EVALUATING EFFECTIVENESS OF INTERVENTIONS FOR AIRPLANE CARGO BAGGAGE HANDLING

Request for Office of Management and Budget (OMB) Review and Approval
for a Federally Sponsored Data Collection

Section A

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October 17, 2014

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SECTION A. JUSTIFICATION

A1. Circumstances Making the Collection of Information Necessary

Background

This is a new information collection request (ICR) from the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). This data collection is authorized by Section 20(a) (1) of the Occupational Safety and Health Act (29 U.S.C. 669) (Attachment A). The 60-day Notice for this collection was published in the Federal Register on February 6, 2014, as required by 5 CFR 1320.8(d) (Attachment B). Approval is being sought for three years.

The proposed information collection will address the need to assess the effectiveness and cost-benefit of occupational safety and health (OSH) interventions for work-related musculoskeletal disorders (WMSDs) among airport baggage workers in the transportation sector. This need is expressed in a number of NIOSH Strategic Goals (Attachment C). This study will provide new important information on the health and safety of air transportation workers that is not available elsewhere. This project is part of the mission of CDC-NIOSH to conduct rigorous scientific intervention effectiveness research to support the evidence-based prevention of occupational injuries and illnesses.

Previous studies have identified WMSDs, including low back disorders (LBDs), as a major workplace health problem in different working populations . The total health care expenditures incurred by individuals with LBDs alone in the United States reached $90.7 billion annually (Luo et al. 2003). Recent data from the Liberty Mutual Research Institute for Safety (2013) showed that WMSDs accounted for about 24% of the total workers' compensation costs, and were estimated to be $14.2 billion a year.

A working population specifically susceptible to WMSDs is baggage handlers in the airport passenger transportation industry. The most recent statistics show that, the overall incidence rate of work-related injuries resulting in days away from work, job transfer or restricted work (i.e., light duty work) in the airport passenger transportation industry was 6.1%, one of the top three rates in all 600 job categories tracked by the Bureau of Labor Statistics (BLS, 2013). This 2012 average rate was 3 times the rates for the private industry as a whole during that year (BLS, 2013). A very large proportion of the injury cases were LBDs that were found in baggage handlers working in the tarmac or ramp area, where airplanes are parked for services (Dell 1998; personal communication with the safety manager from a large airline company).

To investigate the potential causation of the above-mentioned financial burden and high WMSD rates among airport baggage handlers, it is imperative to understand the job tasks performed by them. Airline companies employ baggage handlers to handle baggage transfer at airports. A large portion of the baggage handlers work in the ramp area. An

airport ramp ground crew provides services to an airplane between the time it arrives at a terminal gate and the time it departs. The services include directing the airplane to the gate, securing the airplane by placing a stopper for the airplane front wheel, transferring checked baggage on and off the plane and driving a vehicle that pushes back the plane off the ramp to the taxiway. These services do not include operations of the jet bridge and refueling, which are done by ticket counter personnel and contractors, respectively. Each crew is assigned to one specific gate during the entire work shift and provides the same services to airplanes that arrive and depart at the same gate. The current structure of a ramp ground crew consists of 4-6 workers rotating between the services. Typically, the ramp ground crew is not involved in transferring baggage between baggage carts and conveyor belts inside the sheltered areas of the airport. These jobs are performed by other ground workers.

Of the variety of ramp services provided for each flight, baggage handling for narrow-bodied airplanes (e.g., McDonnell Douglas or MD Super 80, Boeing 737 and 757) poses a high risk for WMSDs. Baggage handling operations for the narrow-bodied airplanes are performed in three main job positions, shown in Figure 1 These job positions are (1) lifting baggage from baggage cart to a belt loader (a self-propelled conveyor used for transferring baggage to the cargo compartment of the airplane, (2) lifting/puling/pushing baggage from the belt loader to the airplane baggage cargo compartment (a small room located in the belly of the airplane) at the compartment door, (3) stacking baggage in the compartment. The order of the tasks follows the flow of baggage traffic. The baggage handling tasks are performed in a reversed order when baggage is unloaded from the airplane. The ceiling heights of the cargo compartments in the narrow-bodied airplanes range from 46-55 inches (1.2-1.4 m), resulting in a restricted working environment. Speed, efficiency and accuracy are important for the ground services to minimize operational costs. Short turnaround time and restricted cargo compartments make baggage transfer a very physically demanding job.

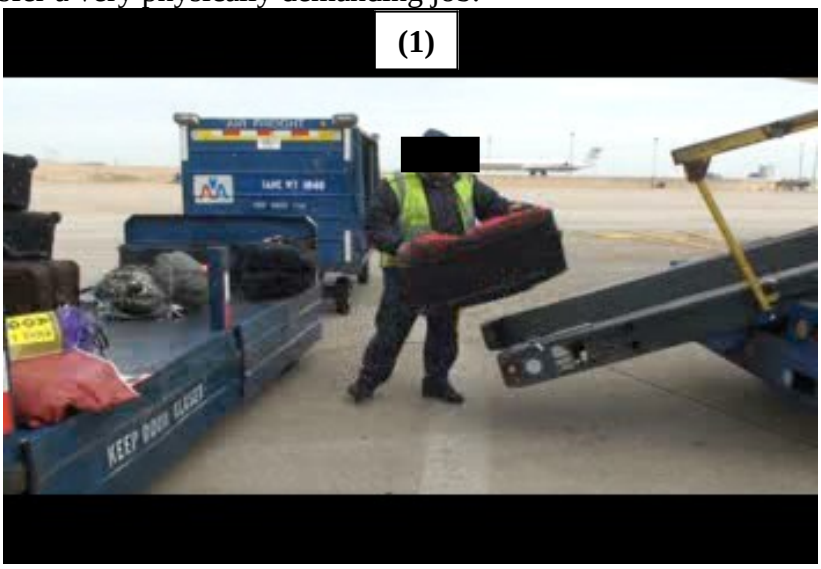

Figure 1. Job positions for bagage handling for narrow-bodied airplane in the ramp area

Because of the physically demanding working environment, many WMSD risk factors, such as awkward postures, heavy lifting, high lifting frequencies (5-10 lifts per min) and dynamic body movements, are inevitably present in the ramp services. These observed risk factors for WMSDs have been documented by previous published investigations for baggage handlers (ARTEX, 1980; Hogwood, 1996; Berube, 1996; Dell, 1997). Dell (1998) indicated manual baggage lifting and handling with restricted working posture is usually the only option available to load and unload baggage in narrow-bodied airplanes. Dell (1998) further suggested that when it comes to aircraft design, airplane manufacturers are only concerned about range, payload and low fuel burn. To avoid these risk factors and increase baggage handling efficiency, some automatic container systems for loading/unloading baggage are installed in larger airplanes, such as the Boeing 767. At present, the automatic baggage loading/unloading container systems for narrow-bodied airplanes are unavailable.

In absence of the automatic container systems for narrow-bodied airplanes, some companies designed after-market mechanical lifting aids for the airplanes. These commercially available mechanical aids include the sliding carpet loading system, the "ACE" loading system and the Ramp Snake (Riley, 2009). Among the lifting aids, the Power Stow (PS) equipment (a similar version of the Ramp Snake) is of our study partner's interest because its durability in severe weather and low maintenance records.

A recent literature review by Tapley and Riley (2009) indicates that there is little published information relating to evaluations of these mechanical lifting assist devices. In that review, only three papers pertaining to evaluations of the devices were identified (Riley, 2009). These three papers (Jorgensen, 1987; Stokholm, 1988; Egeskov, 1992), however, primarily discuss the benefits of the mechanical lifting assist systems and their efficiency in handling baggage. No comprehensive risk, injury and cost benefit information associated with the devices was reported.

Clearly there is a need to conduct experimental research to evaluate the effectiveness and cost-benefit of control interventions for reducing WMSDs in airport baggage handlers. A partnership between NIOSH and the American Airlines (AA) provides an opportunity to conduct such research in a relevant, efficient, and impactful manner. A letter of support from the large airline company is provided in Attachment D. Two engineering control interventions to be included in the present study are chosen based on an overall reduction of the WMSD risk factors in the three job positions. One intervention is for the job position inside the airplane (positions 2 and 3) and the other is for the job tasks outside the airplane for loading/unloading baggage to baggage carts (position 1).

The first intervention is an extendable conveyor system (Power Stow Rollertrack System® or PS) that can be extended into the cargo space of a narrow-bodied airplane from the existing conveyor being used in the ramp area. This system appears to make manual baggage lifting easier, as compared with complete manual lifting without any conveyor system. A detailed description of the system is in Attachment E. The PS is proposed to be used inside the airplane cargo space.

The second intervention is a vacuum lifting (VL) assist system (Vaculex Inc., Model: TPH). This lifting assist system has been evaluated by NIOSH as an effective intervention for the Transportation Security Administration (TSA) workers at airports (Lu et al., 2014). A detailed description of the system is in Attachment F. The VL is proposed to be used for baggage handling from/to baggage carts outside the airplane. It may be mounted onto a belt loader for the power source and the anchor point for using the device in an appropriate range.

In summary, NIOSH will collaborate with airline companies on a multi-site intervention study in the United States. Two engineering control interventions (PS and VL) will be tested for their effectiveness in reducing self-reported pain in multiple body parts (neck, shoulder, back and knees) and injury records of 960 employees performing baggage handling tasks using a prospective experimental design. Information on WMSD risk factors including job rotation, duration of MMH, working methods, personal and

psychosocial status of workers will be collected. A complete randomization nested in crew and shift sampling strategy will be used for recruiting study participants. WMSD risk and incidence data will be collected at baseline, 1 and 2 years after implementation of the two interventions. The effectiveness of the interventions will be assessed by a significant reduction in WMSD risks or incidence rates at the end of the two follow-up periods. Costs and benefits (i.e., cost savings for reduced WMSD cases) associated with using the interventions will be calculated in monetary terms in a cost-benefit analysis. This cost-benefit analysis will have a component demonstrating a return on investment (ROI) in different terms, typically 5, 10 and 20 years into the future, using depreciation of the investments on the interventions and projected injury costs. Additionally¸ through the prospective study design, a potential exposure-response relationship between the WMSD physical risk factors and WMSD incidence, adjusted for personal and psychosocial factors, will be evaluated for airport baggage handlers.

A2. Purpose and Use of Information Collection

All information collected will be used to determine whether the assessed MSD interventions are effective in reducing self-reported pain symptoms and other health related health outcomes (sickness absence, seeking medical attention, work compensation cost) among airport baggage handlers. Results of the study (in de-identified and aggregated form) will be disseminated in the scientific literature and in educational materials through NIOSH and industry trade websites. The information will also be disseminated to the public through professional meetings annually during the study period and in about 3 years after the completion of the study. The privacy of all data collected will be protected to the extent legally possible, as covered by the Privacy Act of 1974, Title 5, United States Code, Section 522 (a). Individual participant personal information will not be published in any identifiable form.

The data collection is justified because very few clinical trials for the effectiveness of engineering controls for reducing the risk of WMSDs have been conducted. Clearly there is a need to conduct rigorous experimental research to define further the effectiveness and return-on-investment of WMSD control interventions. This will allow the cost-benefit of such interventions and related programs to be properly calculated and enable evidence-based practices to be shared with the greatest audience possible. Such data has practical utility to the federal government, state government, and private stakeholders.

This experimental study is recognized as an important research project and fully funded by the CDC-NIOSH federal center using the National Occupational Research Agenda (NORA) funds. The CDC-NIOSH will use data from this project to develop guidance for conducting economic analyses of OSH interventions. A major part of OSH project planning is to conduct a cost-benefit analysis for future intervention projects. This study will provide a necessary piece of information that is often lacking for such analyses, which is the range of expected effectiveness (in terms of reduced injury/illness incidence, severity, and cost) for particular types of WMSD interventions.

The results of the current study are also relevant for private companies in the aviation industry. Manual baggage handling is an essential task for airline companies. Airline companies do not have information on the effectiveness of engineering controls in reducing WMSDs associated with manual baggage handling. Compiling such information, especially cost-effective information will allow airline companies to make accurate projections for savings.

A3. Use of Improved Information Technology and Burden Reduction

Improved information technologies include web-based survey, computer assisted telephone interview and portable computerized questionnaire (i.e., a tablet form). These technologies are not feasible for the study population because (1) study participants do not have access to computer at work to use a web-based survey, (2) study participants work at wide spread locations (different gates at different airports) and cannot be centralized for using a limited number of tablets, and (3) telephone interview is not suitable for some questions items requiring visual identification of pain symptoms. Telephone interview, however, will be used to follow up missing data on the questionnaires. It allows NIOSH to track missing information effectively, since respondents have already completed the questionnaires and understood the questions well. An estimated 5% (or 48 participants) of the study participants will submit incomplete surveys that need follow up. In addition, an exit phone interview will be conducted to track respondents' reason for leaving the study. An estimated 20% (or 192 participants) of the study participants may leave the study during the study period. We plan on using this improved technology to collected data on this portion of respondents.

A4. Efforts to Identify Duplication and Use of Similar Information

NIOSH has searched the scientific literature including professional meeting proceedings and abstracts, contacted colleagues at NIOSH, contacted university faculty, contacted professional, labor and industry organizations representing air transportation workers. To date, NIOSH is unaware of any prospective WMSD intervention effectiveness study being conducted in the aviation sector with such an experimental design as the proposed study. As evidenced by the letters of support (Attachment D) from AA company (a study partner), there is a need to conduct this study.

A5. Impact on Small Businesses or Other Small Entities

The targeted airline companies (i.e., study site and population) are not considered small business. Therefore, the study does not collect information on small businesses.

A6. Consequences of Information Collected Less Frequently

Respondents will be asked to respond to the data collection at baseline and monthly for a 2 year period. The data being collected includes self-reported pain symptoms in multiple body regions, baggage handling exposures and usage of the WMSD intervention (Attachments I-1 and J-1). The frequency of this data collection is justified because (1) musculoskeletal pain and exposures can vary over time (McGorry et al 2011) and less frequent measures would not be sensitive to episodes of pain that resolve within one month period or to changing work exposures; and (2) baggage handling (i.e., risk exposure) varies largely according to flight schedules on a weekly and monthly basis. The planned frequency of data collection is already at a minimum level to reduce burden on respondents while also retaining sensitivity for a valid intervention effectiveness study. There are no legal obstacles to reduce the burden.

A7. Special Circumstances Relating to the Guidelines of 5 CFR 1320.5

There are no special circumstances associated with this data collection activity. This request fully complies with regulation 5 CFR 1320.5.

A8. Comments in Response to the Federal Register Notice and Efforts to Consult Outside the Agency

In accordance with 5 CFR 1320.8(d), a review of the proposed study was sought through a 60-day publication period in the *Federal Register* (February 6, 2014, Vol. 79 No. 25 pages 7193-7194 (Attachment B). No comments were received in response to the Federal Register notice.

NISOH has consulted with many individuals and organizations outside the agency regarding the availability and usefulness of the proposed data collection. The following summarized NIOSH's efforts to consult outside the agency in a chronological manner.

In 2010, NIOSH researchers met several times with the AA Safety Director and several corporate and local airport safety professionals, industrial hygienists, a Vice President who was in charge of occupational safety and health, and baggage handlers' union (Transportation Workers Union) representatives. After assessing a need for collecting new information on baggage handling and related injuries, the MSD intervention study was conceptualized together with the AA Safety Director. A formal letter of support (Attachment D) was then developed to outline a collaborative research partnership. The goal of the partnership is to collect useful information on baggage handling tasks and related injuries for evaluating the impact of safety and health investments on the incidence rates and costs of work-related MSDs in airline baggage handlers.

In 2011, NIOSH researchers conferred with other researchers from the Liberty Mutual Safety Institute and the University of Occupational and Environmental in Japan about the design of the study. Their researchers were the experts in the area of occupational biomechanics and stress research and opined that there was a need to develop the NIOSH MSD intervention study. The researcher from the Liberty Mutual Safety Institute is now

a professor at the National Taiwan Tsing Hua University. Their contact information is below:

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From March to July 2011, the MSD intervention study was peer-reviewed by the NIOSH National Occupational Research Agenda (NORA) competitive process for intramural research for the fiscal year (FY) 2012. The review was conducted by a panel of 14 reviewers from a variety of universities and research organizations. The review was based on project approach, potential impact, innovation and significance. The project received favorable scores from the review panel and was chosen for funding by NIOSH later in 2012. The review panel for the NORA FY 12 funding competition is listed below.

2012 NIOSH NORA Peer Review **Intervention Evaluation**		
Bryan Hardin, Ph.D., **Chairperson** Assistant surgeon general (retired) Veritox Expertise: Environmental Health Sciences	Randal Keller, Ph.D., **Scientist Reviewer** SRA International Inc. Expertise: Health and Civil Services Sector	Phillip Bishop, Ed.D., **Scientist Reviewer** Fulbright Senior Specialist University of Alabama Department of Kinesiology Expertise: Physiology
Lezah Brown-Ellingon, Ph.D., **Scientist Reviewer** Assistant Professor Illinois State University Health Sciences Department Expertise: Occupational Safety and Health Outcomes	David DeJoy, Ph.D., **Scientist Reviewer** Professor Emeritus University of Georgia College of Public Health Department of Health Promotion and Behavior Expertise: Worker Health Promotion	Laure Geer, Ph.D., **Scientist Reviewer** Assistant Professor SUNY Dowstate School of Public Health Department of Environmental and Occupational Health Sciences Expertise: Dermal Exposure
David Hostler, Ph.D., **Scientist Reviewer** Research Associate Professor	Virginia Howard, Ph.D., **Scientist Reviewer** Associate Professor of	Steve Johnson, Ph.D., CPE, **Scientist Reviewer** Professor of Industrial

University of Pittsburg Department of Emergency Medicine Expertise: Cardiovascular and Cognitive Effects of Firefighting	Epidemiology University of Alabama at Birmingham Expertise: Surveillance	engineering University of Arkansas Expertise: Ergonomics
Monroe Keyserling, Ph.D., **Scientist Reviewer** Associate Director University of Michigan Center for Occupational Health and Safety Engineering Expertise: Computer-aided methods for predicting posture	Kristen Kucera, Ph.D., **Scientist Reviewer** Epidemiologist, Assistant Professor Duke University Department of community and Family Medicine Expertise: Injury Epidemiology	Lina Lander, Sc.D., **Scientist Reviewer** Assistant Professor University of Nebraska Medical Centers Department of Epidemiology Expertise: Sources of occupational injuries and musculoskeletal trauma
Grace Sembajwe, DSc., MSc., **Scientist Reviewer** Research Associate Harvard School of Public Health Department of Environmental Health Expertise: Surveillance	Tracey Wortham, Ph.D., **Scientist Reviewer** Associated Professor Murray State University Department of Occupational Safety and Health Expertise: Repetitive motion injury	

In July 2012, NIOSH researchers attended the "Best Practices in Ergonomics: Applied to Warehousing, Retail and Transportation Industries" national meeting in Minneapolis, MN. The concept of the study was presented to the audience. Discussion was made with the audience and several experts to solicit their input to improve and study design.

In February 2013, NIOSH researchers met with an AA corporate safety professional, local safety professionals and workers' union representative at the Boston Logan International Airport. A pilot testing of the proposed intervention PS was conducted by the AA and the vendor to evaluate the feasibility of using the system. The NIOSH MSD intervention study was discussed with the AA, worker union representatives, several baggage handlers and the vendor. Feedback for improving the study design was received during the discussion. NIOSH continued to consult with the potential study partner, intervention vendors and workers in the airline industry.

In July 2013, to further consult on the study design with external researchers, NIOSH held a meeting with Drs. Arun Garg and Jay Kapellusch (from the University of Wisconsin at Milwaukee) at the 8th International Conference on Prevention of Work-related Musculoskeletal Disorders in Busan, Korea. Both are well-known MSD intervention researchers and have published numerous papers on MSD intervention research. Drs. Garg and Kapellusch provided comments on the study design and gave feedback as to how to produce meaningful results and maximize the impact of the research. They agreed that the study was important and had a potential impact on workers' safety and musculoskeletal health. Their contact information is below:

Arun Garg, Ph.D.

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kap@uwm.edu

A9. Explanation of Any Payment or Gift to Respondents

Participants will not receive any payment or gift for participating in the study.

A10. Assurance of Confidentiality Provided to Respondents

The CDC's Information Collection Review Office has reviewed this application and has determined that the Privacy Act is applicable.

The study will collect potentially sensitive information about health status. Risks to participants are low since the only information in identifiable form (IIF) is being collected for the purposes of informed consent and monthly questionnaire and follow phone calls for missing data. Each participant that enrolls in the study will be subsequently identified only with a code on all other information collection forms. IRB approval for this data collection has been obtained (Attachment L).

Several controls (safeguards) will be put into place to minimize the possibility of unauthorized access, use, or dissemination of the information being collected. The principal investigator is the steward for the network drives on which records are stored. Access to the network drives requires principal investigator's approval. Once the access is granted, a password is required to log on the user's computer account to access the drives. Records will be retained and destroyed in accordance with the applicable CDC Records Control Schedule (see http://aops-mas-iis.od.cdc.gov/Policy/Doc/policy449.htm**)**. Planned controls for accessing the records are summarized in the table below.

Control Descriptions	Control Type
• User Identification • Passwords • Firewall • Virtual Private Network (VPN)	Technical

• Encryption • Intrusion Detection System (IDS) • Common Access Cards (CAC) • Smart Cards	
• Guards • Identification Badges • Key Cards • Closed Circuit TV (CCTV)	Physical
1. **Security Plan:** The system security plan for this information collection is detailed in Attachment G. 2. **Contingency Plan:** Files will be backed-up weekly using an offsite Microsoft SQL server based in Atlanta, GA CDC offices. 3: **User Manuals**: Created for this information collection. 4. **Personnel Training**: All CDC and contract personnel (principal investigator, managers, operators, contractors and/or program staff) will receive yearly training using the system and made aware of their responsibilities for protecting the information being collected and maintained. 5. **Contractor Adherence**: Contracts for staff that operate or use the system will include clauses ensuring adherence to privacy provisions and practices. 6. **Access Levels**: Methods will be put into place to ensure the least privilege possible (e.g., access is "role based" on a "need to know" basis). Accountability will be ensured through yearly security reviews. 7. **IIF Policy**: There are CDC policies or guidelines in place with regard to the retention and destruction of IIF.	Administrative

10.1 Privacy Impact Assessment Information

Overview of the Data Collection System

Annual and monthly questionnaires will be self-administered by a hard copy. Because most study subjects (i.e., baggage handlers) do not have access to computer at work, a web-based survey instrument is not feasible for this study. A phone interview will be

used to follow up on missing data and participants that drop out of the study by the end of a 2-year follow-up period. The questionnaires will comply with applicable 508 requirements to accommodate individuals with disabilities (http://www.hhs.gov/od/508policy). NIOSH researchers will primarily conduct the data collection. Contractors will be used in support roles for data analysis and management. Information will be maintained 5 years after the completion of the study.

The study will collect both potentially sensitive data (workers' compensation records for WMSDs, self-reported MSD symptoms and detailed physical demands for the job) and personal identifiers (name, address, phone number, employee clock number). The method of handling the information will comply with the Freedom of Information Act and the Privacy Act of 1974.

Items of Information to be Collected

Information in identifiable form (IIF) will be collected as part of the informed consent form (Attachment H-1**)** for this study. This includes: first and last names, street address, phone number, email address (if available), and date of birth. Additionally, company records including sickness absence and workers compensation data collected by participating study site will be obtained. For participants that prefer a Spanish version, Attachment H-2 is available.

All information will be used to determine whether there are significant differences in reported WMSD symptoms and WMSD records when intervention and control groups are compared. Individual participant personal information will not be published in any identifiable form and will be protected according to the Freedom of Information Act and the Privacy Act. The questionnaire data are standard tools used to evaluate pain due to WMSDs among the participants. The study is designed to determine the usefulness of the prophylactic interventions in preventing WMSDs.

Primary Questionnaires (administered to all 960 participants at baseline and two annual follow-up visits; 30 minutes estimated time for each participant per data collection):

- Personal information: The first portion of the questionnaire is to collect personal information including first and last names, employee number (clock number), home address, phone number, demographic information and health behavior questions (17 items; Attachment I-1 Section A).
- Job information: The second portion is to collect work information including work history, job position, work arrangement, work hours and methods, and information on the second job (15 items; Attachment I-1 Section B).
- Physical activity outside of work: This portion asks for physical activity that may confound with the main physical demands required by work (i.e., manual baggage handling) (3 items; Attachment I-1 Section C)

- Health information: This portion collects information on general health and pain symptoms in multiple body regions, including neck, shoulders, low back and knees (28 items**;** Attachment I-1 Section D).
- Work environment: This portion is to collect work organizational and psychosocial factors related to the risk of WMSDs (36 items**;** Attachment I-1 Section E).

Monthly Questionnaires (administered to all 960 participants; 10 minutes estimated time for each participant per data collection)

- Personal information: The first portion of the questionnaire is to collect personal information including first and last names, and employee number (clock number) (4 items; Attachment J-1 Items J-4).
- Work information: The second portion is to collect work information including job change, work hours and methods, pain symptoms in the neck, shoulders, low back and knees (17 items; Attachment J-1 Items 5-11).

Exit interview (administered to participants who choose to leave the study; 5 minutes estimated time for each participant per data collection)

- Reasons for leaving the study will be collected using the questions for a phone interview (Attachment K-1).

In addition to the attachments I-1, J-1 and K-1, attachments I-2, J-2 and K-2 are provided for respondents that may prefer a Spanish version.

A limited amount of digital video is planned to be collected on participants to document their work posture for the types of job tasks being performed with and without using the interventions. A force gauge will be used to estimate their hand forces for the job tasks. All video data will be kept secure and managed in accordance with the Privacy Act of 1974, Title 5, United States Code, Section 522 (a). To ensure participants' privacy, the only identification in the video databases will be a NIOSH assigned participant company code and task code. The code identifiers will be kept in a secure location in the principal investigators' office. Videos will be saved on a NIOSH computer network that is only accessible by the principal investigator, study co-investigators, and some supporting staff for the study. The participating company will not have access to the videos. Prior to the video data collection, participants will be asked for consent for recording video, and uses of the video data (Attachment H-1 Item #15 Video/Photo release consent). The digital video data will be saved on the NIOSH network hard drives and password protected. Only the principal investigator and research staff have access to the protected network drives.

How Information will be Shared and for What Purpose

The findings from this project will be transferred to private stakeholders and OSH practitioners using several main channels below:

NIOSH (website, publications, and personnel)

- NIOSH publications pertinent to the research findings will be made and disseminated on a special topic web page linked to the NIOSH homepage. The principal investigator will work with other NIOSH program directors, such as the Prevention Through Design (PtD) program, to disseminate the publications to the large audience possible.

Airline industry organizations (website, publications, and personnel)

- Links to the NIOSH dissemination products will be provided directly to several trade organizations, such as the Airlines for America (formerly known as Air Transport Association of America), the International Transportation Workers' Federation (covering aviation workers in 110 countries). Aspects of the studies will also be submitted for publication in trade journals, such as Journal of Air Transport Management.

Peer reviewed journals

- For this study, at least one manuscript will be submitted for publication in a peer reviewed journal. Main audiences for these types of journals are fellow researchers, but also OSH practitioners.

Impact of Proposed Collection on Respondent's Privacy

Information in identifiable form (IIF) will be collected as part of the informed consent form (Attachments J-1) for this study. This includes: first and last names, street address, phone number, email address, and date of birth. Individual information will not be collected on the other surveys, which will be identified only using unique identifier (created by NIOSH) to track the responses of the participant over the course of the study. Workers' WMSD records, compensation data and daily baggage load information from the participating company will also be collected. The company records will be coded using a claim number. Individual participant personal information will not be published in any identifiable form and will be protected to the extent allowed by law (Freedom of Information Act and the Privacy Act). Information will be maintained until the conclusion of the study. The IIF data will only be used by NIOSH researchers for the purposes outlined below.

IIF Being Collected	**Purposes**
First and last names of individual participant	The participant's first and last names (in combination with their clock number) will be used to link to a unique identifier (created by NIOSH) to track the responses of the participant over the course of the study.

Street address of individual participant	The street address will be used to send the participant hard copy questionnaires during the follow-up periods. The street address will also be used to send a hard copy of final study results if requested by the individual.
Phone number of individual participant	The phone number will be used for follow up on missing data on the questionnaires. If the participant gives permission, the phone number will also be used to prompt participants to submit completed questionnaires. If the participant gives permission, the phone number will also be used for the early exit interview to contact those participants who choose to leave the study.
Email address of individual participant	If the participant gives permission, the email address will be used to prompt participants to submit monthly questionnaire.
Date of birth	The participant's date of birth will be used for determining their age, which will be used as a covariate in data analyses.

Individuals Informed that Providing Information is Voluntary or Mandatory

Participants are informed that the participation in the study is voluntary, and that they may discontinue the survey at any time.

Opportunities to Consent

Respondents will be asked to sign a written consent form for questionnaire data collection and video recording (Attachments H-1 and H-2). The forms describe how respondents are informed about the intended uses of the information collection and plans for sharing the information. They will also be advised that they will not lose any benefits to which they are otherwise entitled if they chose not to participate. The Privacy Act does apply and the informed consent form addresses the effect on the respondent of not responding to the data collection request, the intended uses of the data, with whom information will be shared, and the legal authority for the data collection.

How Information will be Secured

Access to individual data will be limited to authorized NIOSH researchers and contractors. The security measures include (1) physical controls: NIOSH facilities have 24-hour security guards, and key card ID badges must be used to enter the buildings. Data in hardcopy form will be stored in locked rooms or cabinets; (2) technical controls: all electronic data will be stored on secure servers that are protected with firewalls and passwords. Any contractor charged with data preparation, analysis, or management tasks

to be performed away from a NIOSH facility will be required to follow equivalent procedures.

The process for handling security incidents is defined in the system's Information Security Plan (Attachment G). Event monitoring and incident response is a shared responsibility between the system's team and the Office of the Chief Information Security Officer (OCISO). Reports of suspicious security or adverse privacy related events should be directed to the component's Information Systems Security Officer, CDC helpdesk, or to the CDC Incident Response Team. The CDC OCISO reports to the HHS Secure One Communications Center, which reports incidents to US-CERT as appropriate.

All data collection and records management practices and systems will adhere to all applicable federal, Health and Human Services (HHS), Centers for Disease Control (CDC), and NIOSH IT security policies and procedures [Security Requirements for Federal Information Technology Resources, January 2010; Health and Human Services Acquisition Regulation (HHSAR), Clause 352.239-72]. For example, data will be stored on encrypted CDs, flash drives, and/or ftp sites according to applicable Federal Information Processing Standards Publications (FIPS PUBS, see http://www.itl.nist.gov/fipspubs). See the Information Security Plan in Attachment G for more information.

Whether a System of Records is being Created under the Privacy Act

An existing system of records notice (SORN) 09-20-0147, "Occupational Health Epidemiological Studies and EEOICPA Program Records", will be used for this research. The federal register notice for this SORN is June 14, 2011 (Volume 76, Number 114)] [Notices] [Page 34706-34711].

A11. Justification for Sensitive Questions

The proposed survey contains some questions that may be considered sensitive. The question that appears most sensitive is (item #16 in Section A, Attachment I-1) the question related to alcohol consumption shown below.

16. In the past year, on average, how many alcoholic beverages did you have?

- ☐ None
- ☐ Less than 12 drinks
- ☐ Less than 3 drinks per week
- ☐ 3 to 7 drinks per week
- ☐ 8 to14 drinks per week
- ☐ More than 14 drinks per week

The above question is necessary for investigating the risk factors for WMSD symptoms. This question has been used in many previous studies to control for its confounding effect with other risk factors for WMSDs. Other sensitive questions include race, smoking

history and frequency, general health, pregnancy information, job insecurity and relationship with the supervisor. To remove these questions may negatively affect the scoring of the questionnaire and comparisons to numerous other studies that have used the same questions. For example, the stress model used extensively in the literature for assessing WMSDs requires inclusion of the questions about job security and relationship with supervisor. Without the psychosocial questions, the job strain from the stress model cannot be scored and compared with previous research findings (Karesek, 1998). Information on race, smoking, general health and pregnancy information is also critical in assessing the risk factors for WMSDs because these questions are highly relevant to the prevalence of WMSDs (Hoogendoorn, 2000). Exclusion of the questions will mask the effects of the underlying physical risk factors associated with the interventions. Answering these sensitive questions poses little risk to the participant since the answer to this question will be coded with a participant ID and only linked to data of individually identifiable form (IIF) that is being collected for the informed consent process.

A12. Estimates of Annualized Burden Hours and Costs

A. Annualized Burden to Respondents

No direct costs will accrue to respondents other than their time to complete the survey. We estimate that 576 individuals will participant in the data collection throughout the two-year data collection period. This includes 60 individuals in two intervention groups and 516 in the control group. These numbers are based on a 20% annualized combined uncertainty factor (refusal and attrition rates) of the originally planned 960 individuals during the study period. It is estimated that 90% of participants will be male, based on expected demographics of the baggage handler population. The hour-burden estimates include the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. All hour-burden estimates were derived based on estimates reported in the literature for these instruments, from prior CDC-NIOSH studies that utilized these forms, and informal in-house pilot testing. No new formal samples of respondents were performed. The number of respondents with missing data (approximately 5 questionnaire items across the annual and monthly questionnaires per respondent) is estimated to be 5% annually. The number of early exit interviews is based on an estimated 20% exit rate for the entire data collection period. Annualized, over the course of the three year study, this amounts to 64 participants annually completing the early exit interview. The informed consent will be collected one time at the beginning of the study from all participants. Annualized, over the course of the three year study, this amounts to a burden of 320 participants annually completing the informed consent form. The burden hours are summarized in Table A.12-1.

Table A.12-1. Estimated Annualized Burden to Respondents

Type of Respondents	Form Name	No. of Respondents	No. of Responses	Avg. Burden per Response	Total Burden

			per Respondent	(in hrs)	(in hrs)
Airline baggage handlers in ramp areas	Self-reported annual questionnaire survey for MSD symptoms and risk factors	768	1	30/60	384
	Self-reported monthly questionnaire for MSD symptoms and work method	768	12	10/60	1,536
	Informed Consent Form	320	1	5/60	27
	Follow-up on missing questionnaire data	48	5	1/60	4
	Early Exit Interview	64	1	5/60	6
				Total	1,957

B. Annualized Cost to Respondents

The total estimated annualized cost to respondents is $61,537, as summarized in Table A.12-2. The mean hourly wage rate for baggage handlers in the airline industry is $26.02 (Bureau of Labor Statistics: http://www.bls.gov/oes/current/oes531011.htm: Hourly mean wage rates for scheduled airline industry, May 2012).

Table A.12-2. Estimated Annualized Cost to Respondents

Type of Respondents	Form Name	Total Burden (in hours)	Average Hourly Wage Rate	Total Respondent Costs
Airline baggage handlers in ramp areas	Self-reported annual questionnaire survey for MSD symptoms and risk factors	384	$26.02	$9,992
	Self-reported monthly questionnaire for	1,536	$26.02	$39,967

	MSD symptoms and work method			
	Informed Consent Form	27	$26.02	$703
	Follow-up on missing questionnaire data	4	$26.02	$104
	Early Exit Interview	6	$26.02	$156
			Total	$50,922

A13. Estimates of Other Total Annual Cost Burden to Respondents or Record Keepers

There are no capital, start-up, or maintenance costs to respondents or record keepers.

A14. Annualized Cost to the Government

Total costs to the Government include work performed over the course of four years (three years for data collection and one year for data analysis) by CDC research personnel (1 industrial hygienist, 1 economist, 1 technician and 1 statistician) and contracted administrative personnel, including tasks such as: (1) development of survey materials; (2) development of sampling frame and sample selection; (3) survey conduction; (4) sample tracking; (5) data receipt and processing; and (6) data entry and delivery. The personnel costs are based on a 3% cost of living increase per year and different allocation of personnel resource (0.5 FTE for the industrial hygienist, 0.1-0.5 FTE for the economist, technician and statistician). Travel costs are estimated by a team of 3 people per visit to the study site for three years. Contractual services are budgeted for equipment maintenance and professional services for assisting in biomechanical modeling for the MSD risk data. Supplies costs are estimated for data collection and printing (e.g., memory cards, tripods, portable hard drives and printing for questionnaires). Other costs are used for intervention equipment ($21,500 per VL X 2 = $43,000 for study year 1; 3 digital camcorders and the cost for shipping intervention equipment to the study site for study year 2; maintenance costs for the equipment for study years 3-4; in-kind costs for the PW are provided by the study partner). On the basis of a 3 year data collection period, the estimated annualized costs to the Federal Government are summarized in Table A.14-1.

Table A.14-1. Estimated Annualized Cost to the Federal Government

	Total Cost	Annualized Cost
CDC Personnel Salaries and	$755,235	$251,745

Benefits		
Travel	$51,950	$17,317
Contractual	$51,190	$17,063
Supplies	$12,300	$4,100
OTHER (intervention equipment, digital camcorders)	$67,800	$22,600
TOTAL	$938,475	$312,825

A15. Explanation for Program Changes or Adjustments

This is a new data collection.

A16. Plans for Tabulation and Publication and Project Time Schedule

A 3 year clearance is being requested for the data collection period to cover any unforeseeable delays. Data collection will be completed over two years, followed by statistical analysis and dissemination of data. For data collection, NIOSH will conduct three data collections for the annual survey at baseline (beginning of the 2-year study period), the first annual follow-up and the second follow-up (the end of the study period). Twelve data collections between baseline and the first follow-up for the monthly survey will take place, followed by another 12 monthly data collections between the first follow-up and the second follow-up visits.

The data analysis plan includes analyses of questionnaire data, posture data in video recording, baggage weight information and company cost data related to WMSDs. Physical risk data, combining posture data and weight information collected at baseline, will be used as respondents' initial physical risk exposure to the interventions. To adjust for changes in crew, shift, gate, absence and flight schedule, the physical risk exposure will be tracked and modified on a daily basis using the company's baggage on-load/off-load record system. The exposure data will be further adjusted on a monthly basis according to their self-reported exposures in different job positions using the monthly questionnaire survey. The effectiveness of the interventions will be assessed first by a significant reduction in the WMSD incidence data, as compared with data for the control group, while matching their work method (sitting or kneeling in the cargo compartments). In addition, to decrease the unknown threat of individual factors (e.g., age, height, weight and sex) to the validity of the analysis for the smaller sample size (n=30) for each intervention group, data in each intervention group will be paired with participants in the control group by the additional individual factors. Since the study population for the control group is large (n=900), the likelihood of matching the participants by individual factors and work method would be high. A Chi-squared test at $p<0.05$ for significance or exact statistics if incidence rates are too small in the intervention groups will be performed at the end of the two follow-up periods. The analysis will be performed separately for different body regions using different case definitions (self-report, workers' compensation record, lost days, etc.). If a reduction in WMSD incidence rates is not significant during the study period, the effectiveness of the interventions will then

be assessed by the secondary assessment—a significant reduction in the physical risk data using the same analysis strategy as for incidence data.

Data combining all the study groups (N=960) will be used to determine the overall participation rates, individual characteristics (gender, age, job experience, etc.), estimated risk exposure levels by intervention type, psychosocial variables (job satisfaction, support at work, skill discretion, etc.), and overall incidence rates of WMSDs at baseline and the end of the two follow-up periods. In the pooled analysis, the effects of personal, physical and psychosocial factors on WMSDs will be evaluated using multivariate logistic regression models, resulting in an odds ratio (OR) at the end of each follow-up period. All the psychosocial factors will be evaluated as dichotomized factors. The categorization of the dichotomized factors will be based on the median values of the study population for the various scales used in the questionnaires (Clay et al., 2007). Cronbach' alpha test will be performed to evaluate the reliability and consistency of answers across the similar psychosocial questions. Unreliable answers to the questions (Cronbach's alpha <0.6) will be removed from the final statistical analysis. Collinearity among the variables will be evaluated, along with statistical significance ($p<0.05$), to determine which variables will remain in final models. The final models for OR calculations will describe relationships between physical risk factors and health outcomes, while controlling for the effect of personal and psychosocial factors. If precise onset of the WMSD cases can be determined, a survival analysis or hazard ratio analysis will be performed to account for the effects of the time course of WMSD cases.

A separate cost-benefit analysis will be performed for the WMSD-related company cost data. The analysis is based on annual direct and indirect costs for using the interventions. Capital or direct costs for installing the interventions will be collected from company purchase records. Indirect costs and benefits associated with the interventions will be converted to net present values in dollar amounts for calculations of the cost-benefit analysis. Intangible costs such as personnel commitment, worker morale, and supervision effort will not be calculated in this portion of the research project due to difficulty in measuring them.

A cost-benefit ratio (Intervention costs / Intervention benefits) equal to or greater than one indicates that the investment for the intervention has not been cost-effective; while a ratio smaller than one indicates that the intervention is cost-effective. This ratio also represents the payback period for the investment for the intervention. For example, if the cost-benefit ratio equals 2.5, it will take 2.5 years to payback the investment for implementing the intervention. In addition, using projected injury costs and depreciation of the investments on the intervention, a return on investment in different terms, typically 5, 10 to 20 years into the future will be calculated to allow flexible planning.

A full description of the statistical protocol is provided in Part B1 and B2 of this ICR. Results will be made available through publication in scientific journals and notices in trade publications, and through digital media such as the Internet.

Table A.16-1. Project Time Schedule

Activity	Time Schedule (Months After OMB Approval)
The MSD interventions will be installed in the recruited establishments. Nine hundred and sixty individuals will be recruited to the study. Among them, 60 will be randomly selected to receive the WMSD interventions. Informed consent form (Attachment H-1) will be completed by all participants. Baseline data including risk exposure (video recording of job tasks) data will be collected on 60 participants in the interventions groups and additional 30 participants in the control group. The questionnaire data (Attachment I-1) will be collected on all participants.	Within 6 months after OMB approval
First monthly data will be collected (self-reported pain symptoms and work exposures, Attachment J-1).	Within 9 months after OMB approval
Second monthly data will be collected (self-reported pain symptoms and work exposures, Attachment J-1). The same monthly data collection will take place for the following 10 months.	Within 10 months after OMB approval
First annual follow-up data will be collected using the same questionnaire (Attachments I-1**)** used at baseline.	Within 20 months after OMB approval
First monthly data after the first follow-up survey will be collected (self-reported pain symptoms and work exposures, Attachment J-1).	Within 21 months after OMB approval
Second monthly data after the first follow-up visit will be collected (Attachment J-1). The same monthly data collection will take place for the following 10 months.	Within 22 months after OMB approval
Second annual follow-up data will be collected using the same baseline questionnaire (Attachment I-1**).**	Within 32 months after OMB approval

The analysis of study data will be completed to determine the effectiveness of multi-site MSD interventions at airport establishments.	Within 44 months after OMB approval
Publications of study results	Within 48 months after OMB approval

A17. Reason(s) Display of OMB Expiration Date is Inappropriate

There is no request for an expiration date display exemption.

A18. Exceptions to Certification for Paperwork Reduction Act Submissions

There are no exceptions being sought to the certification statement.

Literature Cited

Breiman L, Friedman J, Olshen R, et al: *Classification and Regression Trees.* Pacific Grove, CA: Wadsworth; 1984.

Bureau of Labor Statistics: Census of non-fatal occupational injuries. U.S. Department of Labor, Washington DC (2013).

Chaffin D. B. and Erig, M.: Three dimensional biomechanical static strength prediction model sensitivity to posture and anthropometric inaccuracies. *AIIE Transactions*, 23: 215-227 (1991).

Chaffin D.B. and Baker W.H.: A biomechanical model for analysis of symmetrical sagittal plane lifting. *AIIE Transactions*, 2: 16-27 (1970).

Chaffin D.B.: A computerized biomechanical model-development of use in studying gross body action. *Journal of Biomechanics*, 2: 429 (1969).

Chang C., Hsiang S., Dempsey P. and McGorry R.: A computerized video coding system for biomechanical analysis of lifting task. International Journal of Industrial Ergonomics. 32: 139-150 (2003).

Clay E., Bacquer D., Leynen F., Kornitzer M., Kittle F. and Backer G.: The impact of psychosocial factors on low back pain. Spine 32 (2): 262-268 (2007).

da Costa BR and Vieira ER.: Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. American Journal of Industrial Medicine. 53: 285-323 (2010).

Davis K. and Heaney C.: The relationship between psychosocial work characteristics and low back pain: understanding methodological issues. Clinical Biomechanics 15: 389-406 (2000).

Dell G.: Airline baggage handler back injuries: A survey of airline baggage handlers opinion on causes and prevention. Safety Science Monitor. 2(2): 2-12 (1998).

Dell G.: The causes and prevention of baggage handler back injuries: A survey of airline safety professionals. Safety Science Monitor. 1(3): 2-11 (1997).

Egeskov R.: Use of conveyor belts and locker loading on B737 aircraft, Comcare Investigation Report, Comcare, Brisbane (1992).

Garg A., Kapellusch J, Hegmann K.T., moore S., Boda R., Bhoyar P., Thiese M.S.: The NIOSH lifting equation and low back pain, Part 1: Association with low back pain in the BackWorks prospective study. Human Factors 56 (1): 6-28 (2014)

Guo H., Tanaka S., Cameron L., Seligman P., Behrens V., Wild D. and Putz-Anderson

V.: Back pain among workers in the United States: national estimates and workers at high risk. American Journal of Industrial Medicine. 28: 591-602 (1995).

Haratani T., Kawakami N., Araki S., Hurrell J. Sauter S. and Swanson NG.: Psychometric properties and stability of the Japanese version of the NIOSH job stress questionnaire. 25th International Congress on Occupational Health. Book of Abstracts Pt 2:393 (2004).

Hendrick HW: Determining the cost-benefits of ergonomics projects and factors that lead to their success. Applied Ergonomics. 34: 419-427 (2003).

Hogwood N.: Aircraft holds-ergonomic disaster areas, Presentation to the National Safety Council of America, International Air Transportation Section Conference Sydney, National Safety Council of America, Itasca (1996).

Hoogendoorn W., van Poppel M., Bongers P., Koe B. and Bouter L.: Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine, 25 (16): 2114-2125 (2000).

Hurrell J. and McLaney: Exposure to job stress: A new psychometric instrument. Scand J Work Environ Health, 14: 27-28 (1992).

Jorgensen K., Jensen B. and Stokholm J.: Posture strain and discomfort during loading and unloading of flights. An ergnomic intervention study. Trends in Ergonomics/Hunan Factors, Elsevier Science Publishers, New Holland (1987).

Karasek R. Brisson C., Kawakami N., Houtman I., Bongers P. and Amick B.: The job content questionnaire: an instrument for intentionally comparative assessments of psychosocial job characteristics. Journal of Occupational Health Psychology 3(4): 322-355 (1998).

Kingma I., Looze M., Toussaint H., Klijinsma H. and Bruijnen T.: Validation of a full body 3-D dynamic linked segment model. Human Movement Science. 15: 833-860 (1996).

Kourinka I., jonsson B., Kilbom A., Vinterberg H., Biering-Sorensen F., Anderson G. and Jorgensen K.: Standardized

Kumar S.: Cumulative load as a risk factor for back pain. Spine 15(12): 1311-1316 (1990).

Liberty Mutual Research Institute for Safety. Liberty Mutual Workplace Safety Index, Liberty Mutual 175 Berkeley St., Boston, MA 02116 (2013)

Lu M., Waters T., Werren D. and Piacitelli L: Comparisons of accuracies of two methods for assessing trunk posture associated with low back disorders. *Proceeding paper in 17th World Congress on Ergonomics. Beijing, China*. (2009)

Lu M., Waters T., Werren D. and Piacitelli L.: Human posture simulation to assess cumulative spinal load due to manual lifting: Part II - Accuracy and Precision. *Theoretical Issues in Ergonomics Science* 12 (2): 189-203 (2011)

Lu M., Waters T. and Werren, D.: Development of human posture simulation method for assessing posture angles and spinal loads. Human Factors and Ergonomics in Manufacturing and Service Industry (in press).

Lu M., Waters T., Krieg E. and Werren, D.: Efficacy of the Revised NIOSH Lifting Equation to Predict Risk of Low Back Pain Associated with Manual Lifting: A One-year Prospective Study. Human Factors 56 (1): 73-85 (2014)

Lu M., Dick R., Werren D. and Lowe B.: Bag handling assist controls for airport screening processes. DART In-depth survey report. NIOSH Publication Number: EPHB-010-22a (2014).

Marras WS., Lavender SA, Leurgans SE., et al: Biomechanical risk factors for occupationally related low back disorders. Ergonomics 38:377-410 (1995).

Marras WS, Lavender SA, Ferguson SA, Splittstoesser RE, Yang G: Quantitative biomechanical workplace exposure measures: distribution centers. J Electromyogr Kinesiol 20 (5):813-822 (2010).

McGorry RW, Shaw WS, Lin JH: Correlations between pain and function in a longitudinal low back pain cohort. Disabil Rehabil. 33(11):945-52 (2011).

McLaughlin GH. SMOG grading: A new readability formula. Journal of Reading, 12 (8) 639-646. (1969)

Nakata A., Ikeda. T., Takahashi M., Haratani, T., Hojou M., Fujioka Y., Swanson N. and Araki, S.: Impact of psychosocial job stress on non-fatal occupational injuries in small and medium-sized manufacturing enterprises. American Journal of Industrial Medicine. 49: 658-669 (2006)

National Institute for Occupational Safety and Health: Musculoskeletal Disorders and Workplace Factors, a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back. US Department of Health and Human Services (1997).

National Research Council and Institute of Medicine: Musculoskeletal disorders and the workplace. Low back and upper extremities. National Academy Press, Washington D.C. (2001)

Norman R., Wells R., Neumann J., Frank J., Shannon H., Kerr M. and OUBPS Group. A comparison of peak vs. cumulative physical work exposure risk factors for the reporting of low back pain in the automotive industry. Clinical Biomechanics 13: 561-573 (1998).

Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics. 18(3): 233-237 (1987).

Oxenburgh MS: Cost-Benefit analysis of ergonomics programs. American Industrial Hygiene Association. 58 (2): 150-156 (1997).

Reville R., Bhattacharya J. and Weinstein L.: New methods and data sources for measuring economic consequences of workplace injuries. American Journal of Industrial Medicine. 40:452-463 (2001).

Riley D.: Reducing the risks associated with the manual handling of air passenger baggage for narrow bodied aircraft. Literature review update. The Health and Safety Executive, United Kingdom (2009).

Steinberg D, Colla P. *CART—Classification and Regression Trees.* San Diego, CA: Salford Systems; 1997.

Tapley S and Riley D.: Baggage handling in narrow-bodied aircraft: Identification and assessment of musculoskeletal injury risk factors. The Health and Safety Executive, United Kingdom (2005).

Von Korff M, Deyo RA., Cherkin D., Barlow W.: Back Pain in Primary Care Outcomes at 1 year. Spine 18(7):855-862 (1993).

Waters T., Lu M., Werren D. and Piacitelli L.: Human posture simulation to assess cumulative spinal load due to manual lifting: Part I - Method. *Theoretical Issues in Ergonomics Science* 12 (2): 176-188 (2011)

Waters T., Yeung A. Genaidy A., Callaghan, Barriera-Viruet H. and Deddens J.: Cumulative spinal loading exposure methods for manual materials handling tasks Part1: is cumulative spinal loading associated with lower back disorders? Theoretical Issues in Ergonomics Science. 7(2): 113-130 (2006).

Xu X., Chang C., Faber G., Kingma I. and Dennerlein JT.: Comparing polynomial and cubic spline interpolation of segment angles for estimating L5/S1 net moment during symmetric lifting tasks. Journal of Biomechanics. 43: 583-586 (2010).