause I was from the south" (unpublished transcripts, Michigan State University).

Likewise, in-depth investigations conducted as follow-up to reported fatal occupational injuries, which are conducted by Michigan State University (MSU) under its NIOSH-funded Fatal Assessment and Control Evaluation (FACE) program [NIOSH, 2012b], provide a more in-depth understanding of these tragedies than the national Bureau of Labor Statistics "Census of Fatal Occupational Injuries" program [Bureau of Labor Statistics, 2013b]. For example, MSU's follow-up investigation of a 29-year-old male Hispanic landscape laborer, who had died when the nine-foot deep trench he was working in collapsed and covered him with soil, found that he and the 12 other laborers employed by the landscaping company spoke very little English and had not received safety training in Spanish [Michigan State University, 2006].

Although Michigan's occupational health surveillance systems were useful for understanding and addressing work-related health disparities, they had a number of limitations. First, reporting of cases was incomplete because of likely barriers to identifying and reporting cases, including difficulties in access to medical care for poor and disenfranchised workers, fears of job loss, especially among the most vulnerable such as migrant farm workers and difficulties in making a diagnosis of a work-related condition even when medical care was obtained [Azaroff et al., 2002]. Second, although race/ethnicity information is part of Michigan's reporting requirement, it is not always available in the medical records or case reports that are the source of the surveillance data and thus completeness of data varies depending on the surveillance system (48–100%) (Table IV). Patient interviews, which can fill in data gaps, were not always done either because the person could not be contacted or because of limited resources available to perform interviewing.

Improving the completeness of information about patients' race/ethnicity and occupation/employer in medical records and in national surveys is critical to acquiring the data needed to comprehensively identify and address work-related health disparities, and to identify hypotheses that need further research to better describe the social conditions and root causes of health disparities. Two developments have the potential to enhance state and national capacity to examine this issue. The first is the addition, on a pilot basis by approximately 20 states, of occupation and industry information to the Behavioral Risk Factor Surveillance System (BRFSS). This annual telephone survey of the health of adults, which already includes race/ethnicity, is conducted with funding in all 50 states from the Centers for Disease Control and Prevention [CDC, 2013]. The addition of occupational information from survey respondents will increase the utility of this data source by providing data for detailed analyses of reported health conditions by race and ethnicity in specific occupations and industries. Second, the requirements of the federal Centers for Medicare and Medicaid for interoperability of electronic health records and Meaningful Use [Office of the National Coordinator for

Health Information Technology, undated] will ensure capture of race/ethnicity in all patient records. This information will then be available to state occupational health surveillance programs that have injury/illness reporting regulations, ensuring completeness of these data elements. In addition, efforts to promote inclusion of collection of occupation/industry in electronic health records are underway [Institute of Medicine, 2011], and, if successful, will also allow for the generation of valuable data on race/ethnic health disparities associated with specific occupations, which can then be used for targeted interventions.

Occupational health disparities, like other health disparities, reflect broader socio-economic inequalities of income, education, and access to health care [CDC, 2011]. These inequalities have significant social costs; for example, the costs of occupational injuries and illnesses in low-wage workers were estimated to be $15 billion for medical care and another $24 billion for lost productivity in 2010 in the United States [Leigh, 2012]. Historically race/ethnic minorities have been over-represented in lower-paid, manual occupations, which frequently involve dangerous work [Murray, 2003; Lipscomb et al., 2006]. Michigan data on employment demographics from the U.S. Current Population Survey provided here illustrate race/ethnic disparities by wage compensation, and by hazardous occupations. Notable findings were the over-representation of blacks and Hispanics in the lower paid occupations and in some of the occupations with the highest non-fatal work-related injury rates nationally.

The relationships between socio-economic status, race, working conditions and health are complex, and conceptual models have been proposed to consider various causal pathways [Lipscomb et al., 2006; Brenner, 2010; Landsbergis, 2010]. Employment demographic data alone do not explain findings of racial and ethnic disparities in work-related diseases and injuries, but it can be useful for identifying the potential for work-related health disparities. States without resources to conduct case-based occupational health surveillance, at a minimum, can use this approach to call attention to the importance of work in the understanding of health disparities in their jurisdictions.

State capacity to conduct occupational health surveillance, which includes legal authority to collect data from multiple sources, is currently supported by NIOSH in only 23 states, including Michigan. The case reports and detailed data available to these state programs afford states opportunities for in-depth analyses and identification of specific disparities issues such as language or access to care. This allows states to link occupational health disparities data to a variety of educational and work-site interventions. Further, state occupational health surveillance programs have opportunities to collaborate with other state public health programs, including state health equity and worksite wellness programs, to promote strategies to improve working conditions in high-risk occupations with high percentages of minority populations identified by surveillance data. Even in the absence of an occupational health surveillance program, states can use employment data and their BRFSS survey to begin to address the issues of work-related health disparities. Expansion of federal support or state allocation of resources for occupational health surveillance programs would expand public health capacity to address the important issues of work-related health disparities.

REFERENCES

Azaroff LS, Levenstein C, Wegman DH. 2002. Occupational injury and illness surveillance: Conceptual filters explain underreporting. Am J Public Health 92(9):1421–1429.

Berman D. 1978. Death on the job: Occupational health and safety struggles in the United States. New York: Monthly Review Press. p. 9.

Brenner MH. 2010. Social inequities in working environment and work-related health risks. In: World Health Organization—Europe. Environment and health risks: A review of the influence and effects of social inequalities. pp. 118–119. Available at http://www.euro.who.int/__data/assets/pdf_file/0003/78069/E93670.pdf. Accessed October 18, 2013.

Bureau of Labor Statistics. 2007. Chart 22: Number and incidence rate of injuries and illnesses for occupations with the highest incidence rates, private industry, 2006. Available at http://www.bls.gov/iif/oshwc/osh/os/osh06_22.pdf. Accessed August 20, 2013.

Bureau of Labor Statistics. Undated. May 2012 National Occupational Employment and Wage Estimates United States. Available at http://www.bls.gov/oes/current/oes_nat.htm#19-0000. Accessed August 20, 2013.

Bureau of Labor Statistics. 2012. News Release: Non-fatal injuries and illnesses requiring days away from work: 2011. http://www.bls.gov/news.release/pdf/osh2.pdf. Accessed September 11, 2013.

Bureau of Labor Statistics. 2013a. Census of Fatal Occupational Injuries (CFOI): Definitions. May 5, 2013. Available at http://www.bls.gov/iif/oshcfdef.htm. Accessed December 2, 2013.

Bureau of Labor Statistics. 2013b. Census of Fatal Occupational Injuries (CFOI)—Current and revised data. Available at http://www.bls.gov/iif/oshcfoi1.htm. Accessed October 8, 2013.

Byler CG. 2013. Hispanic/Latino fatal occupational injury rates. Mon Labor Rev 136(2):14–23.

Centers for Disease Control and Prevention. 2003. HIPAA privacy rule and public health: Guidance from CDC and the U.S. Department of Health and Human Services. MMWR Morb Mortal Wkly Rep S-52:1–12.

Centers for Disease Control and Prevention. 2011. Rationale for regular reporting on health disparities and inequalities—United States. MMWR Morb Mortal Wkly Rep S-60:3–10.

Centers for Disease Control and Prevention. 2012. Work-related asthma —38 states and District of Columbia, 2006–2009. MMWR Morb Mortal Wkly Rep 61(20):375–378.

Centers for Disease Control and Prevention. 2013. BRFSS: Behavioral Risk Factor Surveillance System. Available at http:///www.cdc.gov/brfss. Accessed June 6, 2013.

Cierpich H, Styles L, Harrison R, Davis L, Chester D, Lefkowitz D, Valiante D, Richardson S, Castillo D, Romano N, Baron S. 2008. Work-related injury deaths among Hispanics—United States, 1993–2006. MMWR Morb Mortal Wkly Rep 57(22):597–600.

Dean AG, Sullivan KM, Soe MM. 2011. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version 2.3.1. Available at www.OpenEpi.com. Accessed June 6, 2013.

DeCoufle P, Wood DJ. 1979. Mortality patterns among workers in a gray iron foundry. Am J Epidemiol 109(6):667–675.

Fleischer NL, Tiesman HM, Sumitani J, Mize T, Amarnath KK, Bayakly AR, Murchpy MW. 2013. Public health impact of heat-related illness among migrant farmworkers. Am J Prev Med 44(3):199–206.

Hunt PR, Won JU, Dembe A, Davis L. 2005. Work-related hospitalizations in Massachusetts: Racial/ethnic differences. Mon Labor Rev 128(10):56–62.

Institute of Medicine. 2011. Incorporating occupational information in electronic health records: Letter report. Washington, DC: The National Academies Press. Available at http://www.nap.edu/catalog.php?record_id=13207. Accessed June 21, 2013.

International Labor Office. 2012. International Standard Classification of Occupations: ISCO-08. Geneva ILO. Available at http://www.ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/—publ/documents/publication/wcms_172572.pdf. Accessed October 10, 2013.

Kutz FU, Yobs AR, Stassman SC. 1977. Racial stratification of organochlorine insecticide residues in human adipose. J Occup Med 19 (9):619–622.

Landsbergis P. 2010. Assessing the contribution of working conditions to socioeconomic disparities in health: A commentary. Am J Ind Med 53 (2):95–103.

Leigh PJ. 2012. Numbers and costs of occupational injury and illness in low-wage occupations. Center for Poverty Research and Center for Health Care Policy and Research, University of California Davis. Available at http://defendingscience.org/sites/default/files/Leigh_Low-wage_Workforce.pdf. Accessed June 6, 2013.

Lipscomb H, Loomis D, McDonald MA, Argue RA, Wing S. 2006. A conceptual model of work and health disparities in the United States. Int J Health Serv 26(1):25–50.

Luginbuhl RC, Jackson LL, Castillo D, Loringer KA. 2008. Heat-related deaths among crop workers—United States, 1992–2006. MMWR Morb Mortal Wkly Rep 57(24):649–653.

Martin CF, Higgins JE. 1976. Byssinosis and other respiratory ailments: A survey of 6,631 cotton textile employees. J Occup Med 18(7):178–185.

McMichael AJ, Spirtas R, Gamble JF, Tousey PM. 1976. Mortality among rubber workers: Relationship of specific jobs. J Occup Med 18 (3):178–185.

Michigan State University. 2006. MIFACE investigation #06MI004. 29-year old male Hispanic landscape laborer dies when nine foot deep trench collapses. E. Lansing MI. Available at http://www.oem.msu.edu/MiFace/Investigation%20Report%2006MI004.pdf. Accessed October 10, 2013.

Murray LR. 2003. Sick and tired of being sick and tired: Scientific evidence, methods, and research implications for racial and ethnic disparities in occupational health. Am J Public Health 93(2): 221–226.

National Institute for Occupational Safety and Health. Undated. State surveillance portfolio; NIOSH extramural research and training programs. Available at http://www.cdc.gov/niosh/oep/statereports.html. Accessed September 22, 2013.

National Institute for Occupational Safety and Health. 2012a. Occupational health disparities program description. Available at http://www.cdc.gov/niosh/programs/ohd/risks.html. Accessed June 6, 2013.

National Institute for Occupational Safety and Health. 2012b. Fatality Assessment and Control (FACE) Program mission, history and objectives. Available at http://www.cdc.gov/niosh/face/brochure.html. Accessed June 21, 2013.

Office of the National Coordinator for Health Information Technology. Undated. HealthIT.gov: What's in it for you? Available at http://www.healthit.gov/policy-researchers-implementers. Accessed June 6, 2013.

Richardson S. 2005. Fatal work injuries among foreign-born Hispanic workers. Mon Labor Rev Online 128(10):63–67. Available at http://www.bls.gov/opub/mlr/2005/10/ressum.pd. Accessed June 6, 2013.

Robinson JC. 1989. Exposure to occupational hazards among Hispanics, blacks and non-Hispanic whites in California. Am J Public Health 79 (5):629–630.

Rosenman KD, Reilly MJ, Kalinowski D. 2012. 2010 Annual Report on Silicosis in Michigan. E. Lansing, Michigan. Available at http://www.oem.msu.edu/userfiles/file/Annual%20Reports/Silica/2010SilicosisAnnualReport.pdf. Accessed October 21, 2013.

Rosner D, Markowitz G. 1991. Deadly dust: Silicosis and the politics of occupational disease in twentieth-century America. Princeton, NJ: Princeton University Press. p. 96.

Schwartz A, Stanbury M. 2007. Occupational Pesticide Illness and Injury Surveillance in Michigan: 2006. Lansing, MI: Michigan Department of Community Health. p. 17. Available at www.michigan.gov/documents/mdch/Pesticides_Annual_Report2006_222912_7.pdf. Accessed October 10, 2013.

Simpson CL, Severson RK. 2000. Risk of injury in African American hospital workers. J Occup Environ Med 42(10):1035–1040.

Souza K, Steege AL, Baron SL. 2010. Surveillance of occupational health disparities: Challenges and opportunities. Am J Ind Med 53 (2):84–94.

US Census Bureau. Undated. Current population survey. Available at http://www.census.gov/cps/. Accessed June 6, 2013.

U.S. Public Health Service. 1953. Health of workers in chromate producing industry. Washington, DC: Public Health Service. Publication No. 192.