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RESEARCH ARTICLE

# Robot-related fatalities at work in the United States, 1992–2017

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## Abstract

**Background:** Industrial robots became more commonplace in the US workplace during the mid- to latter part of the twentieth century. Recent scientific advances have led to the development of new types of robots, resulting in rapidly changing work environments. Information on occupational robot-related fatalities is currently limited for this developing field.

**Methods:** Robot fatalities were identified by a keyword search in restricted-access research files from the Census of Fatal Occupational Injuries (CFOI) surveillance system of the Bureau of Labor Statistics from the years 1992–2017.

**Results:** There were 41 robot-related fatalities identified by the keyword search during the 26-year period of this study, 85% of which were males, with the most cases (29%) occurring within the age group 35–44 years. Fatalities occurred primarily with large employers that were geographically clustered, with the Midwest accounting for 46% of the total. Most of the cases involved stationary robots (83%) and robots striking the decedents while operating under their own power (78%). Many of these striking incidents occurred while maintenance was being performed on a robot.

**Conclusions:** The changing nature of robotics in the workplace suggests that emerging technologies may introduce new hazards in the workplace. Emerging technologies have led to an increase in the number of robots in the workplace and to increased human exposure to robotic machinery. These patterns demonstrate that public health professionals will likely face significant challenges to keep pace with developments in robotics to ensure the safety and health of workers across the country.

KEYWORDS
fatalities, occupational, robot, work-related

## 1 | INTRODUCTION

Robotics in the workplace is not a new phenomenon but is one that has been rapidly expanding and evolving over the last few decades. During the period 1993–2017, the annual installation of industrial robots increased from about 50,000–400,000 worldwide.[1] There are many benefits of robotics in the workplace. For instance, they present the opportunity to decrease hazardous occupational exposures by performing tasks that are repetitive, monotonous, or too hazardous for human workers. Despite the advantages of robots in the workplace, they have the potential to create new hazards for workers.

Industrial robots first came into use in the US workforce in the early 1960s and on a more regular basis in the 1970s, primarily in the automobile manufacturing sectors.[2–4] The first robot installed in an automotive plant was used to extract parts from a die casting machine in 1961.[3,4] Other early robots in the automotive sectors included spot welders and materials handling robots.[4] The 1970s saw advances with the incorporation of microprocessors, electric motor driven actuators, and touch sensors further expanding the functions of industrial robots.[3,4] These traditional robots primarily operated in robotic cages or cells isolated from humans, and were used primarily to carry out heavy, repetitive, dangerous or dull tasks.[5] A second wave of professional service and personal/domestic service robots appeared early in the 21st century. The most common professional service robots currently include laser or autonomous guided vehicles (LGVs and AGVs) and maintenance and inspection robots, including unmanned aerial vehicles (UAVs). Conversely, personal/domestic service robots, a much more economically priced line compared to their professional service robot counterparts, primarily consist of vacuums, lawnmowers, pool cleaners, hobby and game devices, and education and research devices.[6] A third wave of robots are collaborative robots or cobots, which, as the namesake implies, are designed to work alongside and in close contact with human workers. Collaborative robot development has been expediated in part due to increased computational power and artificial intelligence.[2] And some of these robots, such as exoskeletons are designed to be worn by humans.

The increasing use and reliance on occupational robots, particularly collaborative robots that can have direct interaction with humans by performing tasks along with their human coworkers, brings new challenges to safety and health professionals to ensure the safety of human workers from these emerging risks. Yet in this occupational transition to a robotic work environment previously unknown in the 20th century, there is a dearth of information available to understand the potential of increased risk that these robots might introduce in the workplace.

The first robot-related death in the United States occurred at an automotive plant in 1979.[6] The decedent was struck by a robot arm that was used to retrieve parts. The robot continued working, and the decedent was not located for another 30 min.[6] In 1984, the National Institute for Occupational Safety and Health (NIOSH) conducted their first Fatality Assessment and Control Evaluation (FACE) investigation of a robot-related fatality.[7] During this event, the decedent entered the robotic cell of an automated die cast system without first shutting down power or locking out the system and was struck by the robotic arm. The FACE program along with its state partners, have since investigated additional robot-related fatalities. One incident involved a light sensor that was unintentionally tripped, leading to the decedent being struck by a robotic platform; another involved an injection molding machine that automatically cycled while the decedent was on top of the robot looking for recently used maintenance tools; and lastly, a decedent was attempting to remove a piece of debris from an automatic laser guided forklift vehicle when the robot reactivated, crushing the decedent.[8–10] These cases all involved the decedents contacting (or being struck by) an energized robot that was not appropriately powered down and/or locked-out.

Recognizing the emerging risk that workers were facing in these automated environments, NIOSH created the Center for Occupational Robotics Research (CORR) in 2017 to evaluate potential benefits and risks of robots in the workplace, design workplace interventions to prevent robot-related worker injuries and fatalities, and develop guidance for safe interactions between humans and robots.[11] To begin to understand the risk that workers can face and to quantify this risk, NIOSH analyzed fatality surveillance data maintained by the Bureau of Labor Statistics (BLS) to identify and describe robot-related fatalities from 1992 through 2017.[12]

## 2 | METHODS

### 2.1 | Census of Fatal Occupational Injuries

The Bureau of Labor Statistics (BLS) operates the Census of Fatal Occupational Injuries (CFOI) surveillance program as a collaborative partnership with all 50 states and the District of Columbia.[12] The CFOI uses multiple source documents to gather occupational fatality information, including death certificates, medical examiner reports, news reports, independent sources such as funeral homes or online information, and local, state, and federal government information. A follow-up questionnaire can be used if the source documents are missing relevant information. Case inclusion criteria specify that the incident be from a traumatic injury related to work. And in most cases, at least two source documents are used to confirm work-relatedness, although cases for which there is only one source may be included if both BLS and the state agree work-relatedness can be determined from the single document.[13]

CFOI contains several coded demographic variables, including age, sex, race, and industry and occupation. In addition, this surveillance system has several lines of narrative text that describes the incident. While the space available to enter narrative text was somewhat limited in earlier years, this space was greatly expanded in the latter years, starting in 2011. The narrative text provides a basis for BLS to assign Occupational Injury and Illness Classification System (OIICS) *Source of Injury* and *Injury Event or Exposure* codes.[14,15] These items provide the opportunity to gain insight into the types of machines, substances, and other factors that were directly responsible for the injury; and to describe the types of injury events, such as entangled in machinery, falls from height, and transportation.

### 2.2 | Identification of cases-keyword search and coding

There is not a succinct or unambiguous definition of a robot, therefore, identifying robot-related fatalities in CFOI was difficult. Additionally, the OIICS *Source of Injury* codes that are most often used to identify specific machines do not include mutually exclusive codes for robots. For example, OIICS Source of Injury code 3729 "Medical, surgical, x-ray machinery and equipment, n.e.c." includes surgical robots but is not mutually exclusive to only surgical robots as it includes numerous other types of medical equipment.[15] Due to these limitations, a broad keyword search of the narrative text that describes the fatal incidents was used to identify robot-related fatalities in CFOI from 1992 to 2017, which were the most recent data available at the time of analysis. The keywords that were used are listed below. These key words were general in nature and did not include brand names or trademarks as the narrative text in CFOI is abstracted and sanitized to exclude proprietary information.

| Key words | |
|---|---|
| Robot (or) cobot | Autonomous |
| Laser guided | AGV (or) LGV* |
| Driverless | Self-driven |
| Bionic | Exoskeleton |
| Lifting arm [AND] injection molding, stamp press, palletizer, die cast | |
| *AGV/LGV: autonomous or laser guided vehicle | |

Cases identified by the keyword search were manually reviewed to verify that a robot was involved in the fatal incident. For this analysis, only cases that were confirmed to have involved a robot were analyzed. Hypothetical examples of cases that would have been coded as confirmed include incidents such as the robot arm striking and knocking the decedent into another machine, even if the second machine was the immediate cause of death, or if the decedent died from a fall from height while performing maintenance on a robot. Some cases that included the term robot were coded as negative because the actual event lacked information about a robot being involved. For example, the narrative text included the term robot to describe part of the decedent's regular job duties, but upon further review, the incident was found to be due to an event that did not involve a robot.

After the final selection of confirmed cases, the narrative text was manually reviewed a second time to identify relevant items or circumstances of these robot-related incidents. A coding scheme was developed to identify the type of robot and whether there was robot arm or robotic cell/cage/curtain listed in the narrative text. Also of interest was the identification of cases where the robot made direct contact with the decedent while moving/operating under its own robotic power, if the robot was stationary or mobile, and whether maintenance (emergency or planned) was being performed on the robot at the time of incident.

Given the large number of years of CFOI data that were reviewed, code schemes changed. Industry coding in CFOI over the 26-year period involved two different coding systems: the 1987 Standard Industrial Classification (SIC) System[16] and three different versions of the North American Industry Classification System (NAICS) for the years 2002, 2007, and 2012.[17] For this analysis, all industry codes were updated to NAICS 2012 to enable an examination of the data without a break in the series due to different coding systems. The OIICS Source of Injury and Injury Event codes in CFOI from 1992 to 2010 were coded with the OIICS v1.01 scheme and the OIICS v2.01 was used to code the CFOI data from 2011 onward.[14,15] Cases from 1992 to 2010 were manually recoded according to the OIICS v2.01 to create consistency for the entire 26-year period and eliminate a break in series.

## 3 | RESULTS

During the 26-year period from 1992 to 2017, the keyword search and manual review identified 41 robot-related fatalities. The term "robot" was included in 36 (87.8%) of the narrative descriptions, with the other key words accounting for the remainder of cases. Males (85.4%) comprised the majority of cases. There was a 41-year age range among decedents, with the age group 35–44 years comprising the largest percentage (29.3%) (Table 1). The Midwest and South

**TABLE 1** Demographics for robot-related deaths, CFOI* 1992–2017.

| Variable | Number | Percent |
|---|---|---|
| Sex | | |
| Male | 35 | 85.4 |
| Female | 6 | 14.6 |
| Age group | | |
| 20–24 | 5 | 12.2 |
| 25–34 | 9 | 22.0 |
| 35–44 | 12 | 29.3 |
| 45–54 | 8 | 19.5 |
| 55–64 | 7 | 17.1 |
| Year | | |
| 1992–1997** | 7 | 17.1 |
| 1998–2002 | 9 | 22.0 |
| 2003–2007 | 9 | 22.0 |
| 2008–2012 | 7 | 17.1 |
| 2013–2017 | 9 | 22.0 |
| BOC region | | |
| Midwest | 19 | 46.3 |
| South | 17 | 41.5 |
| Other | 5 | 12.2 |
| Employment size | | |
| 50–100 | 6 | 14.6 |
| 100+ | 29 | 70.7 |
| Other/unknown | 6 | 14.6 |

Abbreviation: CFOI, Census of Fatal Occupational Injuries.

*Fatal injury totals were generated by NIOSH with restricted access to CFOI microdata.

**6-years compared with 5-years for the other categories.

regions accounted for 36 (87.8%) of the cases (Table 1), with most incidents occurring in the states of Ohio and Michigan with six fatalities each. Large employers with greater than 100 employees comprised 70.7% of the incidents (Table 1). All 41 robot fatalities occurred in establishments classified as private industry. Nineteen (46.3%) of the robot incidents occurred during the first 13-year period (1992–2004) and 22 (53.7%) during the latter 13-year period (2005–2017). The distribution of cases by 5-year periods was fairly consistent across the entire 26-year period (Table 1).

Seventy-eight percent ($n = 32$) of the robot-related deaths occurred in the manufacturing industry (2012 NAICS- 31–33). The three-digit NAICS category of "Transportation equipment manufacturing" comprised 12 (29.3%) of the total cases. The second leading NAICS three-digit category of "Plastics and rubber products manufacturing" accounted for six cases (14.6%), followed by "Fabricated metal product manufacturing" (9.8%) and "Primary metal manufacturing" (7.3%).

An examination of OIICS Source of Injury identified machinery (70.1%) as the leading source. Within machinery, "Metal, woodworking, and special material machinery" comprised 31.7% of incidents, followed by "Miscellaneous machinery" (26.8%) (Table 2). A majority of miscellaneous machines were "Product assembly machinery, n.e.c." (22.0%). The second leading source of injury was "Vehicles," which comprised 17.1% of the total (Table 2).

The OIICS Injury Event category "Contact with objects and equipment" accounted for most of the incidents (73.2%), followed by "Transportation incidents" (14.6%). Within "Contact with objects and equipment," "Caught in running equipment or machinery during maintenance, cleaning," and "Caught in running equipment or machinery, n.e.c." comprised 26.8% and 34.1% of the total cases, respectively (Table 2).

The manual review of the narrative text revealed that the type of robot was listed in 30 (73.2%) of the incidents. During the first 13-year period (1992–2004) of this study only 52.6% ($n = 10$) of the cases included information on the type of robot compared with 90.9% ($n = 20$) in the latter 13-year period (2005–2017). Die cast and injection mold robots were the most common types, accounting for 6 (14.6%) of the 41 fatalities, followed by forklifts and welders, each accounting for four fatalities (9.8%), while presses accounted for three fatalities (7.3%). The remaining 13 cases that mentioned the type of robot cannot be reported as they did not meet disclosure requirements due to small numbers. Most of the robots were stationary ($n = 34$), while the remaining seven cases were mobile.

**TABLE 2** Source of injury and injury event (OIICS v2.01) for robot-related deaths, CFOI* 1992–2017.

| Variable | Code | Description | Number | Percent |
|---|---|---|---|---|
| **Source of Injury** | **3** | **Machinery** | **29** | **70.1** |
| | 34 | Material and personnel handling machinery | 3 | 7.3 |
| | 35 | Metal, woodworking, and special material machinery | 13 | 31.7 |
| | 353 | Extruding, injecting, forming, molding machinery | 6 | 14.6 |
| | 359 | Other metal, woodworking, and special material machinery | 5 | 12.2 |
| | 39 | Miscellaneous machinery | 11 | 26.8 |
| | 392 | Product assembly machinery, n.e.c. | 9 | 22.0 |
| | **8** | **Vehicles** | **7** | **17.1** |
| | 86 | Off-road and industrial vehicles--powered | 4 | 9.8 |
| | **9** | **All other** | **5** | **12.2** |
| **Injury Event** | **2** | **Transportation incidents** | **6** | **14.6** |
| | 24 | Pedestrian vehicular incidents | 4 | 9.8 |
| | **6** | **Contact with objects and equipment** | **30** | **73.2** |
| | 62 | Struck by object or equipment | 5 | 12.2 |
| | 64 | Caught in or compressed by equipment or objects | 25 | 61.0 |
| | 641 | Caught in running equipment or machinery | 25 | 61.0 |
| | *6411* | *Caught in running equipment or machinery during maintenance, cleaning* | *11* | *26.8* |
| | *6419* | *Caught in running equipment or machinery, n.e.c.* | *14* | *34.1* |
| | **9** | **All other** | **5** | **12.2** |

Abbreviations: CFOI, Census of Fatal Occupational Injuries; OIICS, Occupational Injury and Illness Classification System.

*Fatal injury totals were generated by NIOSH with restricted access to CFOI microdata.

Seventy-eight percent ($n = 32$) of the cases included information in the narrative text that described direct contact between the robot and decedent while the robot was moving under its own power. A robotic arm was listed in nearly half (46.3%) of the 41 cases, while a robotic cell, cage or curtain was included in 24.4% of the total.

Maintenance of the robot at the time of the fatal incident was mentioned in 24 (58.5%) of the 41 fatalities. Seventeen of these maintenance-related fatalities described the type of maintenance being performed, with unjamming, cleaning a sensor, or troubleshooting accounting for 12 of these incidents. Maintenance was mentioned more often during the latter 13-year period (2005–2017) comprising 72.7% ($n = 16$) of the cases during this period compared with 42.1% ($n = 8$) during the earlier years (1992–2004).

## 4 | DISCUSSION

### 4.1 | Findings and research

Robots have been in the US workplace since the mid- to latter part of the twentieth century, yet a succinct or unambiguous definition for a robot is lacking. The NIOSH/CORR states that "Robots are machines or automated technologies that are capable of performing a series of actions to do everything from drive cars to perform surgery."[11] Others have defined a robot as a programmable machine controlled by computer algorithms to perform complex tasks, and in some cases, having the capability to modify tasks based on changes to the external environment.[2] The rapidly expanding nature of robots, or robot-like machines and advances in artificial intelligence (AI), suggest that any definition will need to be dynamic such that it can be expanded to include rapid scientific advancements and developments of new technologies.

During the 26-year period of this study, fatalities were relatively consistent across 5-year periods. Fatalities primary occurred among large employers and were geographically clustered. This geographic clustering among large employers is largely due the automotive manufacturing industries located in Michigan and Ohio. BLS employment statistics show that these two states accounted for the largest employment in the two industries of motor vehicle manufacturing and motor vehicle parts manufacturing in the United States.[18] And as previously mentioned, the automotive manufacturing industries were first to introduce industrial robots in the United States starting in the 1960s, which may, in part, explain the relative consistency of the number of fatalities observed across the period of this study.

The majority of cases involved stationary robots and robots striking the decedents while operating under their own power. Many of these striking incidents occurred when maintenance, including emergency maintenance, was being performed. The large proportion of cases that occurred while doing maintenance was not surprising as the Occupational Safety and Health Administration cited study findings from Japan and Sweden stating that many robot-related injuries occur during maintenance, repair, testing, setup and programming or refinement.[19]

The growing field of robotics and increased levels of autonomous activity are leading to a rapid expansion of robotics in the workplace, either currently taking place or changes that will be seen in the very near future. Most incidents identified for this manuscript appeared to involve traditional industrial robots. These types of robotic systems have large initial installation costs so their use is primarily seen in large establishments. As the cost of robotic machinery decreases, smaller businesses will be able to transform their workplaces with the incorporation of robotic machinery. The growing number of autonomous self-driven mobile robots, including vehicles, large trucks and industrial equipment, and the collaborative and co-existing robots, suggests that workers will face serious occupational exposures in the future, if nothing more than from greater exposure to the increasing presence of robotic machinery.

Incidents involving traditional industrial robots can be most effectively prevented through ensuring compliance with the guarded areas of the robotic cell or cage, with emphasis on complete power shutdown and lockout tagout during nonroutine operations. However, the rapidly changing parameters of newer types of robots require scientific research and leadership to keep pace with the developments in robotics to ensure the safety and health of workers across the country. On-going efforts must include the updating of, and development of new robotic safety standards to serve as guidelines for robotic specifications, ensuring safe operations, and compliance with safety regulations.

Highly automated vehicles, trucks, and industrial equipment is an expanding field of robotics that has the potential to both increase worker safety while also introducing serious hazards to workers as these types of robotic machines involve the mass and speed capable of producing high energy impacts potentially leading to severe injury or fatal injury.[20–24] Working prototypes of highly automated cars and tractor trailers, and self-driving forklifts and other heavy construction equipment are currently in use, and some of these have already resulted in fatalities.[10,25] Further innovations in sensors and AI are required to increase recognition of objects for collision avoidance, such as distinguishing between different objects of the same color and operating in extreme temperatures, poor weather, or low lighting.

Drones or UAVs are another type of robot undergoing rapid growth and that present future challenges. Howard et al.,[26] reported that UAVs can be classified in four broad categories including military, recreational, public, and commercial. UAVs will undoubtably increase in size for use in transportation of heavy materials for building construction, for example,[27] and expand operations of flight paths beyond visual line-of-sight.[28] Plioutsias et al.[29] has identified that most risk assessments for UAVs have been based on data collected from manned aircraft and not from small drones operated in uncontrolled airspace. New developments and the expanding use of UAVs create challenges for occupational safety and health professionals and aviation regulatory authorities.

Another area of growing concern are the collaborative and co-existing robots, sometimes referred to as cobots. Murashov et al.[2] has previously suggested that these robots are designed to work alongside or together with humans to co-perform tasks, and their development has been based on increased computational power and AI. These scientific advancements and development of cobots present the potential to significantly increase robot contact with humans, and thus will result in new and emerging challenges to reduce the risk of injury. It has been suggested that robot collision avoidance can include the design of robots so that the motions of the robot are predictable to humans.[2] However, the movement of humans must be predictable to the robots, even during dynamic and unpredictable situations. Several laboratory efforts at NIOSH/CORR are currently underway to address robot collision avoidance through engineering algorithms to develop “smart path” strategies and to examine pressure and force limits on humans during contact events.

Exoskeletons, or wearable robots, comprise another area of robotic research. While these types of robots have been used extensively in the medical field for rehabilitation over the last three decades, these clinical devices are limited for use in an occupational setting as they are large, bulky, and generally designed for one specific movement.[30] Development of exoskeletons for the workplace requires lightweight designs that provide more autonomy of movement for workers. Research into exoskeletons for workers includes a wide range of varying technologies. Research has led to designs such as a semi-active arm support to aid in an overhead reach utilizing low energy springs to assist with force.[31] More recent research includes development of flexible, soft exoskeletons or ‘exosuits' that aid in the performance of multiple tasks while not impeding walking motions using cable and pneumatic actuators to reduce multiple forces exerted on the body.[32,33]

### 4.2 | Strengths/Limitations

The strengths of this study are largely related to the data source itself. CFOI is a multi-source national fatal surveillance system that contains case-specific information, including a narrative description of the injury incident. A BLS study noted that an advantage of using multiple sources of information is that each source of information, or type of document has specific information related to the original purpose of the source.[34] For example, death certificates are a good source of demographic information, while state and federal fatal incident investigations contain very detailed information on the etiologic circumstances of the incident.[34] Additionally, CFOI is not restricted due to regulatory limitations. Therefore, all traumatic work-related cases should theoretically be captured by the surveillance system without limitations such as industry, business size, or type of employment (i.e., public, private, or self-employed). While the true sensitivity of the CFOI system may be unknown, a study comparing the death certificate's *Injury-At-Work* item to a multi-source surveillance system showed that both the manufacturing industry and machinery-related incidents had high levels of sensitivity, suggesting a greater likelihood of robot-related incidents being captured by CFOI.[35]

The primary limitation of this study was the methodology used for identification of robot-related fatalities in CFOI. Without a clear and unambiguous definition or mutually exclusive OIICS Source of Injury codes for robots, this study relied on a keyword search to identify robot-related fatalities. The sensitivity of identifying robot-related fatalities relied on these terms being included in the narrative description of the incident and adequate detail included in the narratives to classify the case as a confirmed robot. Additional key words might have been helpful to identify additional cases, such as manipulator, effector, AMR (autonomous mobile robot), and potentially others. The author believes that the reliance on the use of a limited keyword search and limited detail in some narratives may have led to an undercount of robot-related fatalities. The BLS is currently exploring the possibility of updating the OIICS Source of Injury to include mutually exclusive codes for robots, which should greatly reduce the difficulty of identifying robot-related incidents in the future by eliminating the need for a keyword search methodology.

Lastly, the interpretation of the qualitative analysis of the narrative text that examined the type of robot, whether a robot cell or cage was mentioned, or if maintenance was being performed relied upon the detail included in the narratives, and these distributions provide only lower bound estimates. Lack of detail in the narrative text became apparent when comparisons were made between the first 13-year period and the second 13-year period. For example, in the first period only 52.6% of cases contained a description of the type of robot compared with 90.9% during the second; additionally, maintenance was mentioned in 42.1% of cases in the first period compared to 72.7% in the second. These differences between the periods could arise from various factors. First, the increasing prevalence of robots in the workplace and the additional attention from occupational safety and health professionals may have led to an increase in available information during the latter years of this study. Second, the disparities between time periods could also be the result of the maturation of the CFOI system, with improvements seen over the years as the BLS and its state partners refined their understanding and techniques for collecting data, such as expanding the space available for the narrative text and entering more detailed descriptions.

## 5 | CONCLUSIONS

The incorporation of robotics in the US workplace became more common in the mid- to latter part of the twentieth century. New technologies have led to the development of semi- and completely autonomous mobile robots and collaborative robots that perform tasks with or alongside humans, and even collaborative robots designed to be worn by humans. The increasing number of robots that result from emerging technologies will lead to an increase in the number of robots in the workplace, a greater number of tasks performed by robots, and an increase in human exposure to robotic machinery. Occupational safety and health professionals will likely face great challenges in keeping pace with the developments in robotics to ensure the safety and health of workers across the country.

## AUTHOR CONTRIBUTIONS

Larry Layne is the sole author responsible for the design, analysis and interpretation, writing, final approval, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

## ETHICS APPROVAL AND INFORMED CONSENT

All work was performed within the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC) and classified as surveillance that did not involve research requiring CDC human subjects oversight.

## DISCLAIMER

The findings and conclusions in this report are those of the author and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Through a memorandum of understanding with the Bureau of Labor Statistics (BLS), NIOSH receives CFOI research files with restricted access requirements. Research for this document was conducted by NIOSH using these restricted access files. The views expressed herein do not necessarily reflect the views of BLS. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

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