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Ergonomics and the Potential for Sharps Injury Reduction: Developing a Strategy to Assess Mobile Dentistry in Rural Alaska

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by

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Abstract

This report describes the development of an ergonomic assessment strategy for a Rural Alaska mobile dental team (n=3). An examination of available peer reviewed literature was conducted to identify known physical risk factors associated with musculoskeletal disorders and the practice of dentistry. The report also explored the association between ergonomics, work-related musculoskeletal disorders, and a reduction in dental sharps injury.

The known physical risk factors associated with work-related musculoskeletal disorders, sharps injury prevalence data, and results from Nordic Questionnaires were collected as baseline data. A sharps injury report from January through October of 2016 was obtained from the Bristol Bay Area Health Corporation to determine a dental sharps injury prevalence of 14%. A variant of the self-administered Nordic Questionnaire provided a prevalence of physical aches and pains associated with work-related musculoskeletal disorders for a dental department (N=13). This data was used in a strategy to develop a decision matrix to prioritize ergonomic assessments of mobile dental team job tasks.

A manual material handling task was targeted by the decision matrix as the number one priority for ergonomic evaluation. The manual material handling evaluation included the collection of psychophysical data (n=3) using self-administered Borg intensity scales for exertion, fatigue and pain. Data analysis identified a significant difference between intensity levels of a mobile dental team's perception of exertion compared to fatigue. Implementing proper ergonomics may prevent further escalation of fatigue during manual material handling and decrease the risk of injury.

Keywords

Ergonomics, Sharps Injury, WMSDs, Exertion Fatigue, Pain, Manual Material Handling

Dedication:

To Lacey, Samuel, Faye, Claire, and Julia for all their loving support.

Acknowledgements

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Glossary of Terms

Term	Definition
Work-related Musculoskeletal disorder (WMSD)	A condition or disorder that involves the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs. These disorders are not typically the result of a distinctive, singular work event, but are more gradual in their development. WMSDs are cumulative-work type injuries (NIOSH, 1997).
WMSD risk factors	Actions or conditions that increase the likelihood of injury to the musculoskeletal system. Risk factors have components of duration, frequency, and level of exposure. Exposure to WMSD risk factors leads to discomfort and pain. This leads to more serious disorders of the musculoskeletal system (NIOSH, 2004).
Ergonomics	A discipline or science and art of fitting workplace conditions and job demands to the capabilities of the worker. Many consider ergonomics a multidisciplinary field of applied science where knowledge about human capabilities, skills, limitations, and needs is taken into account when examining the interactions among people, technology, and the work environment (Stack, Ostrom, and Wilhelmsen, 2016).
Sharps Injury	A sharps injury is a penetrating stab wound from a needle, scalpel, or other sharp object that may result in exposure to blood or other body fluids (CDC, 2011). For the purpose of this report, sharps injury includes needle sticks.
Fatigue	Cumulative effect of physical and mental stressors. The level depends on the intensity and duration of the physical or mental effort (Stack, et al., 2016).

1. Introduction

This report was conducted with the cooperation and approval from the Bristol Bay Area Health Corporation (BBAHC). BBAHC is a Tribal Health Organization that provides comprehensive health care, including dental services, for 28 Alaska Native member tribes. BBAHC employs over 300 people throughout the Bristol Bay Region of Southwest Alaska.

The villages BBAHC serves are geographically isolated and span an area about the size of Ohio. There are no connecting road or rail systems so travel is typically by small plane or skiff. The 28 Alaska Native villages that make up BBAHC have populations that range from less than 20 to over 500, with a regional estimated population of 7,000 (AK Census, 2015). When patients from remote villages require additional medical or dental care they may be flown to the BBAHC Kanakanak Hospital in Dillingham or to the Alaska Native Medical Center in Anchorage.

The economy in Bristol Bay is driven by a robust commercial, sport, and subsistence salmon fishery. Five types of pacific salmon return from the Pacific Ocean and surrounding seas in abundance to spawn in the freshwaters of Bristol Bay. During their return wild chinook (king), sockeye (red), coho (silver), pink (humpy), and chum (dog) salmon are caught by fishermen, prepared by fish processors, and shipped globally to supply one third of the world with sockeye salmon. In 2016 the Alaska Fish and Game celebrated the 2 billionth sockeye salmon caught by a commercial fisherman over Bristol Bay’s 133-year fishing history (AKF&G, 2016).

BBAHC also seeks to maintain a healthy and vibrate workforce. They have an active occupational safety and health (OSH) program and have recognized ergonomics as an integral component of their OSH program. BBAHC is supportive of efforts to reduce work place injuries and to keep workers healthy. As part of their OSH program the BBAHC Dental Department has expressed a desire to reduce physical risk factors associated with WMSDs and reduce dental sharps injuries (Tijerina, 2016). It is demonstrated that ergonomics prevents work-related musculoskeletal disorders (WMSDs) by applying ergonomic principles to identify, evaluate, and control workplace physical risk factors (Stack et al., 2016). However, an effort to understand the possible association between ergonomics and a reduction in dental sharps injury lacks study.

The Dental Department provides oral health care at the main clinic in Dillingham and for the villages of BBAHC. When fully staffed the Dental Director, Dr. Tijerina is responsible for 20 or so dental professionals including; dentists, dental assistances, dental hygienists, front desk support, and dental health aides. They maintain regular office hours, provide on call service for emergency oral health care, and also provide mobile dental care to a majority of BBAHC villages.

Dental care in the villages is provided by a 3-4 person Mobile Dental Team (MDT). The MDT typically consists of a dentist, 2 dental assistants, and when available, a dental hygienist. The MDT rotates between working at the Dental Clinic in Dillingham and traveling to the villages. The Dental Department deploys 3-4 MDTs depending on the dentist staffing levels at the main clinic in Dillingham. Each team typically spends 1-2 weeks each month from September through June providing mobile dental care, often under austere field conditions. The MDT encounters many physical risk factors associated with WMSDs and are at risk of dental sharps injuries while providing dental health care in rural Alaska.

2. Background

There is a high demand for dentists in Rural Alaska. It is predicted that over the next 10 years the number dentists practicing in rural Alaska will decrease (Lamster and Formicola, 2011). Another study predicts that there are going to be enough dentists to meet the continued demand, and perhaps create a surplus, but those dentists will likely choose to work in the private sector and not wish to work in rural underserved areas (Diringer, Phipps, and Carsel, 2013). Either way these predictions turn out, dentists will still be desperately needed in rural Alaska.

2.1. Access to Dental Care

American Indians and Alaska Natives (AI/AN) suffer disproportionately from dental diseases (IHS, 2016). Historically, access to dental care in Rural Alaska has been lower than the general U.S. population. Alaska Natives face additional access to care hardships as they live in geographically isolated villages, have inadequate sanitary infrastructure, and live below the poverty level (IHS, 2010).

The shortage of dentists and access to dental care is demonstrated in the oral health of American Indian and Alaska Native (AI/AN) preschool children as they have the highest level of tooth decay of any population group in the US, which is more than 4 times higher than white non-Hispanic children. On average, white non-Hispanic children have about 1 tooth with decay while AI/AN children have 4 teeth with decay (IHS, 2014). An estimated 44.5% of persons aged 2 years and older had a dental visit in the past year in the United States, while only 28.8% of American Indians and Alaska Natives (AI/AN) accessed dental care in 2014. The dental data from the United States showed that in 2012 within Alaska Native children, 87% of 4 to 5 year olds and 91% of the 12 to 15 year olds had dental decay while 35% and 51% Caucasian children, age respective, had tooth decay. Among children from the Alaska villages, the 4 to 5 year olds had an average of 7.3 dental caries, and those aged 12 to 15 years had an average of 5.0 dental caries, this was compared with an average 1.6 and 1.8 dental caries in Caucasian children (CDC, 2010).

The Indian Health Service (IHS) suggests some reasons for the high tooth decay rates noted above. They provide that the parents of AI/AN children may not fully understand the importance of early dental visits for treating decay. The IHS also and notes living in relative geographic isolation limits many Tribal populations AI/AN children's access to dental care (IHS, 2014; Phipps and Ricks, 2015; Lamster, et al., 2011).

2.2. Dental Facilities

Dentists require an operatory to provide proper oral health care. Many villages in rural Alaska do not have adequate dental facilities to facilitate proper examination and care. To overcome this, the MDT must transports their operatory back and forth to the village they are working in. The operatory is where the dentist and their team provide the patients with oral health care. The mobile operatory consist of equipment like an adjustable reclining chair for the patient, a chair for the dentist, a chair for the assistant, dental tools, light equipment, supplies, electronics, computers, chemicals, and handheld x-rays. All these items fit into a variety of containers with varying weights that the dental teams lift and load onto small passenger planes.

2.3. Workplace Hazards

Those that provide oral health care are at an increased risk for exposure to numerous workplace hazards. These hazards include bloodborne pathogens, pharmaceuticals, chemical agents, human factors, noise, workplace violence, and ergonomic hazards (OSHA Dentistry, n.d.). Studies are showing that one out of ten dentists are in poor general health and three out of ten dentists report having a poor physical state (Gorter and Eijkman, 2000). Muscular imbalance, neuromuscular inhibition, pain, and dysfunction may also be observed among dental teams (Yamalik and Turkey, 2007).

2.3.1. Dental Sharps

The Dental Team is at risk of increased injury from dental sharps, including needle sticks and burs. These injuries continue to pose serious risk of exposure to bloodborne pathogens. Very small, extremely sharp, carbide steel objects spinning at high revolutions per minute can be used to describe many dental tools; like a #7901 subgingival dental bur. The Dental Department at BBAHC has recently noticed an increase in sharps injury associated with this small bur but it is essential for certain procedures and is without a practical substitute (Tijerina, 2016). Figure 1 contains an image of a #7901 subgingival dental bur (Patterson Dental, 2016).

Figure 1. Dental Bur #7901, Not To Scale
Specifications: Kerr Rotary Mfg., Head Diameter 0.9 mm, Head Length 3.2 mm, and Shank Length 19 mm. (Patterson Dental, 2016)

2.3.2. Mental Stress

Following a contaminated sharps injury the additional stress of an infection adds to the dental professional’s mental stressors. The likelihood of developing a disease after a sharps injury depends on various independent factors: pathogen concentration, depth of the wound, blood volume, the amount of pathogens transmitted, and the infection phase of the pathogen carrier. The infection rate and availability of vaccinations, or post exposure prophylaxis, are factors the newly infected dentist must face. This is along with the consequences of developing acute and chronic diseases from the sharps injury (Wlburn, 2004).

2.4. Physical Risk Factors

Risk factors are defined as actions or conditions that increase the likelihood of injury to the musculoskeletal system (NIOSH, 2004). A significant number of dentist and their dental teams experience musculoskeletal pain and are at risk of developing serious work-related musculoskeletal disorders (WMSDs) (Valachi and Valachi, 2003). Practicing dentistry involves a combination of repetitive, awkward, and stressful motions often with the hands and wrists with demands of working within the same posture for long hours. These physical risk factors result in discomfort, pain, and illness or injury, leading to musculoskeletal disorders. Injuries result in loss time, resulting in disruption or impairment of dental practice, and can then limit a patient's access to dental care (Bedi, Moon, Bhatia, Gagandeep, and Khan, 2015).

2.4.1. Postures

According to the authors of one WMSD dental study, the ideal working posture for a dentist allows one hand for access, visibility and control in the mouth and has the other hand available for physical and psychological comfort throughout the execution of the clinical acts. A more balanced posture provides the dentist working energy, a reduced stress level, increased comfort, lack of pain and muscular tension, and a lower risk for WMSDs (Yamalik, et al., 2007).

Awkward working postures are a high physical risk factor for WMSDs and these unbalanced working postures can induce fatigue, pain, stress, and foster the development of a negative attitude towards work (Pîrvu, Patrascu, Pîrvu, and Ionescu, 2014). The human body is not designed to maintain the same body position for extended periods of time so static tasks increase the risk for WMSDs. There is a neutral zone of movement that does not require high muscle force for every articulating joint and injury may develop with tasks performed outside this zone. Repeated or sustained exertions, unnatural, working postures like forward bending, repeated rotation of the head, neck and trunk to one side, working with the arms abducted away from the body, over extended with shoulders hunched, and sitting in strained positions are examples of awkward postures that attribute to the development of dentistry related WMSDs (Yamalik, et al., 2007).

2.4.2. Vibration and Pinch Grip

Dentists use an extensive array of handpieces while providing patient care. The moving parts of some handpieces can lead to vibration syndrome in the hands and have a cumulative effect of the nerves with long term use (Yamalik, et al, 2007). Dental handpieces and other instruments can have small diameters which demand a pinch grip from the hands and forearms. This can cause muscle fatigue in the thumb and finger muscles or constrict the blood supply leading to the development of WMSDs (Pîrvu, et al., 2014).

2.4.3. Manual Material Handling

In conjunction with a the dental teams regular day to day care, the mobile teams that serve the villages in rural Alaska must bring the dentist office to their patients. Members of the BBAHC Dental Team work within their main dental clinic and also serve as rotational members of a 3 or 4 person Mobile Dental Team (MDT). For a typical 1 to 2 week-long visit over a 1,000 pounds of containers, boxes, and bags of dental equipment, dental supplies, and personal items are hauled out of storage, loaded in a van, and then loaded onto a small plan. Once the MDT arrives in the village they unloaded the plane and load a vehicle with all those dental items to be transported to a facility. Once at the facility they must also unload and set up the dental operatory. All of this occurs before they even see their first patient.

The dental teams are responsible for loading, unloading, setup, and take down of all their equipment. These tasks are considered manual material handling (MMH) and require a person to lift, lower, push, pull, hold and carry objects (Stack, et al., 2016). The figures in Appendix A capture the efforts of the 3 person MDT working through a typical mobilization to a village and set up of some of the necessary operatory equipment and supplies. The entire process is reversed for demobilization back to the BBAHC Dental Clinic in Dillingham.

3. Research Objective

- The objective of this research was to develop applicable ergonomic assessment methods within a Rural Alaska mobile dental team that will lead to control methods that may potentially reduce sharp injury rates.

4. Literature Review, Dental Ergonomics and Sharps Injury

A dentist can spend over 60,000 career hours working in awkward postures (Gupta, 2014). Ergonomic related studies within the dental field have established a causative relationship between awkward working postures and musculoskeletal disorders (WMSDs) (Valachi, et al., 2003). Ergonomics is the solution to many WMSDs (Stack, et al., 2016).

One cross sectional study of 110 dentists practicing Belgaum, India presented that 62% of the dentists were aware of ergonomics in dentistry, and 67% of them were aware that proper ergonomics could prevent many occupational hazards related to dentistry (Viragi, Ankola, and Hebbal, 2013). Yet many dentists work in unbalanced postures out of habit, or through routine, and without ergonomic workstations. Unintentionally ignoring the fact that the human body has its adaptive limits unfortunately pushes the dentist closer to WMSDs. As the dental teams work in awkward postures and exceed the limitations of their body they are further exposed to the risk of WMSDs (Pîrvu, et al., 2014).

Another study explored the effectiveness of ergonomic controls that reduce WMSDs. The authors conducted a cross sectional study of 60 dentists in India and demonstrated that 68% of their participants reported WMSDs. Their study included a meta-analysis of 7 other studies and demonstrated similar distributions for baseline prevalence rates from 60 to 87%. They set α value to 0.05 and reported a p-value of 0.048 when they compared their WMSDs prevalence with the other studies. Then the authors provided control recommendations and conducted a follow up survey to see if ergonomic controls were effective. Of the 60 original participants, only 23 respondents applied ergonomics at their work place but those did, reported a significant ($p<0.05$) reduction in prevalence of neck pain from 48% to 22 %, shoulder pain went from 39 % to 17%, and elbow pain went from 26% to 22% (Bedi, et al., 2015).

4.1. Ergonomics Prevents Fatigue

In just about all occupational environments, including mobile dentistry, it is desirable to reduce fatigue. Fatigue is a multi-factorial hazard and has a complicated mental and physical stressors that can adversely affect the dentist (Garg, Campbell-Kyureghyan, Kapellush, and Yalla, 2011). Ergonomics is effective at reducing the risk factors that contribute to fatigue (Bush, 2012). Fatigue is also associated with WMSDs and many known risk factors are also associated with the development and frequency of WMSDs. When the physical demands exceed the workers capacity the strain will be greater than one and risk of WMSDs increases (Garg, et al., 2011).

$$Strain = \frac{Job\ Physcial\ Demands}{Worker\ Capacity}$$

Equation 1: Strain Equation

The strain equation (Equation 1) gives support to effective participatory ergonomic controls to fit job physical demands over worker capacity (Landsbergis, 2011).

Fatigue experienced by healthcare workers, and medical trainees in particular, might play an important role in the occurrence of sharps related injuries. In a Japanese training hospital researchers used a Borg survey to provide a statistical significant relationship between fatigue and prevalence of sharps injury. The authors indicated that of 350 interviewed subjects, 109 (31%) were medical trainees. The trainees worked more hours per week ($P < 0.001$) and slept less the night before an injury ($P < 0.001$) than did other healthcare workers. Fatigue increased injury risk in the study population as a whole with a prevalence rate ratio of 1.40 with a 95% confidence interval from 1.03-1.90. They noted that medical trainees comprised the bulk of sharps injury with a reported prevalence rate ratio of 2.94 with a 95% confidence interval from 1.71-5.07 and that the sharps injury was absent for other the healthcare workers at the hospital. The authors concluded that fatigue was associated with a 3-fold increase in the risk of sharps injury within the students only (Smith, Mihashi, Adachi, Nakashima, and Ishitake, 2006). Efforts to reduce trainee working hours may result in reduced risk of sharps injuries among health care workers (Fisman, Harris, Rubin, Sorock, and Mittleman, 2007).

Another study looked into the risk factors associated with WMSDs. They surveyed for aches and pains, like lower backache, wrist ache, and neck, and shoulder pain. Around 40% of the participants complained about one or more WMSD. The authors reported prevalence rates of 59-87% for WMSDs. They noted that WMSDs are one of the major factors for premature retirement among dentists along with stress and cardiovascular disease; however these findings were subject to survey bias and should be interpreted as such (Mehta, Gupta, and Upadhyaya, 2013).

4.2. Dental Sharps Injury

A study of a dental academy surveyed 200 student and faculty members at the Army College of Dental Sciences in India. The authors noted that the manipulation of sharp objects caused over 32% of reported needle stick injuries. The results from their cross sectional survey were tested for association between sharps and injury using a Chi square test, p value ($p<0.05$). A majority of participants were also aware of AIDS and Hepatitis B being spread by sharps injury ($p<0.001$) yet, one of their four groups did not know that hepatitis C can be spread by contaminated sharps. They noted that most of the sharps injuries occurred in the student population during extractions ($p<0.001$) while the more experienced dental faculty reported the highest number of sharps injury during suturing ($p<0.001$) (Bindra, Ramana, Chakrabarty, and Chaudhary, 2014).

Researchers have also evaluated causative factors associated with the prevalence of dental sharps injury. Their survey involved 400 dentists working in the Queensland area of Australia. The authors discovered that the dental devices that caused the top two number of sharps injury were hollow bore and suture needles at 14% and then burs at 10%. Around 28% of respondents in this study indicated at least one sharps injury in the previous 12 months and 16%

of all respondents reported contaminated sharps injuries while providing patient care. The authors acknowledged reporting/survey bias (Leggat and Smith, 2006).

A dental study at a UK dental teaching hospital noted similar findings with over one fifth 22% (n = 63) of all sharps injuries that occurred between 2005 and 2010 were from local anesthetic needles. Dental drill burs were the second most common cause of injury18% (n = 51), followed by dental probes 9% (n = 27) and suture needles 6% (n = 16). Splash incidents accounted for 19 (7%) of the incidents. The authors included an ‘other’ category and collected 27 incidents that occurred rarely but added up to almost 10% of the reported sharps injuries. The ‘other’ sharps injuries involved tweezers, pliers, wires, mirrors, clasps, and from the patients biting the dentist (Hughes, Davies, Hale, and Gallagher, 2012).

4.3. Ergonomics Reduces Sharps Injury

The only study found associating ergonomics and sharps injury was conducted by the Creighton University Medical Center. They noted a statistically significant difference in the frequency of the overall sharps related incidents, over a pre and post implementation of ergonomic controls in an operating room (OR). A Wilcoxon Signed Rank test, p level ≤ 0.05, revealed a 64% decrease in sharps injury prevalence rate among the OR staff, and a 44% decrease in prevalence rate was found among students and residents, pre and post ergonomic control implementation. Notably, a 55% decrease was found in the sharps incident rate of events related to sharps injury among all the OR teams over the first seven months of implementing the ergonomic process improvement. The ergonomics training for the prevention of injuries from sharps incorporated physical, cognitive and teamwork measures. Ergonomic trained professionals delivered the ergonomics injury prevention training and they had management participate in supporting and facilitating the program implementation (Kalaga, et al., 2016).

5. Methods and Design

This section describes a subjective observational approach used in the development of an ergonomic assessment strategy for a Rural Alaska Mobile Dental Team (MDT). The strategy was designed by the author and has not been subject to peer review. The strategy proposed utilizes the information gathered about the job tasks, sharps injuries, Nordic Questionnaire, and the physical risk factors associated with the development dental WMSDs to develop a subjective method of prioritization to use for ergonomic evaluation. The following describes the process of decision matrix development used to prioritize the job tasks for ergonomic evaluation.

5.1. Baseline Data

Collecting baseline data was the beginning of the assessment strategy. The literature review established 7 physical risk factors (repetition, force, posture, vibration, lifting, awkward posture, and static work posture) known to be associated with dentistry work-related musculoskeletal disorders and sharps injuries. Interviews and conversations with the BBAHC Dental Director and members of the Dental Department were essential to the gain more detail into understanding job tasks. The prevalence of sharps injury and WMSDs provides insight into recognizing the physical risk factors associated with reported WMSDs and will be used for development of the ergonomic assessment decision matrix.

5.1.1. Prevalence of Sharps Injury

The BBAHC Dental Team communicated a desire to reduce their sharps injuries. The data used to calculate sharps injury prevalence was provided by the BBAHC Infection Control program (BBAHC, 2016). Their current sharp injury prevalence of 14% is shown in Equation 3.

5.1.2. Work-Related Musculoskeletal Disorders

The entire dental team (N=14) was requested to complete a NIOSH adapted version of the Nordic Questionnaire which is used to record work related musculoskeletal symptoms in working populations (Kuorinka, Jonsson, Kilborn, Vinterberg, Biering-Sorensen, and Anderson, 1987; NIOSH, 2004). This data was gathered from the BBAHC Dental Team to identify a baseline of self-administered body area discomfort that could possibly be associated with musculoskeletal disorders. The time demand to complete the survey was estimated at about 5 minutes. A written cover page was attached describing the objectives of the assessment, provided an overview of what the data would be used for, and explained why it is worth the participant's time to complete it. The Nordic Questionnaire survey tools used in this report are found in the Appendix B.

5.2. Decision Matrix Development

The first step in reducing risk was to identify the Dental Team job tasks that involved the physical risk factors associated with WMSDs (NIOSH, 2004). The job tasks performed by the Mobile Dental Team (MDT) were broken down into general job task areas (AIHA, 2011). A discussion with the Dental Director, members of the Dental Team, and the literature review provided the basis of understanding for each job task and the task relationship to sharps injury

(Tijerina, 2016). Since WMSDs are strongly associated with MMH, those tasks are singled out for immediate MMH ergonomic evaluation and would take priority over the other job tasks (AIHA, 2011; NIOSH, 2007).

5.2.1. Physical Risk Factors to "Demands"

A subjective rating was assigned to each non-MMH job task based off the strength of evidence for causal relationships that links 7 physical risk factors to WMSDs (NIOSH, 1997; McGlothlin, 2011). Using Table 1, if the job task seems most likely to be associated with known WMSD physical risk factors then that task was scored with a "3." If the task seemed likely to be associated with a given WMSD physical risk factor it was scored a "2" and when the task seemed less likely associated it was scored at "1." These scores are then totaled for each job task.

To exaggerate the severity of a possible sharps injury, a multiplier of 1.5 was arbitrarily assigned to the job tasks most likely associated with sharps usage and multiplier of 1.0 was assigned to those tasks not so likely associated with sharps injury. Once the multiplier is applied, to the total the resultant is called a "Demands" score (Table 1).

Table 1: Deriving the "Demands" Score Used in Decision Matrix.

Deriving the "Demands" Score Used in the Decision Matrix: Using a Subjective Application of the Evidence for Causal Relationships between Physical Risk Factors and WMSDs, Physical Risk Factors by Job Task with Sharps Multiplier (NIOSH, 1997 and McGlothlin et al., 2011)										
Job Task	**Repetition**	**Force**	**Posture**	**Vibration**	**Lifting**	**Awkward Posture**	**Static Work Posture**	**Total**	**Sharps Injury Multiplier**	**"Demands" Score**

<table>
<tr><td>Job Task Name Insert Rows as Needed for Additional Tasks</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>Insert Total risk factor ratings here</td><td>** Obtain Multiplier from Key below</td><td>Apply Sharps Multiplier to Total and insert product here for “Demands” Score</td></tr>
<tr><td></td><td colspan="7">Using the Key below subjectively weight knowledge of Job Task against Evidence of Casual Relationship between Physical Risk Factors and WMSDs to determine score for each risk factor. If task subject to possible sharps injury apply Sharps Injury Multiplier. Use NIOSH, 1997 Table 1 in Appendix C as a guide to assign associative scoring.</td><td></td><td></td><td></td></tr>
<tr><td colspan="11">Key
If MMH , Then Priority Evaluation

For Non-MMH tasks:
*If Job Task is Most Likely Associated with Physical Risk Factor, Then Score 3

*If Job Task is Likely Associated with Physical Risk Factor, Then Score 2

*If Job Task Less Likely Associated with Physical Risk Factor, Then Score 1

**If Job Task has Possible Association with Sharps Injury, Then apply 1.5 Multiplier

**If Job Task has Low association with Sharps Injury, Then apply 1.0 Multiplier</td></tr>
</table>

5.2.2. Prevalence to “Discomfort”

The prevalence of self-reported body area discomfort from the Nordic Questionnaire was used establish a subjective “Discomfort” rating of; "1,” "2,” or "3.” Table 2 was used to derive the “Discomfort” score. If 50% or more of the Dental Department self-reported discomfort within a specific body area, then that percentage was given a score of “3.” A score of “2” was assigned when the group prevalence of self-reported body area discomfort ranged from 49-30% and a “1” was given for body area discomfort with prevalence reported at 29% or below (NIOSH, 2004). The specific body area scores were totaled for an overall combination or systemic representation of discomfort among the Dental Team. This total was use then used to illustrate discomfort among the entire task group and called the “Discomfort” score (Table 2).

Table 2: Using the Nordic Questionnaire to Derive “Discomfort” Score.

Using the Nordic Questionnaire to Derive “Discomfort”: **Percentage of Discomfort by Body Area Responses Reported on the Nordic Questionnaire for Systemic Representation of Overall Body Discomfort within Job Title**

Worker Title	**Neck**	**Shoulders**	**Elbows**	**Wrist/ Hands**	**Upper Back**	**Lower Back**	**Hips/ Thighs**	**Knees**	**Ankles/ Feet**	
Insert Worker Title"	In this row insert the calculated prevalence (as %) of specific body area discomfort, as reported by the worker(s) on the Nordic Questionnaire									
Score based off % above for system representation	* Using the Key below, compare % from specific body area inserted above to assign a rank of 1, 2, or 3. Add the numbers up to determine systemic representation of "Discomfort" and record the number as the "Discomfort" Score	*	*	*	*	*	*	*	*	**"Discomfort" Score (Total of 7 Risk Factor Ranks from this row)**
*** Key** **If Job Title discomfort is 50-100%, then score that specific body area a 3** **If Job Title discomfort is 49-30%, then score that specific body area a 2** **If Job Title discomfort is 29-0%, then score that specific body area a 1**										

5.2.3. Ergonomic Evaluation Priority Ratio

The "Demands" score over the "Discomfort" score provides an Ergonomic Evaluation Priority Ratio (EEPR). The EEPR is not intended to describe risk, as the Strain Equation (Equation 1) does, but rather just a way to subjectively prioritize ergonomic assessments based on the ratio of physical risk factors association with WMSDs and the self-reported combination of body area discomfort. Equation 2 demonstrates the EEPR.

$$Ergonomic\ Evalation\ Priority\ Ratio\ (EEPR) = \frac{"Demands"}{"Discomfort"}$$

Equation 2: Ergonomic Evaluation Priority Ratio

The EEPR can be used to prioritize non-MMH tasks for ergonomic evaluations (Table 3). An EEPR above ">1" would indicate that the "discomfort" score exceeds the "Demands" score and an ergonomic evaluation of this job task should be given priority over other task evaluations. An EEPR score of "=1" would indicate that the "Discomfort" score is equal to the "Demands" score and that task should be evaluated following those with an EEPR above ">1." The job tasks with an EEPR is below “<1” would indicate that the “Discomfort” score is not above the “Demands” score and should be scheduled for ergonomic evaluation following the others (Table 3). When multiple tasks have EEPRs above or below 1, the tasks can be prioritized alpha numerically.

Since WMSDs are strongly associated with MMH, those tasks are singled out for immediate MMH ergonomic evaluation and take priority over the other job task evaluations (AIHA, 2011; NIOSH, 2007). This decision matrix should lend itself to prioritizing multiple job tasks that would be good candidates for further ergonomic evaluation within the BBAHC Dental Department.

Table 3: Decision Matrix for Job Task Prioritization of Ergonomic Evaluation.

Decision Matrix for Job Task Prioritization of Ergonomic Evaluation: Job Task Classification by Manual Material Handling or Ergonomic Evaluation Priority Ratio (EEPR)

Job Task	**“Demands” Score**	**“Discomfort” Score**	**“Demands”/ “Discomfort”**	**EEPR**	**Priority Rank for Ergonomic Evaluation**
MMH Tasks					1
Insert Job Task	Insert “Demands” Score from Table 1	Insert “Discomfort ” Score from Table 2	Insert “Demands” over “Discomfort”	Divide “Demands” by “Discomfort” and record ratio here	Compare EEPR (left) to Key below to assign priority rank here.
Insert rows as needed for additional Job Tasks					

$$Ergonomic\ Evalation\ Priority\ Ratio\ (EEPR) = \frac{"Demands"}{"Discomfort"}$$

Key

MMH	**Schedule Task for Ergonomic Evaluation Priority 1**
EEPR > 1	**Schedule Task(s) for Ergonomic Evaluation Priority 2, 2a, 2b, etc.**
EEPR = 1	**Schedule Task(s) for Ergonomic Evaluation Priority 3**
EEPR < 1	**Schedule Task(s) for Ergonomic Evaluation Priority 4, 4a, 4b, etc.**

6. Results

The EEPR decision matrix was used to prioritize the MDT's job tasks. The job tasks performed by the Mobile Dental Team (MDT) were broken down into general job task areas, 1) MMH, 2) providing dental patient care, and 3) health data entry (AIHA, 2011). The MMH task was identified using the decision matrix and prioritized for ergonomic evaluation. The physical risk factors for the MMH were then evaluated.

6.1. Prevalence of Sharps Injury

The studies in the literature reviewed favored reporting sharps injury data with prevalence rates. The 2016 the Dental Team had a sharps injury prevalence of 14% (Equation 3) (BBAHC, 2016). Queensland dentists provided a sharps injury prevalence rate of 28% (Leggat, et al 2006). U.S. national data indicates that in 2011, all reporting hospitals had a sharps injury prevalence of 20% (EPINet, 2011). The prevalence of sharps injury for 2016 was calculated from BBAHC sharps injury data as reported by BBAHC Infection Control (BBAHC).

$$\textit{Sharps Injury Point Prevalence} = \frac{2\ \textit{sharps injuries in}\ 2016}{14\ \textit{Members of the}\ 2016\ \textit{Dental Team}}\ x\ 100 = 14\%$$

Equation 3: 2016 Sharps Injury Prevalence, BBAHC Dental Department

6.2. "Demands" Score

The ergonomic assessment strategy utilizes the EEPR decision matrix to prioritize job tasks for ergonomic evaluation. The "Demands" score was achieved using a subjective rating assigned to each non-MMH job task based off the strength of evidence for causal relationships that links physical risk factors to WMSDs (NIOSH, 1997; McGlothlin, 2011). These rankings were totaled and a sharps injury multiplier was applied to the total. The "Demands" score for providing dental care scored a "25.5" and the data entry task scored a "15." This score is used to in the EEPR for a job task representation of "Demands" (Table 4).

Table 4: Derive "Demands" Score for BBAHC Mobile Dental Team.

Deriving the "Demands" Score Used in the Decision Matrix:
Using a Subjective Application of the Evidence for Causal Relationships between Physical Risk Factors and WMSDs, Physical Risk Factors by Job Task with Sharps Multiplier
(NIOSH, 1997 and McGlothlin, et al., 2011)

Job Task	Repetition	Force	Posture	Vibration	Lifting	Awkward Posture	Static Work Posture	Total	Sharps Injury Multiplier	"Demands" Score
MMH	3	3	3	1	3	3	1		N/A MMH Priority Evaluation	
Providing Dental Health Care	3	2	3	2	1	3	3	17	1.5	**25.5**
Data Entry	3	1	3	1	1	3	3	15	1.0	**15.0**

Key
If MMH , Then Priority Evaluation

For Non-MMH tasks:
***If Job Task is Most Likely Associated with Physical Risk Factor, Then Score 3**

***If Job Task is Likely Associated with Physical Risk Factor, Then Score 2**

***If Job Task Less Likely Associated with Physical Risk Factor, Then Score 1**

****If Job Task has Possible Association with Sharps Injury, Then apply 1.5 Multiplier**

****If Job Task has Low association with Sharps Injury, Then apply 1.0 Multiplier**

6.3. "Discomfort" Score

The "Discomfort" score component of the EEPR decision matrix and was calculated from the Nordic Questionnaire data (Table 5) above. The "Discomfort" score for the Dental Department was determined to be "18" and totaled from the subjective scores assigned to the Dental Team's percentage of specific body area discomfort. This "Discomfort" score will be used in the EEPR for a systemic representation of the BBAHC Dental Department's overall view of body discomfort (Table 6).

The goal was to have the entire dental team complete the Nordic Questionnaire. The specific body areas noted by the respondents, as causing discomfort, can be associated with WMSD risk factors (McGlothlin et al., 2011; NIOSH, 1997). Of the 14 Nordic Questionnaires requested 13 were returned completed. The data in the table below displays those responding "yes" to aches and pains, per specific body area, by the BBAHC Dental Team (N=13). The results are also listed per specific Job Title (Table 5).

Table 5: Discomfort by Body Area Responses BBAHC Dental Department.

Prevalence (Percentage) of Discomfort by Body Area Responses For Entire Dental Department and Within Specific Job Titles BBAHC Dental Team 2016 (N=13)									
Job Title	**Neck**	**Shoulders**	**Elbows**	**Wrist/Hands**	**Upper Back**	**Lower Back**	**Hips/Thighs**	**Knees**	**Ankles/ Feet**
BBAHC Dental Department (All Job Title Groups) (N=13)	38%	54%	31%	31%	54%	54%	46%	23%	23%
Job Title	**Neck**	**Shoulders**	**Elbows**	**Wrist/Hands**	**Upper Back**	**Lower Back**	**Hips/Thighs**	**Knees**	**Ankles/ Feet**
Dentist (n=3)	67%	33%	33%	33%	33%	33%	33%	0%	0%
Dental Assistants (n=6)	33%	67%	33%	33%	67%	50%	33%	33%	50%
Dental Health Aide(n=1)	0%	100%	0%	0%	100%	100%	100%	0%	0%
Dental Hygienist(n=1)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dental Clinic Manager (n=1)	0%	0%	0%	0%	0%	100%	100%	100%	0%
Front Desk (n=1)	100%	100%	100%	100%	100%	100%	100%	0%	0%

Table 6: Derive "Discomfort" Score for the BBAHC Mobile Dental Team.

Using the Nordic Questionnaire to Derive "Discomfort" Score for the BBAHC Mobile Dental Team: Percentage of Discomfort by Body Area Responses As Reported From Nordic Questionnaire for Systemic Representation of Overall Body Discomfort within Job Title, BBAHC Dental Department										
Job Title	**Neck**	**Shoulders**	**Elbows**	**Wrist/Hands**	**Upper Back**	**Lower Back**	**Hips/ Thighs**	**Knees**	**Ankles/ Feet**	
BBAHC Dental Department (All Job Title Groups) (N=13)	38%	54%	31%	31%	54%	54%	46%	23%	23%	
Score based off % above	*2	*3	*2	*2	*3	*3	*2	*1	*1	**"Discomfort" Score (Total of this Row)**

for system representation										**18**
Key * **If Job Title discomfort is 50-100%, then score that specific body area a 3** **If Job Title discomfort is 49-30%, then score that specific body area a 2** **If Job Title discomfort is 29-0%, then score that specific body area a 1**										

6.4. Decision Matrix: Utilizing the "Ergonomic Evaluation Priority Ratio"

The "Demands" score and the "Discomfort" score determined the EEPR. The EEPR is compared to the prioritization key at the bottom of the EEPR table. An alphanumeric system can be used to determine a subjective priority assignment for ergonomic evaluations of additional job tasks scoring above or below 1. The priority assignments are displayed in the EEPR decision matrix (Table 7).

Table 7: Decision Matrix of Job Task Prioritization for Ergonomic Evaluation.

Decision Matrix of Job Task Prioritization for Ergonomic Evaluation: Job Task Classification by Manual Material Handling or Ergonomic Evaluation Priority Ratio (EEPR)					
Job Task	**“Demands” Score**	**“Discomfort” Score**	**“Demands”/ “Discomfort”**	**EEPR**	**Priority for Ergonomic Evaluation**
MMH					1
Providing Dental Health Care	25.5	18	25.5/18	1.4	2
Data Entry	15	18	15/18	0.83	3

$$Ergonomic\ Evalation\ Priority\ Ratio\ (EEPR) = \frac{"Demands"}{"Discomfort"}$$

KEY

MMH	Schedule Task for Ergonomic Evaluation Priority 1
EEPR > 1	Schedule Task for Ergonomic Evaluation Priority 2, 2a, 2b, etc.
EEPR = 1	Schedule Task for Ergonomic Evaluation Priority 3
EEPR < 1	Schedule Task for Ergonomic Evaluation Priority 4, 4a, 4b, etc.

6.5. Manual Material Handling

The EEPR decision matrix identified the MMH task as a top priority for ergonomic evaluation (Table 7). Further identification of the risk factors associated Mobile Dental Team mobilization and demobilization of the dental operatory was assessed with a Manual Material Handling Evaluation Tool (Stack, et al., 2016). The evaluation identified the risk factors of weight, posture, object characteristics, safe handling training, and duration. A slightly modified version of the observational job aide that was used to identify the physical risk factors associated with the manual materials handling task (Appendix F).

Weights on the boxes and bags of dental equipment and supplies were obtained using generic household scale. An effort was made for a single point field calibration of 45 pounds. Dimensions and weights were obtained on a majority of the Mobile Dental Team’s equipment.

The average weight of the items to be mobilized lifted by a single Mobile Dental Team member is 41pounds with each item handled 4 times during mobilization and another 4 times during demobilization. The duration of lifting is faced paced with an average load and unload times of 17 minutes. The two person lift items have an average weight of 72 pounds. Only 7 of the containers are of a standardized dimension the other containers vary considerably in shape and size.

6.5.1. Psychophysical Scales Used for MMH Ergonomic Evaluation

The Borg Scale for RPE was used to survey psychophysical perception for exertion. The Borg CR-10 scales surveyed for perceived feelings of fatigue and pain within the Mobile Dental Team. The scales were administered twice during mobilization and twice during demobilization. Table 8 demonstrates mean exertion, fatigue and pain values reported by the Mobile Dental Team (n=3) during this MMH job task. Figure 2 shows the mean value of exertion during mobilization and demobilization. Figure 3 shows a comparison of the mean values for fatigue and pain.

Table 8: Means of Exertion, Fatigue, and Pain for Mobile Dental Team.

Means of Perception of Exertion, Fatigue, and Pain Values for the Mobile Dental Team: During Operatory Mobilization and Demobilization (n=3), Manual Material Handling Job Task		
Perceived Feeling	**During Mobilization**	**During Demobilization**
Exertion from RPE Scale	13.67	14.17
Fatigue from CR-10 Scale	1.67	2.00
Pain from CR-10 Scale	0.33	0.33

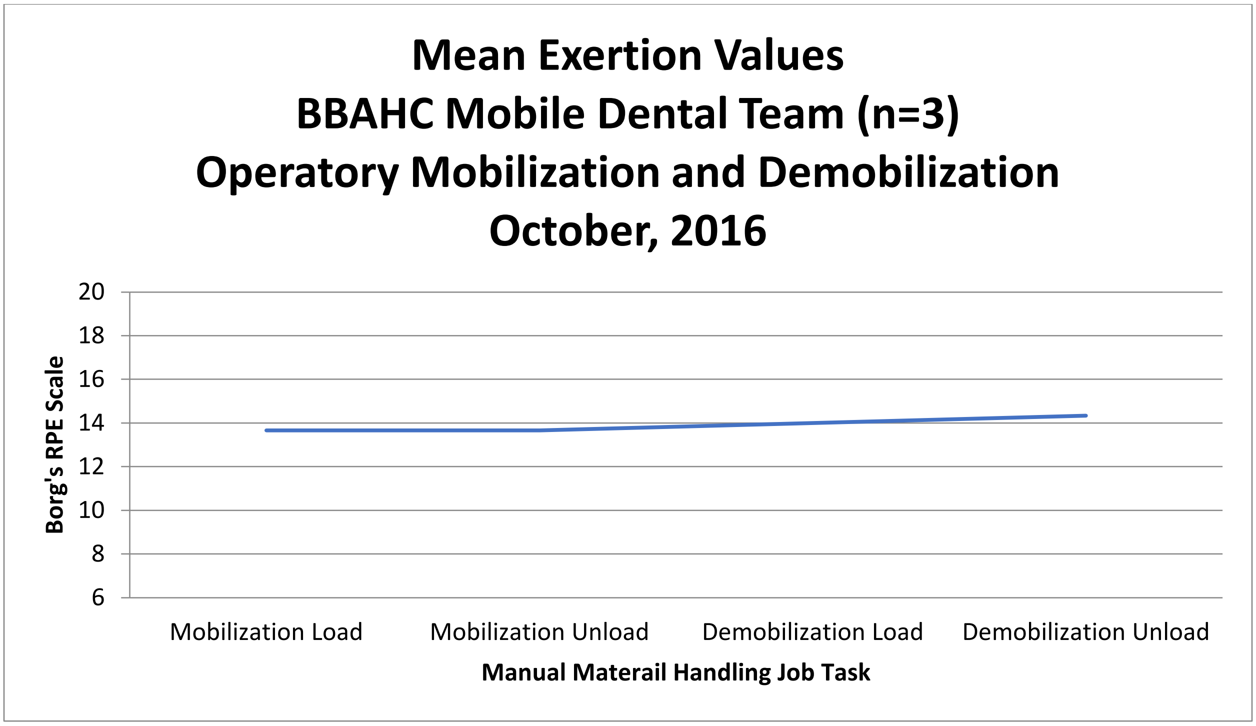

Figure 2. Mean Exertion Values: Mobile Dental Team Mobilization and Demobilization.

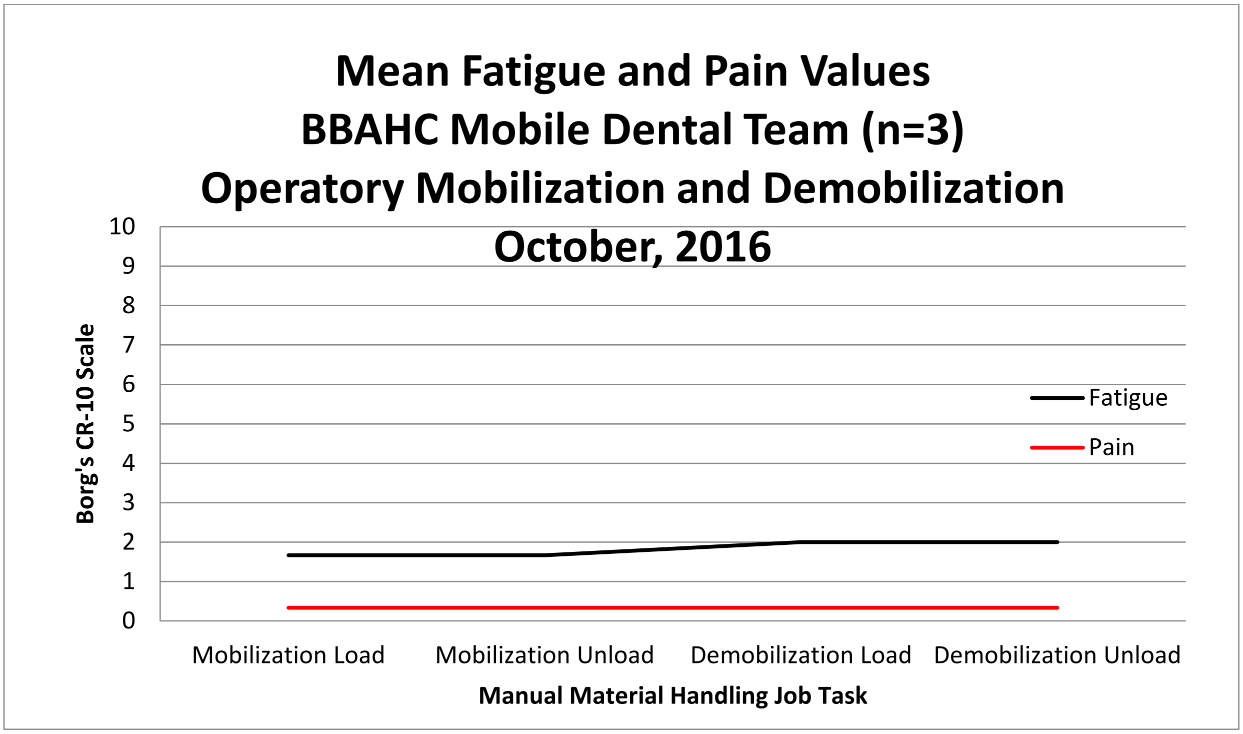

Figure 3. Mean Fatigue and Pain Values: Mobile Dental Team Mobilization and Demobilization.

The data analysis was conducted using Microsoft Excel's 2010, Data Analysis Tab. The Student's t-test demonstrates that the MDT's perception of exertion did not significantly increase at the beginning of mobilization compared to the ending demobilization period (Table 9 and Figure 2). The data analysis also demonstrated that the MDT's perception of fatigue and pain did not vary significantly from the beginning of mobilization and the end of demobilization (Table 10). The data analysis demonstrated that the MDT's perception of exertion and fatigue varied significantly during demobilization unloading (Table 11).

Table 9: Results of t-Test for Exertion during Mobilization Load and Demobilization Unload.

Factors	Mobilization Load-Exertion	Demobilization Unload-Exertion
Mean	13.67	14.33
Variance	1.33	2.33
Observations	3	3
df	2	
t Stat	2	
P(T<=t) one-tail	0.09175171	
t Critical one-tail	2.91998558	

Table 10: Results of t-Test for Fatigue and Pain during Demobilization Unloading.

Factor	Demobilization Unload-Fatigue	Demobilization Unload-Pain
Mean	1.67	0.337
Variance	2.58	0.08
Observations	3	3
df	2	
t Stat	1.511857892	
P(T<=t) one-tail	0.134851628	
t Critical one-tail	2.91998558	

Table 11 Results of t-Test for Exertion and Fatigue.

Factor	Demobilization Unload-Exertion	Demobilization Unload-Fatigue
Mean	14.33	2
Variance	2.33	4.75
Observations	3	3
df	2	
t Stat	27.96 (Cl=99.85%, 22.33-31.60)	
P(T<=t) one-tail	0.00064	
t Critical one-tail	2.92	

7. Discussion

During 2016 the Dental Team (N=14) reported 2 sharps injury for a point prevalence of 14% (BBAHC, 2016). The sharps injury prevalence rates found during the literature review ranged from 22-28% (Bindra, et al., 2014; Leggat, et al., 2006; Hughes, et al., 2012). The BBAHC point prevalence is below the sharp injury percentages presented in literature review. The study population is small and the addition of on just one more sharp injury would place the mobile dental team within the range found within the literature review. The BBAHC Dental sharps injury data consists of all new cases over the entire Dental Team (N=14) population (Equation 2).

More ergonomic evidence is needed to answer the research question presented in this report. The literature review revealed a paucity of studies looking into the association between ergonomics, WMSDs, and sharps injury prevention. Only one study was found demonstrating a significant reduction in OR sharps injury rates following implementation of an ergonomics program (Kalaga, et al., 2016). The results of that OR study provided promising evidence that ergonomics can control sharps injury but it was not related specifically to dentistry nor did focus on WMSDs.

The EEPR decision matrix indicated additional ergonomic assessments are still needed for MDT job tasks within 1) dental patient care and 2) data entry tasks. Once these evaluations are complete and ergonomic controls implemented the prevalence of sharps injury might then be re-assessed and compared to MDT baseline data to complete the research objective.

7.1. Ergonomic Evaluation Priority Ratio Decision Matrix

The EEPR decision matrix is highly subjective and was not intended to assess risk but rather a way to attain a priority ratio used to schedule the MDT tasks for ergonomic assessment. It relies on a prevalence of body area aches and pains to determine a "Discomfort" score. It also requires the IH have understanding of the specific job task to determine a rough estimate on the strength of association between 7 physical risk factors and the job task. The IH must also decide if the task exposes the worker to a possible sharps injury to decide on a "Demands" score.

The Ergonomic Evaluation Priority Ratio (EEPR) decision matrix used physical risk factors, knowledge job tasks that might involve sharps, and the results from the Nordic Questionnaire to prioritize ergonomic assessments for job tasks performed by the MDT. Contributing risk factors like duration, temperature, rest breaks, or the workers familiarity with the task were not included (Stack, et al., 2016). Anthropometric data was also not collected as it was demonstrated as not have a statistically significant association the risk factors of with pain and fatigue (Stack, et al., 2016). However, if this data was collected it may have reduced the subjectivity of the EERP decision matrix.

The EERP was developed with an inductive reasoning approach. Failure to identify a job task for evaluation may overlook a critical risk factor and that could lead to a preventable injury. To mitigate this the EERP decision matrix neither asses risk nor does it reject any job tasks for ergonomic evaluation, it simply prioritizes job tasks for timely ergonomic assessment (Jensen, 2012). It is however possible that the all this effort to develop the EERP decision matrix really just complicated a simple job hazard analysis.

The EERP decision matrix and the subsequent ergonomic evaluations are also subject to other systematic errors in design and confounding. Randomization was not controlled for and the size of the MDT is small (n=3). Information and survey bias are a problem as the decision matrix relies on surveys that gather information about feelings and perceptions. Some confounding variables were also overlooked, such as the contributing risk factors and may really be missing a true relationship between ergonomics and sharps injury.

7.2. Work-Related Musculoskeletal Disorders

During the literature review it was observed that the Nordic Questionnaire was widely referenced and provided data for many surveys requesting the self-administered reporting of body specific aches and pains (Kuorinka, et al., 1998). This peer reviewed tool has also been widely used in many WMSD peer reviewed published studies and by NIOSH to collect WMSD self-reported survey data. The questionnaire also has many reviews of verifying its validity as a good WMSD measurement tool, making it appropriate to use with the BBAHC Dental Team to collect basic WMSD data. (Pinheiro, Troccoli, and Carvalho, 2002).

Table 5 displays the reported body area discomfort data gathered from the Dental Department as they responded to the Nordic questionnaire and creates a baseline for future comparisons, as well as the “Discomfort” score used in the EEPR decision matrix. The highest prevalence of body area discomfort reported by the Dental Department was in the shoulders, upper back, and lower back. The EEPR decision matrix indicated the MMH task was identified for ergonomic assessment, as that task has been strongly associated with low back WMSDs (NIOSH, 1997).

7.2.1. Manual Material Handling

A Manual Material Handling (MMH) evaluation of the risk factors along with ergonomic improvements was conducted with for the Mobile Dental Team. The ergonomic recommendations are based off the MMH evaluation (Appendix H). Weights on the containers and bags of dental equipment and supplies were obtained using a generic household scale. An effort was made for a single point field calibration of 45 pounds, ± 3 pounds. Dimensions and weights were obtained on a majority of the Mobile Dental Team's equipment. The average weight of the items to be mobilized and lifted by a single Mobile Dental Team member is 41pounds with each item handled 4 times during mobilization and another 4 times during demobilization. The duration of lifting is faced paced with an average load and unload times of 17 minutes. The two person lift items have an average weight of 72 pounds. Only 7 of the containers are of a standardized dimension the other containers vary considerably in shape and size.

7.2.2. Psychophysics

Psychophysics explored the relationship between the MDT's perceived feelings of exertion, fatigue and pain and the measurement of those perceived levels of intensity for those feelings (Stack, et al., 2016). A 15 point Borg RPE Scale (6-20) was used to collect indications on exertion. A 11 point category ratio (CR-10) scale was used to collect indications of fatigue and then a separate time for feelings of pain (Table 2). The data analysis indicated little change in the MDTs perception of exertion, fatigue and pain from the beginning of mobilization to the end of demobilization. Exertion, fatigue, and pain are risk factors of interest in this study but have been demonstrated as not strongly associated with anthropometric measurements, so this data was not collected as baseline data for this report (Stack, et al., 2016).

The data analysis indicated a statically significant difference ($p < 0.00064$) with a Cl of 99.85%, for the MDT's perception of exertion compared to fatigue. The MDT's perception of pain was very low for the MMH tasks performed during mobilization and demobilization (Table 8). The data analysis seems to indicate that if the MDT adheres to MMH ergonomic recommendations they may be able to lower exertion levels. Using ergonomics to reduce the intensity of exertion is important because it can prevent the intensity level of fatigue and pain from rising and thereby reduce the risk of injury (Figure 3). Ergonomics can prevent WMSDs by controlling the risk factors of exertion, fatigue and pain (Stack, et al. 2016).

7.3. Manual Material Handling Ergonomic Recommendations

The following table contains ergonomic recommendations for the MMH job task. It was based on the risk factors identified during the MMH (Appendix H). To prevent the possibility of injury during mobilization and demobilization of the mobile operatory, the MDT should consider the recommendations provided in Table 12 (Stack et al., 2016).

Table 12: Ergonomic Recommendations for MDT Mobilization and Demobilization

BBAHC MDT Mobilization and Demobilization Ergonomic Recommendations	
Ergonomic Recommendations	**Corresponding Photo Exemplar in Appendix A**
Standardize container sizes with proper grip handles.	Figures 4 and 7
Minimize and standardize container weights to below 30 pounds for single person lift and carry boxes.	Figures 4, 9 and 11
Utilize two person carry techniques for containers above 30 pounds.	Figures 9 and 11
Practice proper safe handling techniques. Use Proper body mechanics; Turn the feet rather than twisting, Orient work towards worker, and Align origin and destination of lift to avoid twisting.	Figures 6 and 12
When possible load directly from the van to the plane to minimize lifting from the ground.	Figure 8
Utilize a lifting cart or portable roller table to move items from storage shelves to the loading dock.	Figures 4 and 5
(Stack, et al., 2016)	

8. Conclusion

A practical applied approach to introduce ergonomic principles can reduce the prevalence of WMSDs (Garg, et al., 2011). Dental teams, as health care professionals, are highly susceptible to WMSDs. Studies at dental teaching hospitals and universities have demonstrated that it is possible to reduce the prevalence of WMSDs among students by reducing the risk to physical work place hazards (Bedi, et al., 2015). Researchers have also drawn an association between mental fatigue and sharps injuries, at least within dental and medical students; perhaps because they work long hours, experience multiple stressors, get fatigued, and then operate fast spinning surgically sharp instruments (Smith, et al., 2006). The Mobile Dental Team experiences mid to high intensity levels of exertion, and that can lead to fatigue, and to pain. Curtailing fatigue can reduce the probability of injury (Stack, et al., 2016).

Following the MMH job task the EEPR decision matrix indicated that dental patient care and data entry are priority 2 and 3 respectively, for ergonomic evaluation. The Rapid Upper Limb Assessment (RULA) method could be used to estimate the risk factors of upper limb disorders associated with the priority 2 and 3 tasks performed by members of the Mobile Dental Team (Stack, et al., 2016). Once these evaluations are completed, ergonomics can be used to address the identified physical risk factors associated with WMSD. Recommendations and instruction for implementation of an effective ergonomics program should be provided to address the physical risk factors identified during the RULA assessment. After approximately 1 year the following the implementation of the ergonomics program the prevalence of sharps injury can be examined and the results compared to the baseline sharps injury prevalence of 14%. This data may then provide evidence to fully support the research objective; to develop ergonomic assessment methods that will lead to control methods that may potentially reduce sharp injury rates within a Rural Alaska mobile dental team.

Mobilization and demobilization of the MMH job task is fraught with hazards. As the mobile dental teams move the operatory back and forth from the villages their risk of sustaining a work related WMSDs increases. The recommended ergonomic controls (Table 12) should be followed to help reduce the MDTs perception of physical exertion before the MDTs intensity level of fatigue or pain increases as this could lead to cumulative injury.

Ergonomic principles are effective at reducing the prevalence of WMSDs (Stack, et al., 2016). It remains to be seen that if implementing proven ergonomics to reduce the occurrence of WMSDs within the BBAHC Dental Team can also reduce their incidence of sharps injury. The work that mobile dental teams perform will never be free from the risk of injury; however this report cites strong evidence that ergonomics works to reduce exertion, fatigue, pain, and perhaps even sharps related injuries.

It is important to acknowledge the art and science of ergonomics. Ergonomics is rooted in social sciences with a philosophy to promote a fundamental respect given to all people. A thorough understanding of respect to a culture of safety is important to strengthen the science of ergonomics. Respectful human interactions emphasize a fundamental equality between persons (Karwowski, 2006).

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Appendix A: Photo Log, Mobile Dental Team the Mobilization Process

Figure 4. Mobile Dental Equipment Storage (1 of 4 Sets), Transported to Loading Dock.
(Photograph by Calvert, 2016**)**

Figure 5. Mobile Dental Equipment, Lifted from Storage and Staged on Loading Dock.
(Photograph by Calvert, 2016)

Figure 6. Loading Van, Notice Forward Lean with Twisting Lift.
(Photograph by Calvert, 2016)

Figure 7. Van Loaded with Over 1,000 Pounds of Equipment and Supplies.
(Photograph by Calvert, 2016)

Figure 8. Unloading Van and Loading Plane for Flight to Village.
(Photograph by Calvert, 2016)

Figure 9. Mobile Dental Team Loading Plane, Boxes with Handles Facilitate Coupling.
(Photograph by Calvert, 2016)

Figure 10. Mobile Dental Team Still Loading Plane.
(Photograph by Calvert, 2016)

Figure 11. Arrived in Village and Mobile Dental Team Unloading Plane.
(Photograph by Calvert, 2016)

Figure 12. Still Unloading Plane and Loading Van to Transport to Facility.
(Photograph by Calvert, 2016)

Figure 13. Arrive at Facility Mobile Dental Team Off-Loading Van.
(Photograph by Calvert, 2016)

Figure 14. Room at Facility (Village Clinic) for Mobile Operatory Set-Up.
(Photograph by Calvert, 2016)

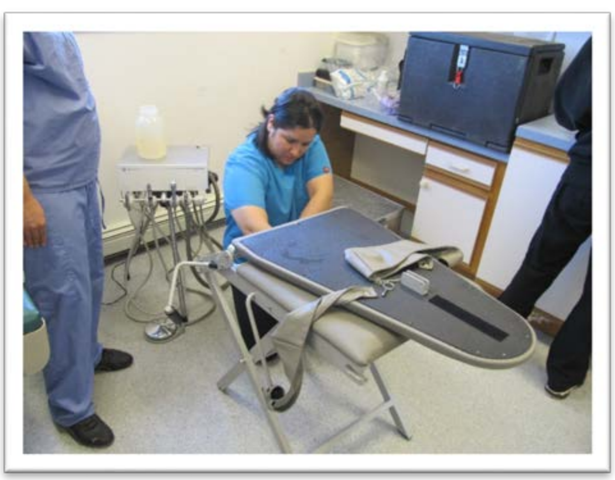


Figure 15. Mobile Dental Team Setting Up Patient Chair.
(Photograph by Calvert, 2016)

Figure 16. Setting Up Dental Assistant Chair.
(Photograph by Calvert, 2016)

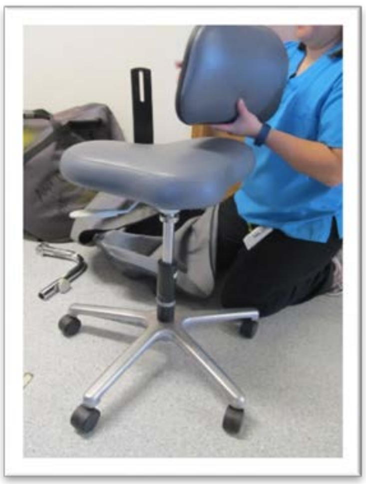


Figure 17. Setting Up Dentist Chair.
(Photograph by Calvert, 2016)

Figure 18. Mobile Operatory Set-Up Complete, Dr. Tejerina Preparing for First Patient.
(Photograph by Calvert, 2016)

Appendix B: Nordic Questionnaire

NORDIC QUESTIONNAIRE
For the
BBAHC Dental Department

Musculoskeletal Discomfort
Survey

The purpose of the survey:

Thank you for volunteering to participate in this study of musculoskeletal pain and discomfort. I am hoping to determine what musculoskeletal risk factors exist in the BBAHC Dental Department. I am interested in the type and location of the pain/discomfort symptoms you may be experiencing. This survey should take no more than 5 to 10 minutes to complete. Thank you for your cooperation.

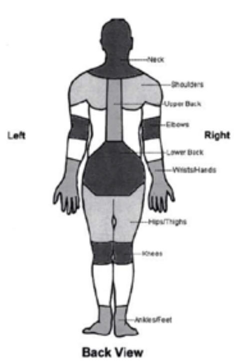
How to answer the questionnaire:
Picture: In this picture you can see the approximate position of the parts of the body referred to in the questionnaire. Limits are not sharply defined, and certain parts overlap. You should decide for yourself in which part you have or have had your trouble (if any).

Table: Please answer by putting an "X" in the appropriate box - one "X" for each question. You may be in doubt as to how to answer, but please do your best anyway. Note that column 1 of the questionnaire is to be answered even if you have never had trouble in any part of your body, columns 2 and 3 are to be answered if you answered yes in column 1.

Initial of first name: __________ Initial of last name:______________________________ Date:____________________

Job Title____________________Section: Gender: M F Height: _______ft._____in. Weight:_______lbs

How long have you been doing this job? ______Years________Months On average, how many hours do you work each week?



To be answered by everyone	To be answered by those who have had trouble	
Have you at any time during **the last 12 months** had trouble (ache, pain, discomfort, numbness) in:	Have you at any time during the **last 12 months been prevented from doing your normal work** (at home or away from home) because of the trouble?	Have you had trouble at any time during **the last 7 days?**
Neck ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
Shoulders ☐ No ☐ Yes, right shoulder ☐ Yes, left shoulder ☐ Yes, both shoulders	☐ No ☐ Yes	☐ No ☐ Yes
Elbows ☐ No ☐ Yes, right elbow ☐ Yes, left elbow ☐ Yes, both elbows	☐ No ☐ Yes	☐ No ☐ Yes
Wrists/Hands ☐ No ☐ Yes, right wrist/hand ☐ Yes, left wrist/hand ☐ Yes, both wrists/hands	☐ No ☐ Yes	☐ No ☐ Yes
Upper Back ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
Lower Back (small of back) ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Hips/Thighs ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Knees ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Ankles/Feet ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

***Based on the Nordic Questionnaire**

(Kuorinka, et al., 1987, NIOSH, 2004)

Appendix C: NIOSH Job Aide Used to Derive the "Demands" Score

"Strong evidence of work-relatedness (+++). *A causal relationship is shown to be very likely between intense or long-duration exposure to the specific risk factor(s) and MSD when the epidemiologic criteria of causality are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors could be ruled out with reasonable confidence in at least several studies.*

Evidence of work-relatedness (++). *Some convincing epidemiologic evidence shows a causal relationship when the epidemiologic criteria of causality for intense or long-duration exposure to the specific risk factor(s) and MSD are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors are not the likely explanation.*

Insufficient evidence of work-relatedness (+/0). *The available studies are of insufficient number, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association. Some studies suggest a relationship to specific risk factors, but chance, bias, or confounding may explain the association.*

Evidence of no effect of work factors (-). *Adequate studies consistently show that the specific workplace risk factor(s) is not related to development of MSD"*
(NIOSH, 1997)

Table 1. Evidence for causal relationship between physical work factors and MSDs

Body part *Risk factor*	Strong evidence (+++)	Evidence (++)	Insufficient evidence (+/0)	Evidence of no effect (-)
Neck and Neck/shoulder				
Repetition		•		
Force		•		
Posture	•			
Vibration			•	
Shoulder				
Posture		•		
Force			•	
Repetition		•		
Vibration			•	
Elbow				
Repetition			•	
Force		•		
Posture			•	
Combination	•			
Hand/wrist				
Carpal tunnel syndrome				
Repetition		•		
Force		•		
Posture			•	
Vibration		•		
Combination	•			
Tendinitis				
Repetition		•		
Force		•		
Posture		•		
Combination	•			
Hand-arm vibration syndrome				
Vibration	•			
Back				
Lifting/forceful movement	•			
Awkward posture		•		
Heavy physical work		•		
Whole body vibration	•			
Static work posture			•	

(NIOSH, 1997)

Appendix D: Decision Matrix Fillable Job Aides

Deriving the “Demands” Score Used in the Decision Matrix:
Using a Subjective Application of the Evidence for Causal Relationships between Physical Risk Factors and WMSDs, Physical Risk Factors by Job Task with Sharps Multiplier
(NIOSH, 1997 and McGlothlin, 2011)

Job Task	**Repetition**	**Force**	**Posture**	**Vibration**	**Lifting**	**Awkward Posture**	**Static Work Posture**	**Total**	**Sharps Injury Multiplier**	**“Demands” Score**
MMH									N/A MMH Priority Evaluation	
	*	*	*	*	*	*	*	*	**	
	*	*	*	*	*	*	*	*	**	

Key
If MMH , Then Priority Evaluation

*If Job Task is Most Likely Associated with Physical Risk Factor, Then Score 3

*If Job Task is Likely Associated with Physical Risk Factor, Then Score 2

*If Job Task Less Likely Associated with Physical Risk Factor, Then Score 1

**If Job Task has Possible Association with Sharps Injury, Then apply 1.5 Multiplier

**If Job Task has Low association with Sharps Injury, Then apply 1.0 Multiplier

Deriving the “Discomfort” Score used in the Decision Matrix
Percentage of Discomfort by Body Area Responses As Reported From Nordic Questionnaire for Systemic Representation of Overall Body Discomfort within Job Title, BBAHC Dental Department

Job Title	**Neck**	**Shoulders**	**Elbows**	**Wrist/Hands**	**Upper Back**	**Lower Back**	**Hips/ Thighs**	**Knees**	**Ankles/ Feet**	
Percentage from Nordic Questionnaire in this row by work group										
*Score based off % above for systemic representation										**“Discomfort” Score (Total of this Row)**

Key
***If Job Title is 50-100%, then score that specific body area a 3**

***If Job Title is 49-30%, then score that specific body area a 2**

*** If Job Title is 29-0%, then score that specific body area a 1**

Decision Matrix for Job Task Prioritization of Ergonomic Evaluation:
Job Task Classification by Manual Material Handling and Ergonomic Evaluation Priority Ratio (EEPR)

Job Task	**“Demands” Score**	**“Discomfort” Score**	**“Demands”/ “Discomfort”**	**EEPR**	**Priority Rank for Ergonomic Evaluation**
MMH Tasks					1
Insert rows as needed for additional Job Tasks					

$$Ergonomic\ Evalation\ Priority\ Ratio\ (EEPR) = \frac{"Demands"}{"Discomfort"}$$

Key

MMH	**Schedule Task for Ergonomic Evaluation Priority 1**
EEPR > 1	**Schedule Task(s) for Ergonomic Evaluation Priority 2, 2a, 2b, etc.**
EEPR = 1	**Schedule Task(s) for Ergonomic Evaluation Priority 3**
EEPR < 1	**Schedule Task(s) for Ergonomic Evaluation Priority 4, 4a, 4b, etc.**

Appendix E: RPE

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

While doing physical activity, please rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

For instance:

- 9 corresponds to "very light" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes
- 13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.
- 17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.
- 19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Exertion	**RPE**
No exertion at all	6
Extremely light	7
	8
Very light	9
	10
Light	11
	12
Somewhat hard	13
	14
Hard (heavy)	15
	16
Very hard	17
	18
Extremely hard	19
Maximal exertion	20

(Borg, 1998; NIOSH, 2004)

Appendix F: CR-10 Fatigue

Instructions for Borg Rating of Perceived Fatigue (CR-10) Scale

This is a scale that asks you to rate your fatigue. It starts at number 0 where the task is causing you no difficulty at all and progresses through to number 10 where this task difficulty is maximal. During this lifting task please indicate how much fatigue do you feel right now.

Instructions for the CR-10, A rating of 10 is "Extremely strong" and will sever as your bow anchor. It is the strongest perception of fatigue you have ever experienced. It may be possible to experience something stronger; therefore, "Absolute maximum" is further down the scale without a number just a dot (•). If you perceive a fatigue intensity stronger then 10, you can use the dot.
Please start with a verbal expression and then choose a number. If the perception is 'Very Weak" say 1; if "Moderate" say 3, etc. You can use fractions if you feel like it. It is important that you record what you perceive and not what you think others would like you to say. Be honest and try not to over- or underestimate the fatigue intensities.

Rating of Perceived Fatigue
Category-Ratio Scale

Fatigue
0 Nothing at all
0.3
0.5 Extremely weak Just noticeable
0. 7
1 Very weak
1.5
2 Weak Light
2. 5
3 Moderate
4
5 Strong Heavy
6
7 Very strong
8
9
10 Extremely strong "Maximal"
11
• Absolute maximum Highest Possible

(Borg, 1998; NIOSH, 2004)

Appendix G: CR-10 Pain

Instructions for Borg Rating of Perceived Pain (CR-10) Scale

This is a scale that asks you to rate your pain. It starts at number 0 where the task is causing you no pain at all and progresses through to number 10 where this task difficulty is maximal. During this lifting task please indicate how much pain you feel right now.

Instructions for the CR-10, A rating of 10 is “Extremely strong” and will sever as your bow anchor. It is the strongest perception of pain you have ever experienced. It may be possible to experience something stronger; therefore, “Absolute maximum” is further down the scale without a number just a dot (•). If you perceive a pain intensity stronger then 10, you can use the dot.
Please start with a verbal expression and then choose a number. If the perception is ‘Very Weak” say 1; if “Moderate” say 3, etc. You can use fractions if you feel like it. It is important that you record what you perceive and not what you think others would like you to say. Be honest and try not to over- or underestimate your pain intensity.

Rating of Perceived Pain
Category-Ratio Scale

Pain
0 Nothing at all
0.3
0.5 Extremely weak Just noticeable
0. 7
1 Very weak
1.5
2 Weak Light
2. 5
3 Moderate
4
5 Strong Heavy
6
7 Very strong
8
9
10 Extremely strong “Maximal”
11
• Absolute maximum Highest Possible

(Borg, 1998; NIOSH, 2004)

Appendix H: Manual Material Handling Evaluation

Manual Material Handling Evaluation Job Aide			
Item	**Weight**	**YES or NO**	**Solution**
1	When standing is object less than 30lbs?	NO	Reduce Weight, Lift Team, More Pushing less lifting and pulling
2	When seated is object less than 10lbs?	YES	No seated lifting observed
3	Are objects handled between knuckle and shoulder height?	NO	Unload items from van directly to plane, avoid unloading everything to ground when possible
4	Are objects within arm's length, allowing worker to reach without bending back?	NO	Move closer to lift
5	Lifting in open space allowing worker to move feet and arms?	YES	Avoid, when possible stacking items in path of lifting and carry
6	Does the worker move without twisting the back during handling process?	NO	Use Proper body mechanics; turn the feet rather than twisting. Orient work towards worker, align origin and destination of lift to avoid twisting
7	Does the worker perform the same motion less than once every 5 min?	YES	Minimize the number of times the same item is lifted
8	Does the worker use different parts of the body every hour, giving the muscle groups time to rest	YES	Duration of lifting and loading typically takes about 15-17 minutes.
9	Is the object easy to handle, balanced and stable	NO	Modify object, standardize boxes with weights less than 30 lbs. for single lift or mark items heavy for two man lifts
11	Does object provide a power grip handle in neutral posture	NO	Provide lift cart, modify objects, avoid lifting above shoulder height
12	Is worker trained in material handling	NO	Provide proper instruction
13	Does worker's clothing and personal protective equipment allow for safe handling	YES	Provide work gloves
14	Environment -Weather	YES	Always a factor in Alaska
GPC, 10/24/2016, Mostly Sunny 42^{O}F, 10:00am Adapted from (Stack, et al., 2016)			