Enclosure I

NIOSH Assessment of Risks for 16- and 17-Year Old Workers Using Power-Driven Patient Lift Devices

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Objective

To determine under what circumstances or conditions 16- and 17-year-old youth can safely operate or assist in the operation of power-driven patient lift devices, NIOSH researchers explored available data, reviewed relevant scientific literature, and conducted a biomechanical analysis.

I. Review of Literature

A. Surveillance Data

It is unclear how many 16- and 17-year olds are currently employed in jobs that involve the use of power-driven patient lift devices. Such work may occur in a variety of job titles or occupations in a variety of health care settings. NIOSH analyzed microdata files from the Bureau of Labor Statistics' Current Population Survey (CPS) to provide insight into the potential number of youth workers, using the job titles of nursing aides, orderlies and attendants, and the job settings of nursing care facilities and hospitals.

Based on 2009 CPS data, there were an estimated 3,979 16- and 17-year old fulltime equivalents (FTE) (one FTE=2,000 hours worked per year; 40 hours per week for 50 weeks per year) working as nursing aides, orderlies and attendants [NIOSH 2010]. Eighty-three percent were females (3,307) and forty percent (1,585) worked in nursing care facilities. Employees 16- and 17-years of age represented less than 1% of nursing aides, orderlies and attendants FTEs. An estimated 7,407 16- and 17-year olds FTE worked in nursing care facilities in a variety of job titles, and an additional 5,334 16- and 17-year old FTE worked in hospitals, in a variety of job titles.

B. Epidemiologic Data

NIOSH was unable to locate epidemiologic data that identified the incidence or risks for injury specifically associated with patient handling devices among 16- and 17-year-olds or older workers. Nationally, nonfatal occupational injury data are coded to a scheme that does not allow the differentiation of injuries associated with a specific task, such as use of powered patient handling devices from other types of material handling machinery and equipment. A query of NIOSH state partners who collect unique state data did not identify relevant data.

C. Literature on the Risk of Manual Patient Handling

Historically, the caregiver has used his or her own physical strength to provide manual assistance to the patient. Extensive research has documented that manual patient lifting and repositioning tasks result in high levels of biomechanical stress and place adult worker caregivers at very high risk for development of low back disorders [Gagnon et al. 1986; Lloyd 2004; Marras et al. 1999; Ulin et al. 1997; Zhuang et al. 1999]. Studies have documented that manual patient handling creates very high internal spinal forces that often exceed recommended exposure limits, thereby significantly increasing risk for development of work-related low back disorders. Marras et al. [1999] demonstrated that many common manual patient transfer tasks, such as manually moving a patient from a bed-to-chair, create very large compression forces on the worker's spine that could easily damage the intervertebral discs that act as cushions between the vertebral joints. When these discs are damaged, the space between the vertebral joints narrows, compressing the nerves and resulting in severe back pain. Marras et al. [1999] concluded that patient handling tasks are high risk for low back disorders, even for patients weighing only 110 lbs and when two workers performed the task.

D. Literature on the Ineffectiveness of Body Mechanics Training

Training alone has not been shown to reduce the risk of patient-lifting related injuries to nursing personnel [Dehlin and Lindberg 1976; Dehlin et al. 1981; Nelson et al. 2003; Snook et al. 1978; Wood 1986]. After it became known that the hazard of lifting human bodies could not be alleviated by training alone, subsequent studies examined patient lifting from an ergonomic viewpoint; researchers began conducting biomechanical evaluations of patient handling activities with the intent of redesigning and adapting patient handling tasks to not exceed the lifting capacities of caregivers.

E. Literature on Biomechanical Laboratory Evaluations of Patient Handling Devices

Recent advances in design of patient handling equipment have resulted in powered floor-based and overhead-mounted transfer equipment that significantly reduce the risk of low back injuries for workers who handle patients. Laboratory-based biomechanical studies have shown that floor-based and ceiling-mounted mechanical patient lifts significantly reduce the caregiver's back compressive forces per transfer when compared to manual patient lifting methods [Garg et al. 1992; Harber et al. 1985; Marras et al. 1999; Owen 1987; Zhuang et al. 1999]. The collective conclusion from the biomechanical laboratory studies is that floor-based and ceiling-mounted patient lifts provide a safe alternative to manually lifting patients because the lifts substantially reduce the biomechanical stress, excessive forces and extreme postures that can occur when manually lifting patients (Garg et al. 1992; Harber et al. 1985; Marras et al. 1999; Owen 1987; Zhuang et al. 1999).

F. Literature on Comprehensive Safe Patient Handling and Movement Programs

After laboratory studies demonstrated that mechanical patient lifting equipment could significantly reduce the physical stresses imposed on caregivers under controlled conditions in the laboratory, the next phase of research was to validate the effectiveness of mechanical lifting

equipment in real-world settings. A strong body of intervention effectiveness research conducted by NIOSH [Collins et al. 2004] and others [Alamgir et al. 2008; Badii et al. 2006; Engst et al. 2005; Garg 1999; Garg and Owen 1992; Miller et al. 2006; Nelson and Fragala 2004; Yassi et al. 2001] has documented that comprehensive safe patient handling and movement programs that incorporate mechanical lifting equipment can effectively reduce injury incidence and workers' compensation costs, and improve the quality of care delivered to patients. A comprehensive safe patient handling and movement program includes mechanical lifting equipment, worker training on the use of the lifting equipment, written safe patient lifting policies, and a medical management program to rehabilitate and safely reintegrate injured workers back into the work force.

G. The Nature of the Load Handled

When the load handled by the power-driven lifts is a person rather than an inanimate object, additional complexities and risks are introduced into the task. Unlike a box or other inanimate object, if a nursing home resident is dropped or mishandled, severe or fatal injury can occur. The Student Textbook on "How to be a Nursing Assistant" published by the American Health Care Association describes some of the complexities of transferring and positioning nursing home residents [Casey-Mederios and Masucci 2008]. Many residents in long-term care are frail and have health conditions that affect their posture, balance and mobility. In addition to the size and weight of the resident and their compromised medical condition, the following factors can contribute to the complexity of lifting, moving or positioning a resident:

- recent surgery
- special equipment such as feeding tubes, oxygen, intravenous lines, or a prosthesis
- fragile skin or bones
- limited ability to assist with the transfer
- limited range of limb motion
- inability to understand verbal instructions
- inability to see or hear
- open wounds, bandaged areas, casts or splints,
- confusion or disorientation
- combativeness
- propensity to fall or lose balance, and
- unexpected changes in behavior, weight-bearing ability, or balance.

Many residents in long-term care facilities require assistance with their Activities of Daily Living such as transferring, walking or bathing and certain medications can affect a resident's

balance. The condition of a resident can change throughout the day requiring critical decisions about how to safely move and transfer the resident to provide optimum care.

H. The Ability of Working Youth to Recognize Hazardous Tasks

Research demonstrates that 16- and 17-year old youths lack the ability to recognize the risk associated with performing hazardous tasks, such as handling and transferring patients. When examining the ability to assess risks specific to work situations, adolescent workers have been shown to greatly underestimate the risks associated with tasks known be hazardous [Vladutiu et al. 2010]. Vladutiu et al. [2010] interviewed a nationally representative sample of 858 adolescents (age 14–18) to investigate the extent to which young workers who performed hazardous tasks (e.g., driving forklifts or other power-driven hoisting equipment, working with blood and body fluids, moving or lifting objects weighing more than 50 lbs.) recognized those tasks to be hazardous. Among respondents who performed tasks known to be hazardous, few recognized these tasks as being hazardous or dangerous. The tasks least likely to be recognized as hazardous or dangerous were operating power equipment, with only 1.6% of respondents who perform these tasks recognizing them as hazardous. Of the 36 working youth who reported operating a forklift or other hoisting equipment, none (0%) of the respondents recognized these tasks as hazardous or dangerous. Vladutiu et al. [2010] found that receipt of safety training did not produce a difference in hazard recognition.

Risk-taking gradually declines between adolescence and young adulthood because of maturation of the brain's cognitive control system which improves an individual's capacity for self-regulation [Steinberg 2008]. Studies have demonstrated that compared to adults, adolescents may misperceive certain behaviors as less risky, and may be overly optimistic about their ability to recognize and avoid threatening situations [Benthin et al. 1993; Cohn et al. 1995].

I. Research Identifying Increased Injury Risk for Younger Workers and Shorter Job Tenure

Numerous epidemiologic analyses have demonstrated that nonfatal occupational injury risks are usually highest for workers less than 25 years of age [Salminen 2004], including a recent analysis of U.S. emergency department data for the 10 year period, 1998–2007 [CDC 2011]. Emergency department data suggest that nonfatal occupational injury rates are highest for workers 18 to 19 years of age, with rates declining steadily as age increases [CDC 2007]. A systematic review found consistent evidence that high rates of injuries among young workers were associated with increased hazards in their workplaces (e.g. ladders and knives), along with perceived work overload [Breslin et al. 2007].

Most relevant to the question of the safety of younger workers using patient lifting devices are findings from a NIOSH evaluation of "best practices" lifting programs in six nursing homes. In this occupational setting with programs that included patient lifting devices, policies that prohibited manual lifting, and comprehensive training, nursing assistants less than 25 years of age and/or with less than one year of job tenure were at significantly increased risk for musculoskeletal injury when lifting and transferring residents in nursing homes, based on workers' compensation data [Collins et al. 2004].

II. NIOSH Analysis

NIOSH analyzed the risks for 16-17 year olds incorporating a biomechanical analysis of tasks, psychophysical forces for pushing and pulling, and the types of equipment.

A. NIOSH Biomechanical Analysis

To assess the biomechanical risks associated with 16- and 17-year old workers using power-driven patient lift devices, NIOSH examined existing guidelines for log rolling patients (an activity needed to get the patient into a sling and prepare them for the lifting portion of the task). A task force convened by the National Association for Orthopaedic Nurses (NAON), Veterans Health Administration, and NIOSH [Gonzalez et al. 2008] developed a guideline for workers 18 years of age and older to log roll patients. For purposes of our current assessment, we modified the NAON guideline for 16- and 17-year old workers by adjusting the strength limits using the NAON logic and the NIOSH two-dimensional Youth Static Strength Model [Waters and Garg 2010] to estimate the arm strength for 16- and 17-year old females. To be considered safe, the strength demands must be acceptable to 75% of 16- and 17-year old females.

B. Psychophysical Maximum Acceptable Forces for Pushing and Pulling

To assess the potential risk of injury associated with the pushing and pulling components of using the lifting devices, NIOSH examined the literature relating required operating forces to published tables of psychophysically-determined maximum acceptable forces for pushing and pulling. These tables were developed to determine whether certain pushing and pulling tasks are within the strength capabilities of various percentages of adult female workers.

C. Type of Powered Equipment

Powered equipment allows the patient to be lifted with minimal manual effort, but certain elements of the lifting activity represent a potential risk of low back disorder for healthcare workers, especially as these risks relate to 16- and 17-year old individuals. These potential risks are outlined below by type of lifting equipment:

(1) floor-based vertical powered patient lift devices
(2) ceiling-mounted vertical powered patient lift devices
(3) powered sit-to-stand patient lift devices
(4) powered tuggers and equipment movers

1. Floor-based vertical powered patient lift devices

These devices consist of a metal framework mounted on wheels with a motorized articulating lift arm attached to a sling that vertically lifts the full body weight of a patient off of a support surface (usually a bed, chair, or table) for transfer to another support surface. The sling must first be placed under the patient by either turning the patient on their side to position the sling

under them (this activity may also be referred to as log rolling the patient) or by sliding the sling under the patients buttocks and legs. Once the sling is fully in place under the patient, it is attached to the articulating lift arm to perform the prescribed lifting activity. The patient is lifted vertically by activating the lift motor which raises the articulating arm, allowing the full body weight of the patient to be lifted off the supporting surface. Once the patient has been lifted off the surface, the operator generally has to push, pull, or rotate the fully loaded device to another location (e.g. away from or to the bed, chair, or table). Potential risk factors for 16- and 17-year old operators include (a) excessive forces required to place the sling under the patient and (b) excessive forces required to push, pull, and rotate the fully loaded lifting device along the floor.

(a) <u>log rolling a patient for sling placement prior to lift</u> –

The NAON guideline specifies that a single adult caregiver should not manually log roll a patient weighing more than 78 pounds without assistance. This recommendation is based on the assumed maximum 75th percentile female[1] arm strength limit of 22 lbs. of vertical lifting force for two arms, arms fully extended, and vertical component of arm force assumed to be 30 degree angle from actual applied force. Using the NAON logic and the NIOSH two-dimensional Youth Static Strength Model, it can be estimated that the arm strength for 16- and 17-year old females [Waters and Garg 2010] under similar conditions would be approximately 15% lower than for those above 18 years of age. These assumptions result in a maximum patient weight of 68 lbs. for one 16- to 17-year old individual to manually log roll a patient. Based on this assessment, it is likely that using the log rolling technique manually placing the sling under a patient weighing more than 68 lbs would represent increased risk of low back disorder for 16- and 17-year old individuals.

(b) <u>pushing, pulling, and rotating a fully loaded floor-based vertical lifting device</u> –

Several studies have been conducted recently that assessed pushing, pulling, and rotating forces for fully loaded floor-based vertical lifting devices. These studies show that the required operating forces for pushing, pulling, and rotating floor-based lifting devices for one adult caregiver could place workers at significant risk of musculoskeletal disorders (MSDs). Rice et al. [2009] showed that required pushing, pulling, and rotating forces for moving patients in floor-based lifts were significantly greater than for similar movements with ceiling-mounted devices. In another study, Marras et al. [2009] assessed the potential risk of pushing, pulling, and rotating fully loaded floor-based vertical patient lifting devices. The spinal shear force developed in the L1/L2 intervertebral discs for one adult caregiver during a move of a fully loaded floor-based device on tile floors were in a range that biomechanics research found to be unsafe, especially during the highly controlled rotating phase of a movement activity [Marras et al. 2009]. Operating forces for floor-based lifts on carpet and other non-tile surfaces were also "*found to be of a magnitude sufficient to lead to disc damage and degeneration*" for operators of floor-based patient lifting equipment [Marras et

[1] 75th percentile female arm strength was chosen as the design limit based on Snook's finding (1978) that if a job is designed so that 75% of the exposed population has the strength to do the job, then risk of low back pain is minimized (Waters et al. 1993).

al. 2009]. Based on these assessments that show the forces required to push, pull, and rotate a fully loaded floor-based lift device are associated with increased risk of MSDs for an adult caregiver, the risks for MSDs among 16- and 17-year old individuals would also be increased. A task force convened by the Association for Perioperative Registered Nurses, Veterans Health Administration, and NIOSH developed a guideline for pushing and pulling heavy objects [AORN 2007]. The limits published in the AORN guideline are consistent with the NIOSH finding that pushing and pulling fully loaded floor-based patient lifts exerted forces on the spine that were in a range considered by biomechanics researchers to be unsafe for many workers.

2. Ceiling-mounted vertical powered lift devices

These devices consist of an overhead metal support framework or support beam attached to the ceiling of the room to which a moveable sliding support device and electrically powered motor is attached. The motor is attached to a sling for placement under a patient to vertically lift the full body weight of a patient off of a support surface (usually a bed, chair, or table). The sling must first be placed under the patient by either turning the patient on their side to position the sling under them (log rolling) or by sliding the sling under the patients buttocks and legs. Once the sling is fully in place under the patient, it is attached to the articulating lift arm to perform the prescribed lifting activity. The patient is lifted vertically by activating the lift's motor which raises the articulating arm, allowing the full body weight of the patient to be lifted off the supporting surface. Once the patient has been lifted off the surface, the operator generally has to push, pull, or rotate the fully loaded device from one position to another (e.g. away from or to the bed, chair, or table). The required forces for pushing, pulling, and rotating patients in a ceiling-mounted device have been shown to be safe for most individuals [Rice et al. 2009, Marras et al. 2009, Waters et al., forthcoming]. For overhead-mounted lifting equipment, the primary risk factor is excessive forces required to place the sling under the patient. The basis for these findings is the following:

(a) <u>log rolling a patient for placement of sling prior to lift</u> – The worker must still place the sling under the patient prior to the lift activity as described above for floor-based lifts. Therefore, the same risks are present for 16- and 17-year old workers as for the floor-based lift described above.

(b) <u>pushing, pulling, and rotating a fully loaded ceiling-mounted vertical lifting device</u> – As noted above, several studies compared the potential risk of MSDs from pushing, pulling, and rotating fully loaded "floor-based and ceiling-mounted" patient lifting equipment [Rice et al. 2009, Marras et al. 2009, Waters et al., forthcoming]. In general, the studies found that the required pushing, pulling, and rotating forces required to operate the ceiling-mounted lifts are significantly lower than for operation of floor-based vertical lifting devices, and likely would not have high risk for MSDs. Santaguida et al. [2005] measured the cumulative spinal loading patterns in a bed to chair transfer task with five mechanical lifting devices. Overhead devices resulted in lower cumulative spinal loads than the floor devices during the transport phases when performing the bed to wheelchair transfer task. The nurse volunteers also rated the overhead devices as the most preferred.

3. Powered sit-to-stand devices

Powered sit-to-stand devices are similar to the floor-based vertical patient lifting devices described above, but these devices are designed to assist a person who can stand on their own, but may have difficulty moving from a sitting to a standing position. Similar to the floor-based lifts, these devices consist of a metal framework mounted on wheels with a motorized articulating lift arm that is attached to a sling that is placed on a patient prior to the assisted lifting activity. To operate the sit-to-stand lift, the device is placed in front of the sitting patient, and the feet are placed into receptacles on the foot support shelf that is attached to the metal framework to provide a base of support for the patient while they are standing. The device also has a shin support upon which the legs rest when in the sitting position. The sling is then placed behind the individuals back and the operator activates the motor to cause the articulating arm to pull the patient upward and forward against the shin supports, thereby raising the patient from a sitting to a standing position. Once the person is standing on the device, the entire fully loaded device can then be pushed, pulled, or moved to transfer the patient between two locations. Potential risk factors for MSDs for this task include (a) placing the sling behind the patient, and (b) pushing, pulling, and rotating the patient while they are standing in the device.

(a) <u>placing the sling behind the patient prior to lift</u> – This task is easier to perform than the placement of the sling for vertical lifting tasks. Minimal strength is needed to perform this task, so the risk of MSDs are expected to be low for 16- and 17-year old workers to perform.

(b) <u>pushing, pulling, and rotating a fully loaded ceiling-mounted vertical lifting device</u> – As discussed previously, several studies examined the potential risk of pushing, pulling, and rotating fully loaded vertical patient lifting equipment [Rice et al. 2009, Marras et al. 2009, Waters et al., forthcoming]. Due to the similarities in design, it can be assumed that the risk of MSDs due to pushing, pulling, and rotating fully loaded sit-to-stand devices would be very similar to those for the floor-based vertical patient lifting devices. The wheel designs are similar and the total mass of the device and patient would be similar. Therefore, this task would likely create significant risk of MSDs for 16- and 17-year old individuals when pushing, pulling, or rotating the devices on non-tile floor surfaces or in confined areas where control of the device would create significantly increased risk for low back disorders.

4. Powered tuggers and equipment movers

Powered tuggers and equipment movers are motorized equipment that can be attached to beds and various types of heavy equipment to make them easier to move and transport. Typically they have a handle or control device that is used to control the speed and direction of movement. In general, these devices do not require significant strength for operation and therefore should represent minimal risk of MSDs.

NIOSH was not asked to comment on non-powered mechanical patient handling equipment, such as a hand or foot operated floor-based patient transfer devices. The risk of injury from using these non-powered mechanical patient handling devices would be equal to or higher than that for use of powered patient handling devices, and the same recommendations would apply.

<u>AHCA and VA Recommendation for Using a Power-Driven Patient Lift</u>

On page 283, the Student Textbook on “How to be a Nursing Assistant,” published by the American Health Care Association, states, “If a resident cannot help when they need to be lifted or transferred, at least two people are needed to transfer a resident with a mechanical lift”.

The Patient Care Ergonomics Resource Guide: Safe Patient Handling and Movement [Nelson 2003] also recommends that when a mechanical lift is being used to lift or transfer a resident who cannot bear weight or offer assistance during the transfer, two caregivers perform the transfer.

Summary

1. Adolescent workers (age 14–18) have been shown to greatly underestimate the dangers associated with tasks known be hazardous.

2. The physical demands associated with operating a floor-based vertical lift device are likely to exceed the maximum recommended strength requirements for many 16- and 17-year old workers. This conclusion is based on excessive force requirements to place the sling under the patient, as well as excessive forces to push, pull, or rotate a floor-based lift loaded with a patient, especially if the floor is carpeted.

3. The physical demands associated with operation of a sit-to-stand lift assist device loaded with a patient is likely to exceed the maximum recommended strength requirements for many 16- and 17-year old individuals. This is based on excessive force requirements to push, pull, or rotate a sit-to-stand lift loaded with a patient across the floor, especially if the floor is carpeted.

4. While use of ceiling-mounted patient lifting devices generally requires less physical strength during the pushing, pulling, and rotating phase of the transfer, they still may present a potential risk of injury for 16- and 17-year old workers because of the excessive force requirements to place a sling under a patient. Although the forces required to push, pull, and rotate a ceiling-mounted lift are sufficiently low to avoid risk of MSDs, the forces required to place the sling under the patient are the same as for floor-based devices.

5. Operation of powered tuggers and equipment movers should be acceptable for 16- and 17-year old workers, assuming all safety precautions are followed. To be considered safe, the strength demands must be acceptable to 75% of 16- and 17-year old females.

6. Two caregivers (one of whom should be an experienced caregiver at least 18 years of age) are recommended when using a power-driven patient lift to lift or transfer non-weight bearing residents.

7. Specific training alone is not sufficient to protect young workers from patient-lifting related injuries.

Conclusions

Based on a review of the relevant scientific literature regarding evaluations of patient handling devices and biomechanical analyses, NIOSH has determined that many 16- and 17-year-old employees cannot safely operate power-driven hoists to lift and transfer patients *by themselves,* although they may be able to safely work as part of a team to assist another caregiver to transfer or move a patient/resident. Independent use of power-driven hoists by 16- and 17-year olds

would put them at increased risk for serious musculoskeletal injuries. The biomechanical analyses indicated that 16- and 17-year-old workers do not have the physical strength required to 1) independently manipulate patients/residents when placing slings under them, and 2) safely push, pull, or rotate a portable hoist on wheels when loaded with a patient/resident. Moreover, the scientific literature indicates that most 16- and 17-year old workers do not have the ability to properly assess the risks associated with using power-driven lifts. It is recommended that two caregivers (one of whom should be an experienced caregiver at least 18 years of age) operate a mechanical lift to transfer a non-weight bearing resident.

NIOSH also encourages the Wage and Hour Division to consider regulations prohibiting youth less than 18 years of age from manually lifting residents who cannot bear weight or assist when being transferred. The hazards for youth to manually lift and transfer residents and patients exceeds the risks associated with the use of powered lifting patient devices.

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