A DESCRIPTIVE STUDY OF WORK-RELATED MUSCULOSKELETAL DISORDERS AND OTHER OCCUPATIONAL SAFETY & HEALTH ISSUES AMONG AGRICULTURAL WORKERS IN PUERTO RICO

by:

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Abstract

Given the diverse tasks that are performed in a farm, agricultural workers are constantly exposed to injuries, suffer discomforts, and at risk of developing musculoskeletal disorders (MSD). With an estimated population of 30,000 agricultural workers in Puerto Rico, commonly from socio-economically disadvantaged communities, it is critical to evaluate their work conditions. In the first phase of the study, medical records of 4,686 patients were analyzed to compare the presence of MSD diagnostics among agricultural and non-agricultural workers who received services at the Castañer General Hospital Out-patient (OPD) clinic. With a Bonferroni corrected α-value=0.005, a Two-Sample proportion test (Z=3.35, P-value=0.000) show that as a group, agricultural workers receive a higher number of MSD diagnostics when compared to non-agricultural workers. However, no statistical difference was found within gender variables. The median of MSD diagnostics by agricultural workers is 2.25 while for non-agricultural workers is 1.94 (H=8.22, p=0.004). No significant difference was found among average number of MSD diagnostics for gender and work category. Among agricultural workers, the three most common body areas affected by MSD conditions were low back (19.9%), neck (8%), and the right shoulder (4.7%). For non-agricultural workers, the most common body areas affected were lower back (18.4%), neck (8.7%), and the left knee (4.5%). MSD conditions were classified in four groups: a) Pain, b) Arthritis, c) Discs and nerves conditions, and d) Muscle conditions. For agricultural and non-agricultural workers, MSD conditions in the category of Pain were the most common with 67.12% and 65.08%, respectively. It was also found that agricultural workers suffered more from conditions in the category of Pain than for Muscle conditions when compared with non-agricultural workers (*Z*=4.95, P-value=0.000). In proportion, it was also found that agricultural workers suffered more from Arthritis related conditions than by Muscle

conditions (Z=5.23, P-value=0.000). Agricultural workers were found to suffer more of Discs and Nerves conditions than by Muscle conditions when compared with non-agricultural workers (Z =4.65, P-value=0.000). The data from the OPD Clinic showed enough evidence that agricultural workers as a group are at more risk of developing MSD conditions when compared with those who are not agricultural workers.

For the second phase of this study, a questionnaire was designed to gather data of demographics information, musculoskeletal discomforts, and health and safety practices at the farms. A modified version of the Standardized Nordic Questionnaire was used to determine the parts of the body in which agricultural workers suffered pain in the periods of 7 days and 12 months. A visual and numeric scale based in the "Faces Pain Scale Revised" was included to facilitate the characterization of the level of pain in the different parts of the body. The sample consisted of 95 men and 5 women agricultural workers from farms in the south and west area of Puerto Rico in which their principal crops were coffee, mango, banana, plantain, and fruit trees. In a 12-month period, 66% reported pain in the lower back area, 51% in the shoulders, and 43% in the hands/wrists. In a 7-day period, 58% of the participants reported pain in the lower back area, 51% in the hands/wrists, and 38% in the shoulders. Moderate lower back pain was also reported with the higher average level of pain among participants (Average= 6.39; SD=2.79) for the period of 12 months and 7 days (Average=6.72; SD=2.53). These results can be compared with the information from the OPD clinic as low back pain and pain in the shoulders were the most common MSD conditions among agricultural workers treated at the clinic. In fact, of those participants of the questionnaire who reported suffering from lower back pain and pain in the shoulders, 74% and 56% respectively, reported to have received some type of medical treatment to relieve the pain in these areas.

The analysis of the partial plots of a Random Forest analysis concluded that the reported level of pain is mostly affected by participant's age, the body area, years of experience, and the academic degree. Most of the participants reported a moderate discomfort in all parts of the body. The area of the ankles and the lower back are more commonly to report "strong" levels of pain. On the other side, the area of the hands/wrists, knees, and shoulders were mostly related to moderate discomfort or pain. Participants within 30 to 40 years of age were less likely to report light discomfort while participants between 30 to 60 years of age were associated to reporting strong levels of pain. Those participants with more than 10 years of experience were more likely to report strong pain levels while those with less than 5 years of experience tend to report unbearable pain. Related to academic degree, participants with Intermediate, High School, or Associate/Technical Degree were more likely to report light to moderate discomfort and less likely to report unbearable pain independently of their academic degree level.

During this research it was found that: a) the proportions of agricultural workers who suffer from MSD is higher than for non-agricultural workers, b) the median of MSD diagnostics for agricultural workers is significantly higher than for non-agricultural workers, c) agricultural workers suffered more from conditions classified as Pain, Arthritis, and Discs and nerves conditions when compared with non-agricultural workers, d) lower back and the shoulders were the most affected body areas among agricultural workers, e) there is no clear understanding by this population about trainings or knowledge required to perform the tasks in a safely manner. Inherently, it can be said that agricultural workers are at more risk of injuries, body discomforts, and MSD conditions when compared with non-agricultural workers.

Resúmen

Debido a la diversidad de tareas realizadas en una finca, los trabajadores agrícolas están continuamente expuestos a sufrir molestias, lesiones y en riesgo de desarrollar desórdenes musculo-esqueletales (DME). Con una población estimada de 30,000 trabajadores agrícolas en Puerto Rico, es de suma importancia determinar las condiciones de trabajo de esta población que en su mayoría está compuesta de grupos socioeconómicamente desventajados de la sociedad. En la primera fase de este estudio, los expedientes médicos de 4,686 pacientes de la Clínica de pacientes externos del Hospital General de Castañer fueron analizados para comparar la incidencia de DME entre trabajadores agrícolas y trabajadores no agrícolas. Luego de realizar una corrección de Bonferroni para un α-valor=0.005, una prueba de Proporciones de dos muestras (Z=3.35, P-valor=0.000) demostró que, proporcionalmente hablando, hay más diagnósticos de DME entre trabajadores agrícolas que entre trabajadores no-agrícolas. No se encontró evidencia que hay más diagnósticos de DME entre hombres trabajadores agrícolas que hombres trabajadores no-agrícolas y entre mujeres trabajadoras agrícolas y mujeres trabajadoras no-agrícolas. También se encontró que, en promedio, los trabajadores agrícolas tienen una mediana de 2.25 diagnósticos de DME cada uno, mientras que los trabajadores no-agrícolas tienen 1.94 diagnósticos de DME cada uno (H=8.22, P-valor=0.004), siendo esta una diferencia estadísticamente significativa. Sin embargo, al comparar hombres trabajadores agrícolas (2.13 diagnósticos DME por trabajador agrícola) y hombres trabajadores no-agrícolas (1.85 diagnósticos DME por trabajador no-agrícola) no se encontró diferencia significativa. De igual forma, tampoco se encontró diferencia significativa entre la cantidad promedio de diagnósticos de DME entre mujeres trabajadoras agrícolas y no-agrícolas. Entre los trabajadores agrícolas, las tres áreas del cuerpo más comúnmente afectadas por DME son espalda baja (19.9%), cuello (8%) y hombro derecho (4.7%). Por el otro lado, entre trabajadores no-agrícolas las áreas del cuerpo

más comúnmente afectadas por DME son espalda baja (18.4%), cuello (8.7%) y rodilla izquierda (4.5%). Los DME fueron divididos en cuatro clasificaciones: a) Dolor, b) Artritis, c) Condiciones de los discos y nervios, d) Condiciones de los Músculos. Tanto para trabajadores agrícolas y no agrícolas, la mayoría de las condiciones de DME se encontraron en la clasificación de Dolor con 67.12% y 65.08%. Se encontró que los trabajadores agrícolas sufren en mayor proporción de condiciones en la clasificación de Dolor que de Condiciones de los Músculos al ser comparados con trabajadores no-agrícolas (Z=4.95, P-valor=0.000). De igual forma se encontró que los trabajadores agrícolas sufren más de condiciones de Artritis que de Condiciones de los Músculos al ser comparados con trabajadores no- agrícolas (Z=5.23, P-valor=0.000). Los trabajadores agrícolas también sufren más de condiciones de los Nervios y discos que de condiciones de los músculos al compararse con trabajadores no-agrícolas (Z=4.65, P-valor=0.000).

En la segunda fase de este estudio, se diseñó un cuestionario para recopilar información demográfica, dolores musculo esqueletales, salud y seguridad en fincas de Puerto Rico. Se utilizó una versión modificada del Cuestionario Estandarizado Nórdico para determinar las partes del cuerpo en las cuales los trabajadores agrícolas reportaron dolor en periodos de 7 días y 12 meses. Una escala visual y numérica basada en el "Faces Pain Scale-Revised" fue incluida para facilitar la caracterización del nivel de dolor. La muestra consistió en 95 hombres y 5 mujeres trabajadores agrícolas de fincas del área sur y oeste de Puerto Rico cuyos principales cultivos son café, mangó, guineo, plátano y árboles frutales. La edad promedio de los participantes del cuestionario fue 39 y 50 años para hombres y mujeres respectivamente. Para los pasados 12 meses, 66% de los participantes reportaron dolor en la espalda baja, 51% reportaron dolor en los hombros y 43% reportaron dolor en las manos/muñecas. Para el período de 7 días, 58% de los participantes reportaron dolor en la espalda baja, 51% reportaron dolor en

las manos/muñecas y 38% en los hombros. Dolor en la espalda baja fue reportado con el promedio de dolor más alto entre los participantes con 6.39 (SD=2.79) para el periodo de 12 meses y 6.72 (SD=2.53) para el período de 7 días. Estos resultados pueden ser comparados con la información obtenida de la clínica del Hospital Castañer ya que dolor en la espalda baja y en los hombros fueron de las condiciones DME más comunes entre los trabajadores agrícolas tratados en la clínica. De hecho, de los participantes del cuestionario que reportaron haber sufrido de dolor en la espalda baja o en los hombros, 74% y 56% respectivamente, reportaron haber recibido algún tipo de tratamiento médico para aliviar el mismo.

En base a un análisis de las gráficas parciales del método de "Random Forest" se puede concluir que el nivel de dolor reportado por los participantes del cuestionario está relacionado a la edad, el área del cuerpo, años de experiencia en la agricultura y el grado académico del participante. La mayoría de los participantes reportaron un nivel de molestia moderado en todas las áreas del cuerpo. El área de los tobillos y la espalda están relacionadas a niveles de dolor fuerte. Sin embargo, las áreas de las manos/muñecas, rodillas y hombros están más relacionadas a niveles de molestia o dolor moderado. Participantes entre los 30 y 40 años son menos propensos a reportar niveles de molestia bajos, sin embargo, aquellos entre 30 y 60 años son asociados con reportar niveles de dolor fuertes. Aquellos con más de 10 años de experiencia tienden a reportar niveles de dolor fuertes mientras que aquellos con menos de 5 años de experiencia están más relacionados a reportar in nivel de dolor insoportable. Respecto al grado académico, participantes con grado de escuela intermedia, superior o grados técnicos tienden a reportar nivel de molestia moderado. Entre todos los grados académicos, los participantes tendieron a reportar más con más frecuencia un nivel de dolor moderado y menos comúnmente dolor fuerte o insoportable, independientemente de su grado académico.

Durante la investigación se puede concluir lo siguiente: a) la proporción de trabajadores agrícolas que sufre de DME es mayor que la de trabajadores no-agrícolas, b) la mediana de DME para trabajadores agrícolas es mayor que para trabajadores no-agrícolas, c) trabajadores agrícolas sufren en mayor proporción de condiciones dentro de las clasificaciones de Dolor, Artritis y Condiciones de los discos y nervios que aquellos que no son trabajadores agrícolas, d) espalda baja y los hombros son las áreas más afectadas dentro de la población de trabajadores agrícolas, e) los trabajadores agrícolas no tienen muy claro los conceptos o los adiestramientos relacionados a la manera correcta de realizar una tarea para evitar lastimarse. Inherentemente, se puede concluir que los trabajadores agrícolas están en mayor riesgo de lesiones, dolores musculares y de desarrollar DME que los trabajadores no-agrícolas.

Dedication

To God for guiding me through all my decisions in life, including the pursue of a graduate degree. To my family, especially my mom Deborah Marantes, my dad Julio Martin, and my sister Valerie Martin who have been an invaluable support during my whole life. To my Scoutmaster, Carlos Diaz-Piferrer, a person that taught me everything I know to be a better leader and to leave this world better than we found it. To the love of my life, Kathina Thais for being an important part of all this process, the support needed in the most difficult times of this project. Finally, to Dr. Nelson Caraballo, a friend who despite his life circumstances, is always willing to share his knowledge and friendship with everyone, the type of person that we need to make this world a better place to live.

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Chapter 1

The purpose of this chapter is to establish the problem that motivated this research along with describing its specific objectives and contributions to the scientific community.

1.1 Introduction

According to the 2012 Census of Agriculture, there are around 13,159 farms in Puerto Rico (Vilsack & Reilly, 2014). The agricultural gross income for Puerto Rico during 2013-2014 was estimated at $929,697,000 (Instituto de Estadisticas de Puerto Rico, 2015) and according to the Government Development Bank of Puerto Rico, this sector represents around 0.9% of the net income for the Island (Banco Gubernamental de Fomento para Puerto Rico, 2007). Puerto Rico has a high variety of products that come from the agricultural sector; the most commons being: coffee, pineapples, plantains, bananas, farinaceous, cattle and its derivatives, milk, and chicken meat. In Puerto Rico, this sector has a workforce of around 30,122 farm workers and 13,159 principal operators (Vilsack & Reilly, 2014). This sector of the population is at risk or currently suffering from work-related musculoskeletal disorders or discomforts. This issue can cause economic lossess to the agricultural industry in terms of high abseenteism of the personnel and medical costs as well as making this industry less attractive for potential employees.

Diverse publications associate agriculture with the development of musculoskeletal disorders because of the nature of the different tasks performed by farm workers. Full body vibration, lifting of heavy objects, work at or above shoulder level, and repetitive tasks for a long period of time are all related to different agricultural work activities and associated to injuries and pain in farm workers (Calvo, 2009; Chapman & Meyers, 2001; Faucett et al., 2001; Meyers et al., 2000; Walker-Bone & Palmer, 2002).

In 2013, 50 percent of occupational injuries reported in Puerto Rico were related to musculoskeletal discomfort (Department of Labor and Human Resources of Puerto Rico, 2013). Of the 13,850 occupational injuries and illnesses reported in the Puerto Rican private industry (industries with 11 or more workers), 70 cases (0.51%) were related to farmers. Per the Occupational Safety & Health Administration (OSHA), industries with 10 or less workers are not required to keep an OSHA injuries and illnesses record (Occupational Safety & Health Administration [OSHA], 2001). Because of this, data from farms that operate with 10 or less workers is not easily available, bringing the problem of possible misrepresentation and underestimation of injuries and musculoskeletal disorders of farm workers in Puerto Rico, leaving this population at risk. Also, agricultural workers are considered a socioeconomically disadvantaged group and this prevent them of receiving the required medical treatment and/or information that can help reduce the development of MSD conditions and discomforts.

1.2 Objectives

As described in the introduction, agricultural work has been related to musculoskeletal disorders (MSD's) in workers and considered a hazardous industry. Despite this, there is a dearth of information related to musculoskeletal disorders, discomfort, health, and safety practices in Puerto Rico's farmer population. The purpose of this study is twofold: (1) document the most common musculoskeletal discomforts in a sample of farm workers from the west and south-west region of the Island and (2) quantify the relationship between agricultural work and medical diagnostics received at the Outpatient (OPD) Clinic in Castañer General Hospital of Lares, P.R. This research will provide a solid foundation of information related to musculoskeletal disorders and discomforts present in Puerto Rican farm workers and safety practices at local farms. Also, specific insight about working conditions of agricultural workers

in the Island from a quantitative and qualitative perspective will be discussed. The main objectives of this research are the following:

1) Design, implement, and analyze a questionnaire based on the Standardized Nordic Questionnaire (Kuorinka et al., 1987) and the Agricultural Health Study Questionnaire (Alavanja et al., 1996) to document musculoskeletal discomforts, health conditions, and safety practices of local agricultural workers.

2) Characterize and describe musculoskeletal discomforts among a convenience sample of 100 agricultural workers in Puerto Rico.

3) Analyze information from medical records of agricultural workers that receive services at the Outpatient (OPD) clinic in Castañer General Hospital to determine the most common MSD's among agricultural workers.

4) Compare the MSD diagnostics of agricultural and non-agricultural workers treated at the OPD clinic in Castañer General Hospital.

5) Describe common occupational safety practices and health conditions present among a sample of agricultural workers in Puerto Rico.

1.3 Contributions

The main contributions of this research to the scientific community are the following:

1) Design a questionnaire in Spanish with simple wording for easy understanding to the focus population, based on the Standardized Nordic Questionnaire (Kuorinka et al., 1987) to document discomforts, health, and safety practices of local agricultural workers. Although the original Standardized Nordic Questionnaire asks participants for the presence of discomforts in different parts of the body, the questionnaire designed for this research uses a numeric pain scale to qualify the level of discomfort in different parts of the body. The numeric pain scale is also connected with corresponding drawings from the Faces Pain Scale-Revised (Hicks, Von Baeyer, Spafford, Van Korlaar, & Goodenough, 2001) to help the participants identify their level of discomfort via a visual analog scale. Along with the modified Nordic questionnaire section, questions related to health conditions and safety practices at work were also included to the questionnaire. This questionnaire creates a precedent for future studies related to MSD's among agricultural workers in the Island.

2) Develop a profile related to musculoskeletal discomforts and disorders in agricultural workers in Puerto Rico. No documentation has been found related to this topic in the Island.

3) Describe common occupational safety practices and health conditions among agricultural workers in Puerto Rico. Determine the relationship of training received and reported level of pain among agricultural workers.

Chapter 2

In this chapter, the theoretical background for this study as well as survey methodologies will be described. The literature review will document historical risks associated with agricultural work, common conditions related to MSD, and safety conditions among agricultural workers. A description of the most common musculoskeletal disorders in agricultural workers, awareness, and education as well as pain in different parts of the body is documented in this section.

2.1 Literature Review

2.1.1 Musculoskeletal disorders in agriculture

Agriculture has been of crucial importance for society's development. As the population in the world increases, there has been a need to improve the techniques and machinery that grow and harvest food to supply the high required demands (Frank, McKnight, Kirkhorn, & Gunderson, 2004). As of 2012, there were around 2,109,303 farmworkers in the United States (United States Department of Agriculture, 2014). Because of its nature, agriculture has been often signaled as an industry with high risks of injuries, illnesses, and musculoskeletal disorders (Demers & Rosenstock, 1991; Fathallah, 2010; Frank et al., 2004; Myers, Layne, & Marsh, 2009; S. G. Von Essen, McCurdy, & McCurdy, 1998; Walker-Bone & Palmer, 2002). A study of medical claims performed in 1991 in Washington State, found that claims of agricultural workers were 50% higher than the regular population, showing the inherent risk to health in agricultural work environments (Demers & Rosenstock, 1991).

Musculoskeletal disorders are defined as diseases related to the nerves, muscles, tendons, discs, and other parts of the body dedicated to its support and movement (Putz-Anderson et al., 1997). Despite all technological advances in agriculture, many jobs require farm workers to

perform tasks that have been related to the development of musculoskeletal disorders. Common tasks include repetitive labor over long periods of time, heavy lifting of objects, awkward postures, and full body vibration (Calvo, 2009; Chapman & Meyers, 2001; Faucett et al., 2001; Meyers et al., 2000; Walker-Bone & Palmer, 2002). In a recent study performed in India, 84.3% of the participants reported suffering from musculoskeletal disorders (Hemalatha, Bharanidharan, & Anusha, 2017). The most common MSDs among this population were low back pain, pain in the knee, pain in the shoulders, and pain in the neck.

2.1.2 Pain in different parts of the body

2.1.2.1 Upper and Lower Back Pain

Upper and lower back pain are quite common to the workforce population, and agricultural workforce is no exception. According to literature, 60% of work absenteeism causes are related to back pain (Luttmann et al., 2003). Heavy lifting and full body vibration have been identified as activities that affect the lower back (Calvo, 2009; Luttmann et al., 2003). In a study performed among 458 farms in the state of Colorado with 759 individual farmers, lower back pain was the most affected area both in males and females (Huiyun Xiang, Stallones, & Keefe, 1999). This result is similar to a study performed in Ireland among 600 farmers where 37% of farmers reported back related problems (Osborne et al., 2010). Although different possible causes for back pain were presented to participants in Colorado, 45.4% of males and 43.9% of females assured that activities that required full body twisting, bending of the back, heavy lifting, among others, were the principal causes for back pain. In females, there was no significant difference among those that only performed tasks at home and those that performed heavy tasks in the field. It is important to mention that 47% and 38.3% of males and females respectively, made changes in their tasks or stopped working because of back pain. Another study found that full-time farmers reported higher percent of back pain and lower back pain than part time

farmers, but no significant relationship was found between pain and the number of years in farming (Osborne et al., 2010). Farms dedicated to rice cultivation have also been related to musculoskeletal disorders. In a study performed among workers in rice farms, 48.8% reported suffering from low back pain, being this area the one with the highest prevalence of discomfort among this population (Kar & Dhara, 2007). Repetitive jobs, stoop positions, and long periods of work were found to be the cause of low back pain among this population. Back pain was also related to agriculture activities in a study performed on Latino farm workers in Mendota, California (Xiao, 2011). Xiao did not find any relationship between stooping and bending positions with chronic back pain but there was a relationship between these positions and chronic hip pain. Chronic pain was defined by Xiao as one that lasts longer than six weeks. In both males and females, back pain had the highest prevalence among farm workers. Farm workers were also divided in age groups: 18-30, 30-40, and 40 or older and it was noted that among all age groups, back pain had the highest percentage of prevalence. In another publication in which the posture for different agricultural activities was analyzed among preadolescents in India, it was observed that 100% of the participants suffered from back pain due to digging holes in the soil for sowing seeds, activity that requires bending and twisting of the back (Gangopadhyay, Das, Das, & Ghoshal, 2005). Lower back pain was also identified as the most common symptom during 12 months among workers of the tomato industry with 52.8% of participants suffering it (Palmer, 1996). Combined with upper back pain, 81.5% of workers in the tomato industry suffered pain or discomfort for the period of 12 months. In a study performed among female agricultural workers in Dominican Republic, low back pain and other musculoskeletal disorders were reported by this group as well (Bonilla-Vega, 1998).

As noted in different publications, it is common ground to find that lower and upper back pain are in the top list of areas of the body that causes farmers to suffer pain because of work-related tasks.

2.1.2.2 Neck Pain

Neck pain or discomfort has also been associated as an effect of different activities in agriculture like repetitive neck posture, high neck flexion, and extreme neck rotation for long periods of time (Hartman, Oude Vrielink, Metz, & Huirne, 2005). Luttmann et al., (2003) reported neck and upper extremity injuries as the second most common among workers. A comparison between tomato trainers and pickers demonstrated that 46.4% of trainers suffered from neck pain against 28.8% of pickers (Palmer, 1996). Neck pain was also identified by Palmer as the third most prevalent symptom among the tomato worker industry and by Kolstrup in dairy farmers and farm workers (Kolstrup, 2012; Palmer, 1996). In another study performed in farm workers in Ireland, neck pain was the second most common musculoskeletal disorder reported among this group (Osborne et al., 2010). Also, Kolstrup (2012) found that female farmers were most affected by neck pain than males (48% and 24%, respectively). Given the physical requirements to collect prawn seeds, a study performed among this population analyzed the different postures required to perform this task and found that 76% of males and 84% of females that worked as collectors suffered neck pain, only surpassed by low back pain with 95% and 92% in males and females, respectively (Gangopadhyay et al., 2008). However, no significant relationship was found between neck pain and gender of prawn collectors. Given the nature of agricultural tasks, neck pain has been identified as a common suffering among workers.

2.1.2.3 Shoulder Pain

Repetitive tasks and working at shoulder level have been identified as causes for future development of musculoskeletal disorders among workers (Hagberg & Wegman, 1987). Depending on the fruit to be harvested, cropping above shoulder level is a common task among agricultural workers. A study by Palmer in the tomato industry, showed that 44% of workers in this industry, specifically tomato trainers and pickers, reported shoulder injury or discomfort related to work (Palmer, 1996). Shoulder discomfort was identified as the second most common symptom over a year among this population. Although this type of injury was common among this population, no significant relationship between shoulder discomfort and duration in the same work was found.

On the other side, an analysis performed to coffee workers in Brazil, shoulder pain or discomfort was identified as the most common injury in a 12 months period (Navarro, Minette, Pio da Silva, Paulo de Souza, & Soarez, 2008). In a period of one week, shoulder discomfort was reported as the second most prevalent symptom among coffee workers. Navarro et al., reported that women suffer more from shoulder discomfort than men (76% and 24%, respectively). In another study it was found that women complained more about shoulder or neck injuries than men (Faucett et al., 2001). Shoulder pain is very common among agricultural workers mostly because of repetitive movements and other tasks that are to be performed above shoulder level, such as fruit picking.

2.1.3 Work Related Injuries and Diseases

Given the fact that the agricultural industry has been constantly considered a hazardous industry, in addition to musculoskeletal disorders, a couple of work-related injuries and diseases have been associated with it. Evidence has been found that the use of pesticides among farmers is a common cause of skin diseases (Śpiewak, 2001). Some of the skin diseases that have been

related to pesticides are urticaria, erythema multiform, ashy dermatosis, and contact dermatitis. Contact dermatitis is the most common skin disease related to pesticides among farmers. In another study among Korean farmers, farming was related to pesticide poisoning, peasant syndrome, vinyl house disease, and respiratory diseases (Lee & Lim, 2008). Infectious diseases such as zoonosis, tsutsugamushi disease, hemorrhagic fever with renal syndrome, leptospirosis, among others have also been found in Korean farm workers. Respiratory diseases such as bronchitis, organic dust toxic syndrome (ODTS), and sinusitis are constantly mentioned in studies related to diseases among agricultural workers (Frank et al., 2004; Lee & Lim, 2008; S. Von Essen, Fryzek, Nowakowski, & Wampler, 1999). With respect to injuries, the most commonly reported accidents among agricultural workers are: falls and machinery-related injuries (Nogalski, Lubek, Sompor, & Karski, 2007; H. Xiang et al., 2000). As mentioned before, the nature of agricultural tasks makes this population be at constant risk of suffering work-related diseases or injuries.

2.1.4 Awareness and education

In recent years, more attention has been given to agriculture in terms of ergonomics and safety topics. In 1998, the National Institute for Occupational Safety and Health (NIOSH) organized a conference to gather experts in agriculture from the academia, government, and other organizations to discuss topics related to ergonomics in farm workers (Estill, Baron, & Steege, 2002). From this conference, it was concluded that: a) more actions to improve ergonomics in agriculture are needed, b) cost-benefit analyses are needed to support the evidence of early intervention of ergonomics in agriculture, and c) understanding the differences of cultural beliefs of farm workers is important because of the highly diverse population that works and depends on agriculture. Reports from a survey of 300 farmers from North Carolina showed that 70.1% of farm workers assured that safety was important for their employers, however,

54.2% reported that no safety training was given to them, 85.2% reported lack of safety equipment, and 54.2% of them said that working safely was not rewarded (Arcury et al., 2012). It was also noted that workers had the firm belief that pain and facing risks was part of the nature of working in agriculture (Arcury et al., 2012; Estill et al., 2002). There is a consistent trend in the literature pointing towards the inherent need to create awareness about the importance of ergonomics and safety in agricultural work as well as understanding farm workers' perceptions about these practices.

2.1.5 Minorities in agriculture

Several reports mention the vulnerability of underrepresented populations in agriculture in terms of safety and work-related musculoskeletal disorders. Around the world, children have been identified as huge contributors to agricultural work. In the United States (USA), around 7% of agriculture paid work force is composed of children between the ages of 14 to 17 (Manser et al., 2000). Children normally work at family-owned farms around the USA. Working for long periods of time in awkward positions have been related to the development of musculoskeletal disorders for preadolescents in the future (Gangopadhyay et al., 2005). Using the Ovako Working Posture Analysis System (OWAS), Gangopadhyay et al. identified back bending, arms below shoulder, twisted back, bent knees, and lifting heavy weights for long periods of time as common body postures for agricultural activities such as weeding, spading, planting, etc. These postures have been related to musculoskeletal disorders across literature.

Immigrants are also considered a strong work force in agriculture (Faucett et al., 2001). According to the National Agricultural Workers Survey of 2001-2002, around 78% of farm workers in the United States were immigrants (Carroll, Samardick, Bernard, Gabbard, & Hernandez, 2005). Low literacy level, illegal status in the country, and low income levels are conditions that make immigrant agriculture workers to be considered a special population among

other types of workers (Center for Disease Control and Prevention, 2012). Most immigrants are far from obtaining the necessary access to health care services or prevention mechanisms to avoid injuries and/or musculoskeletal disorders (Faucett et al., 2001; S. G. Von Essen et al., 1998).

Another group that also collaborates with agriculture are women. In the US, around 21% of farm workers are female (Carroll et al., 2005). Singh and Vinay mention that most of the activities performed by women in agriculture, such as sitting, squatting, and repetitive movements are strongly related to musculoskeletal disorders (Singh & Vinay, 2013). In 1992, the National Health Interview Survey concluded that farming ranked second highest in severity for musculoskeletal disability among females (Leigh & Fries, 1992). Throughout the years, agriculture has been mostly related as an occupation for men. Also, farms are mostly listed as male-owned, with only a few owned by females. Historically, women have been associated more as helpers' in light tasks in the farm. Some publications have demonstrated that although women consider themselves more as housekeepers, most of the tasks performed by them on a daily basis is regular farm work (Reed, Westneat, Browning, & Skarke, 1999). Reed et al. (1999) carried out the analysis in women from the states of Kentucky and Texas and noticed similarities between both groups. Tasks that requires bending, full body twisting, repetitive movements for a long period of time, and lifting heavy objects were identified as primary causes for sprains and strains. Since most farms are family-owned, it is a common practice for these female farm workers to not receive a direct wage for the work performed.

Although the contribution of minorities to agriculture is widely recognized, diverse factors place these groups in disadvantage in terms of access to tools and information that improve safe working conditions and prevent musculoskeletal disorders, injuries, and illnesses.

2.1.6 Research and Survey Methods to study MSDs and health conditions

Several methods are commonly used to obtain data related to musculoskeletal disorders and discomforts. The Standardized Nordic Questionnaire has been widely used in the field of ergonomics as it was designed to facilitate the analysis of data while comparing musculoskeletal discomforts in different parts of the body (Crawford, 2007; Kuorinka et al., 1987). The original purpose of the Standardized Nordic Questionnaire was to obtain data related to low back, neck, shoulder, and general discomfort (Kuorinka et al., 1987). The questionnaire consists of general multiple-choice questions in which basic information about the participant is documented and a series of multiple choice questions regarding discomfort in specific areas of the body are presented. The document includes a dorsal view of a human body to assist participants in determining the symptoms and location of the pain or discomfort. This instrument also documents information for events during the past 12 months and the past 7 days. Although it wasn't designed as a method for medical diagnostics, Kuorinka reported that answers of the questionnaire varied in a range of 0-20% against clinical history of patients (Crawford, 2007; Kuorinka et al., 1987). Descatha et al. (2007) concluded that Nordic Questionnaires are useful to gather information regarding symptomatology of upper-limb musculoskeletal disorders, specifically, if it contains a scale to classify its severity. On the other hand, the literature warns that the results of the questionnaire can be affected by the place in which the person is taking it, the context of the questionnaire, bias because of older and less painful events are not remembered as well as recent events, and underreporting because of fear to lose their work (Descatha et al., 2007; Kuorinka et al., 1987). Through literature, it became clear that the use of a Standardized Nordic Questionnaire, adapted to the needs of the agricultural workers in Puerto Rico would be an ideal method to obtain information related to musculoskeletal discomforts in the Island.

Information related to health conditions in farmers have been collected in the past using questionnaires. For example, the Agricultural Health Study (AHS) is a questionnaire focused in licensed pesticide applicators (majority farmers) to obtain information that can be related to different types of cancer and other diseases (Alavanja et al., 1996). The AHS study has been made in different phases, starting in 1993 and updated in following years with more than 89,000 participants. The objectives of AHS were to document the risks associated to developing cancer and other non-cancer health issues related to the use of pesticides in the farm. This study also documented and evaluated the risks of dependents of agricultural workers (spouses and children) of developing diseases by indirect exposure to pesticides.

One of the objectives of our research was to describe common health conditions suffered by agricultural workers in Puerto Rico. To obtain information related to health conditions among agricultural workers in the Island, a series of questions that addressed this topic were included in the questionnaire administered to the participants of this research.

Chapter 3

A detailed description of the methodology followed during this study will be presented in this chapter. The methodology was divided in two phases: a) Clinical Data to establish the rates of illness and injuries among agricultural workers and b) a Questionnaire to document discomforts, health conditions, and safety practices at work. The chapter will explain the steps performed for each phase of the research. Also, corresponding statistical tests will be described. Although the research was divided in two phases, the main purpose is to evaluate the presence of MSDs and associated discomforts and symptoms among agricultural workers in Puerto Rico using statistical and heuristic algorithms.

3.1 Methodology

To develop a profile of Musculoskeletal Disorders (MSD), discomforts, and health and safety practices of agricultural workers, this research study was divided in two phases as shown in Figure 1. The first phase consisted in the analysis of medical records for patients who received medical services at the Outpatient (OPD) Clinic of Castañer General Hospital, located in Lares, Puerto Rico. The second phase consisted in a questionnaire which focused on musculoskeletal discomforts, safety, and health practices among agricultural workers. The two phases were worked in parallel. Although related, each phase was analyzed independently to develop the profile of MSD and discomforts of agricultural workers in Puerto Rico. Data collection begun after the approval of the research methodology by the Institutional Review Board (IRB) committee at the University of Puerto Rico, Mayaguez Campus (See: Appendix A: IRB Approval Letter).

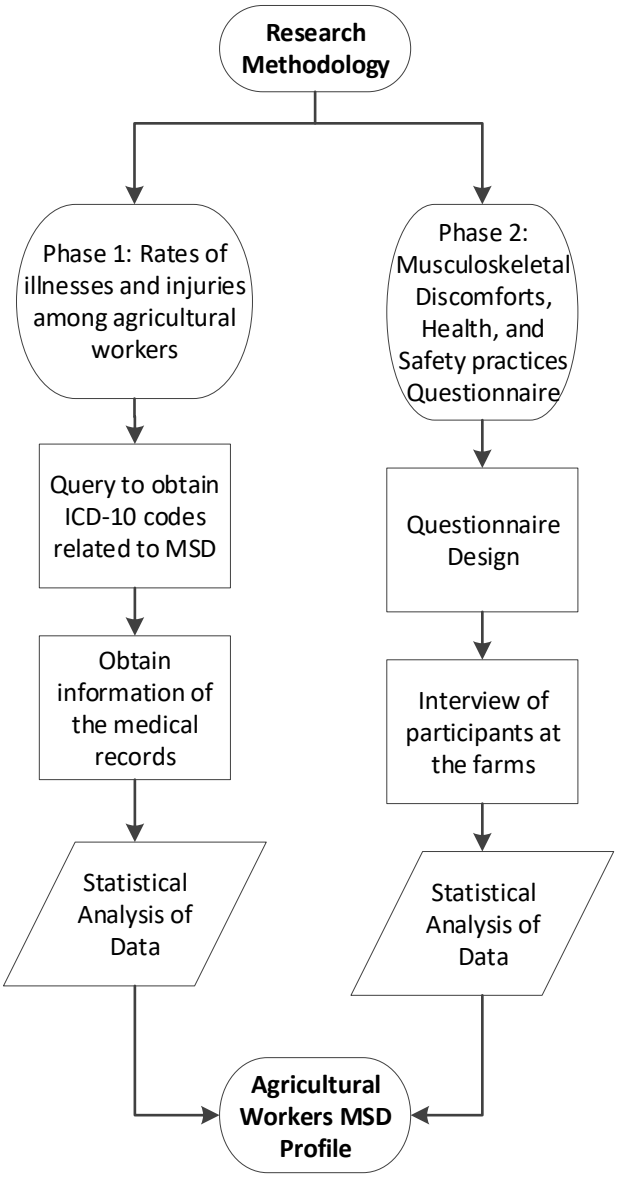


Figure 1: Research Methodology Process

3.1.1 Phase I: Rates of illness and injuries among agricultural workers

3.1.1.1 ICD-10 codes

The purpose of Phase I was to analyze the diagnostics in medical records from the Out-patient (OPD) Clinic at Castañer General Hospital to determine trends related to musculoskeletal disorders among agricultural workers. The World Health Organization (WHO) developed the International Statistical Classification of Diseases and Related Health Problems (ICD) in order to

facilitate the statistical analysis of health conditions around the world (World Health Organization, 2016). Version 10 is the current version of the ICD, known as ICD-10. In the ICD-10, each condition, illness, injury, or health problem is identified with a unique code to standardize the way in which patient information is stored. This standardization helps in the statistical analysis, identifying trending of conditions in different countries, and facilitate the sharing of data among health institutions. These codes are also used by medical providers to bill medical insurance companies after giving service to a patient.

Using the ICD classification system, ICD-10 codes related to musculoskeletal disorders were identified in the medical records, according to the MSD classification criteria from the Bureau of Labor Statistics (Bureau of Labor Statistics, 2016). As ICD codes are divided according to the type of conditions, for this research, queries were selected from three main classifications of the ICD-10:

a) Diseases of the musculoskeletal system and connective tissue (M00-M99)

b) Diseases of the nervous system (G00-G99)

c) Injury, poisoning, and certain other consequences of external causes (S00-T88)

3.1.1.2 Data collection and management

The information of the patient medical record data was obtained electronically through the Census and Statistics Department of Castañer General Hospital. The information requested for the research was: sex, age, height, weight, health diagnostics, and occupation (agricultural worker or non-agricultural worker). To guarantee the privacy of the patients, according to the approved IRB protocol, the information was provided by Hospital personnel as an electronic file without personal identifiable information such as name, social security number, etc. The medical record data corresponded to patients who received services in a 12-month period, between June 2016 to May 2017.

3.1.1.3 Data Description

The data set included information of 4,686 patients (2,729 females and 1,957 males) treated in the OPD clinic between June 2016 to May 2017. The sample included 2,358 (50.32%) cases of agricultural workers and 2,328 (49.68%) of non-agricultural workers. The data set included the following information: sex, age, height, weight, type of worker (agricultural worker or non-agricultural worker), and the diagnostics (primary or secondary) for which they were treated.

Among agricultural workers, information of migrant workers and seasonal workers was included. As described by personnel of the OPD Clinic, seasonal workers are those that work in agriculture only some seasons of the year. Migrant workers are those that temporarily move to the area where the farms are located to work. Non-agricultural workers are dependents or family members of agricultural workers who are not working in agriculture, as well as patients from any other occupation not including agricultural workers.

3.1.1.4 Data Analysis Methodology

Chi-Square Test (X^2) was used to determine if there exist any relationship between the worker occupation, gender, and the number of primary or secondary MSD diagnostics received. Chi-Square Test also helped to determine the relationship between the worker occupation and the total number of MSD and non-MSD diagnostics received. It was found in the literature that Chi-Square test can be used to compare the proportions of two variables when the sample size is considered to be large (McDonald, 2014a).

The formula to calculate the Chi-square is the following:

$\chi^2 = \frac{(O_i - E_i)^2}{E_i}$, where:

O_i=Observed Value

E_i=Expected Value.

The hypotheses for the Chi-Square statistic are:

H_0=Variables are independent

H_A=Variables are not independent

Kruskal-Wallis was used to determine if there was a difference among worker occupation, gender, and median number of MSD diagnostics received. To reduce the family-wise error rate among the statistical tests performed in this research, a Bonferroni correction was applied to the P-value. The corrected α used was 0.005 to achieve a more conservative comparison. An α less than 0.005 was interpreted that the median of both groups differs. Kruskal-Wallis (H-statistic) is a statistical test used as a substitute to the Analysis of Variance (ANOVA) in cases where the data does not comply with the assumptions required by ANOVA test (McDonald, 2014b, Minitab 17 Statistical Software, 2010). It is most commonly used when performing analysis between one categorical variable (i.e. gender or work status) and one numerical variable (i.e. number of diagnostics). If the distribution of both variables is assumed to be the same, the results of Kruskal-Wallis can be analyzed as if the median in both groups is statistically different or not. On the other hand, if the distribution of both variables is different, the mean rank of both groups is evaluated to determine if they differ or are the same.

The hypotheses that are evaluated with the Kruskal-Wallis test are the following (National Institute of Standards and Technology, 2015):

- H_0=medians of the variables are equal
- H_A=medians of the variables are not equal

To calculate the H-statistic of Kruskal-Wallis test, the following equation is used:

$H = \left[\frac{12}{n(n+1)}\sum_{i=1}^{c}\frac{R_i^2}{n_i}\right] - 3(n+1)$, where:

n=sum of sample sizes

R=sum of the ranks in each sample

n_i=size of the i^{th} sample

c=number of samples

As mentioned before, the Kruskal-Wallis test is useful to evaluate the difference in the median number of two variables.

3.1.2 Phase II: Musculoskeletal Discomforts, Health, and Safety Practices Questionnaire

3.1.2.1 Questionnaire Design

The purpose of the second phase of the research was to obtain information related to musculoskeletal discomforts, health, and safety practices from agricultural workers in Puerto Rico by means of a questionnaire (see Appendix B: Questionnaire of musculoskeletal discomforts, health, and safety practices at work among agricultural workers in Puerto Rico). The questionnaire was designed in Spanish, with simple wording and consisted of 24 items in four parts: 1) Informed consent document, 2) Demographic characteristics (11 items), 3) Nordic Modified Questionnaire (4 items), and 4) Safety practices in the work environment and health related questions (9 items). The first section provided participants with an opportunity to learn

about the study and their rights as volunteers. The second section was designed to obtain demographical information of the sample such as: sex, age, citizenship, height, weight, education, and work experience. Given the fact that the focus population is usually comprised of workers who belong to socioeconomically disadvantaged groups, and to encourage their participation in the research study, no identifiable information was collected through the questionnaire and participants were not required to sign a consent form. The third part of the questionnaire is based on the Standardized Nordic Questionnaire (Crawford, 2007; Kuorinka et al., 1987). The Standardized Nordic Questionnaire was primarily designed to facilitate in the collection and analysis of data related to musculoskeletal discomforts, making it easier to compare results of different studies related to this topic in the work environment (Kuorinka et al., 1987). The Standardized Nordic Questionnaire was used in this research to characterize the pain that the participants suffered in different parts of the body. For this project, the Standardized Nordic Questionnaire was translated to Spanish and modified to include a pain scale to address the level of discomfort in different zones of the body for periods of 7 days and 12 months, medical attention received, and impact of discomfort in work activities. In order to facilitate the characterization of the level of discomfort or pain, the Faces Pain Scale-Revised was included as reference for the participants (Hicks et al., 2001) with a corresponding numerical pain scale. This pain scale was developed by the International Association for the Study of Pain (IASP) to help children identify the level of pain. The scale contains different pictures of faces that represent the level of discomfort. A numerical scale of 0-10 with increments of two units was added to this scale, zero being not reporting any type of pain and 10 representing the highest level of pain in the specified area. Table 1 shows in detail the description of each level of the numeric scale.

Table 1: Pain Scale Description

Numeric value	Description
0	No discomfort in the area
2	Light discomfort in the area
4	Moderate discomfort in the area
6	Moderate pain in the area
8	Strong pain in the area
10	Unbearable pain in the area

The use of the Faces Pain Scale-Revised helped agricultural workers with low literacy levels to understand and identify the level of discomfort present in different parts of the body. Participants were also asked about the type of treatment received to reduce their pain in the different areas of the body. The following options were given in the questionnaire: a) None, b) Medical treatment, c) Home treatment, and d) Medical treatment and Home treatment. Medical treatment refers to any type of intervention from medical personnel such as visits to the hospital or a visit to a medical provider's office. Home treatment refers to any type of treatment in which no medical personnel is involved such as over the counter drugs (OTC), massages, or use of heating pads, among others.

The fourth part of the questionnaire was focused on safety practices at work and health related questions. The Agricultural Health Study (AHS) was used as reference for the questions in this section of the questionnaire (Alavanja et al., 1996). The AHS focus on cancer and other health conditions in licensed pesticide applicators, most of them being farmers. The study started in 1993 with the purpose of establishing relationships between lifestyle and genetic factors along the years in the risk of developing cancer and other diseases in farmers. The participants in the 1993 study were farmers from the states of Iowa and North Carolina. In this part, questions addressed the use of personal protective equipment, sun exposure, use of pesticides, risk knowledge, training, use of heavy equipment, and health conditions. Most of the

questions were designed to be answered by multiple choice selections. For this research, participants were asked for the type of equipment/apparel that they use for sun protection as well as other Personal Protective equipment (PPE). Also, there were questions about the agricultural worker's knowledge about safety and their perception of safety at the work environment. These questions are useful to determine future actions to help reduce MSDs, discomforts, and injuries among agricultural workers by offering training and tools to perform the tasks safely.

Once at the farm, and because of limitations of time and availability of the agricultural workers, the questionnaire was completed as an interview.

3.1.2.2 Participant Requirements

To be eligible to participate in this research study, participants had to be 21 years of age or older. Another requirement was that candidates needed to volunteer without receiving any type of compensation and anonymity was guaranteed. Given the fact that the questionnaire asked for discomforts for the last 7 days and the last 12 months, a minimum of one (1) year of experience as an agricultural worker was asked as participation criteria. For the sake of reducing the variability of the discomforts among the agricultural workers, participants were selected from farms in which the process to harvest their main products was similar, such as: mango, plantain, banana, coffee, among other fruit trees. To harvest these fruits, full extension of the arms over the body are required. Although the harvest method among these crops is similar, agricultural workers perform a diverse variety of tasks in the farm which requires all types of movements that can surely contribute with discomforts in different parts of the body.

3.1.2.3 Data collection process

Farms in the west and south-west region of the Island were contacted by phone and e-mail to explain the project objectives to the owners/administrators and asked for permission to visit the farm and offer the questionnaire to their workers. Table 2 and Figure 2 shows the location of the visited farms. During the visits to the farms, which was done during morning hours, a brief explanation of the project was given to the workers just before administration of the questionnaire, following the informed consent process. For those workers interested in voluntarily participating, the Informed Consent Document was read and explained, in a private area, before starting the interview. After verbal agreement to participate in the study, the questionnaire was administered as an interview. In addition to the questionnaire, a separate attachment that contained the Faces Pain Scale-Revised was also shown to each participant during the questions related to discomforts on the different parts of the body.

Table 2: Number of farms visited per town

Town	Number of visited farms
Añasco	4
Yauco	1
Guayanilla	1
Santa Isabel	3

Figure 2: Location of visited farms

3.1.2.4 Data Description

According to the 2012 Census of Agriculture (Vilsack & Reilly, 2014), there are around 30,122 farm workers around Puerto Rico. To be able to perform this research with such a high population, a convenience sample of 100 participants was selected. This type of sampling is used when there are limitations of time, money, and workforce for the data collection. It is also used when the entire population is considerably high and difficult to be accessed (Trochinm, 2006).

Although this type of sampling has the limitation that its results can't be used to make generalizations of the entire population, they are useful for initial studies of a specific subject or qualitative analysis, which is the main purpose of this research (Bornstein, Jager, & Putnick, 2013). Most of the participants came from farms located in the west and south-west area of Puerto Rico. To be eligible for the research, participants were required to be at least 21 years old and with one year of experience in the agricultural industry.

3.1.2.5 Data Analysis Methodology

Random Forest was used in the second phase of this research to determine those variables more related to the level of pain reported by the participants. Random Forest (RF) is a classification algorithm that can help to determine the importance of the variables in a model with respect to a selected response variable. The model works by constructing multiple decision trees with random samples of the available data (Breiman, 2001) (See Figure 3). As can be seen in the example of Figure 3, after passing the data through the trees, the majority of the trees voted for Variable A, making this the most important variable in the model. RF uses the variables of the data to create the splits for each new decision tree. After creating all the decision trees allowed by the data and available variables, a final prediction is made by using a system of

votes. Each tree shows the most significant variable and at the end, a count of the votes per tree for each variable is counted. The variable with the highest number of votes is the most important variable related to the selected response variable. Therefore, the algorithm determines the order of relevance of each variable. RF is useful to work with large data and different types of variables at the same time such as categorical and numerical.

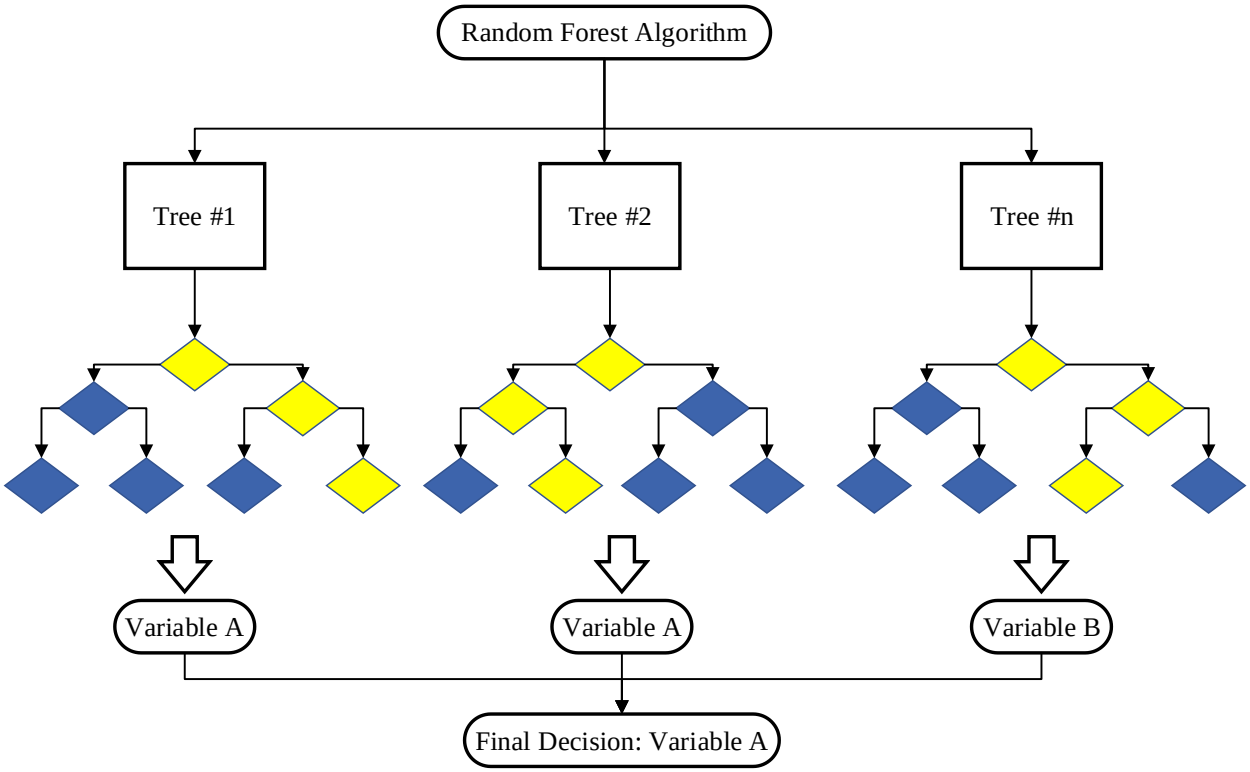


Figure 3: Random Forest diagram

RF has two metrics for measuring the importance of a variable: Mean Decrease Accuracy and Mean Decrease Gini. Mean Decrease Accuracy (MDA) measures the effect in the classification error for the model of each variable (Breiman, Cutler, Liaw, & Wiener, 2015; Dinsdale, n.d.). It works by removing one variable at a time and calculating the accuracy of the Random Forest model. The higher the reduction of accuracy of the model after removal of a

variable, more relevant is the variable to the model. Mean Decrease Gini (MDG) is related to the impurity of the nodes in a classification model. When a variable is used to split a node in the classification tree, the Gini Index is calculated and compared with the previous Gini Index value. At a higher the MDG, more important is the variable for deciding the split in a node. Both MDA and MDG are different types of metrics related to the relevance and importance of a variable in the RF model.

In our analysis, Random Forest was used to determine the ranked importance of the variables described in Table 3 with respect to the reported level of pain of the participants described in Table 1. RF was useful because there were numerical and categorical variables to be considered in the model and this algorithm can work with big amounts of different types of data.

Table 3: Predictor Variables for reported Level of pain

Predictor Variables	**Type of variable**
Age	Numerical
Sex	Categorical
Years of experience	Numerical
Weight Status according to Body Mass Index	Categorical
Days of work per week	Numerical
Highest academic degree	Categorical
Hours of work per day	Numerical
Work related training received	Categorical
Period of pain	Categorical
Body area	Categorical

Finally, Fishers Exact test was used to determine the difference, if any, between the reported level of pain in agricultural workers that completed the questionnaire among both periods of 7 days and 12 months. The alpha (α) value used for this test was 0.05. The data was

placed in a 2-Row- 5-Columns table where the rows represented the variables of interest and the columns represented the level of pain in both periods of time.

To calculate Fisher's Exact Test, the following formula is used (Weisstein, n.d.):

$$N = \sum_i R_i = \sum_j C_j$$

$$P_{cutoff} = \frac{(R_1!\, R_2! \ldots R_m!)(C_1!\, C_2! \ldots C_m!)}{N! \prod_{ij} a_{ij}!}$$

where:

R=Row sums

C=Column sums

a_{ij}=number of observations

Fisher's exact test of independence is useful in determining the difference in proportions among categorical variables (McDonald, 2014c). Basically, the purpose of this test is to determine if the proportion of one variable is statistically the same to the other variable although the values are different. This would be the null hypothesis for this statistical test. The test assumes independence among the data. The P-value is then used to determine if there is a significant difference among the proportions of both groups. Fisher's exact test is recommended when the sample size is small, opposite to Chi-square test in which a large sample size is recommended.

3.1.2.6 Relevant variables for the analysis

An important part of this study was to determine the variables that were most relevant in the reported level of pain of the participants. For this, ten (10) predictor variables were chosen from the questionnaire (See Table 3) and the response variable for the algorithm was Level of pain. As described in Table 1, the scale of pain for this research runs from 0 to 10 with

increments of 2. A level of pain of 0 represents "No discomfort in the area" and a level of 10 is described as "Unbearable pain in the area.

Random Forest classification technique was used to determine the relevance of these 10 variables in the level of pain reported by the participants. This algorithm was applied by using R Statistical Software (R Core Team, 2017). Missing values were imputed from the data using the *missForest* function in R ("Missing Value Imputations by randomForest," n.d.). The maximum percent of missing data is 2.56% (See Appendix E: Percent of missing data per variable). Continuous missing data was replaced by using a weighted average of the available data. A categorical missing data was replaced by the category that had the highest average proximity. Given the fact that the main objective of this phase was to determine the most relevant variables that affect the level of pain reported by the participants, the data used for the analysis was the one in which pain was reported on the scale of 2-10 according to Table 1. Data of participants who did not report any pain were excluded from the analysis.

3.1.2.9 Data Management

All the data from the questionnaire was managed in confidentiality to protect participant's anonymity and to comply with the IRB requirements. The Questionnaire did not ask any identifiable information about the participants. As part of the Questionnaire, an Information Sheet that explained the purpose of this research was read to the participants before the interview. To assure the participant anonymity, a signature waiver from the participant was requested to the IRB Committee for participation in the research.

After completion of the questionnaire, the data was transcribed to a Microsoft Excel® Data Sheet. This file was stored in a Google Drive® folder that was only accessed by the

researcher. The main software's used for the data analysis were Microsoft Excel ®, R Statistical Software®, and Minitab 17®.

Chapter 4

In this chapter, the results obtained for both phases of this study will be presented. Analysis of the data as well as discussion of results will be included. The results and analysis will be supported with tables and graphs to facilitate the interpretation of the data.

4.1 Results and Discussion

4.1.2 Phase I: Rates of illness and injuries among agricultural workers at the OPD Clinic of Castañer General Hospital

4.1.2.1 Demographics Data

Demographics of the patients older than 21 years that were treated in Castañer General Hospital are shown in Table 4. A total of 4,686 patients were treated at the OPD Clinic of Castañer General Hospital during a 12-month period between June 2016 to May 2017. Most of the sample were females (58.2%) and agricultural workers made 51% of the treated population in the OPD Clinic (50.3% females and 49.7% males).

Table 4: Demographics of all patients treated at the OPD Clinic

	Male		**Female**	
	Agricultural	**Non-agricultural**	**Agricultural**	**Non-agricultural**
Average Age (years) (SD)	53.54 (16.29)	46.98 (16.81)	50.92 (16.90)	49.3 (17.43)
Average Height (cm) (SD)	168.50 (8.56)	170.05 (8.59)	156.77 (7.21)	157.61 (7.39)
Average Weight (kg) (SD)	83.03 (18.49)	86.16 (21.03)	74.04 (17.88)	74.04 (18.63)
# of worker (%)	1264 (26.97)	693 (14.79)	1094 (23.35)	1635 (34.89)

Using the height and weight of patients, Body Mass Index (BMI) was calculated as a measure of the height with respect to the weight of the individual (Center for Disease Control and Prevention, 2015). The BMI is widely used to determine the weight status of a person. Although it does not calculate body fat, BMI is successfully used to determine some diseases related to overweight. BMI can't be used for diagnostic purposes but it can be useful as an

indicator of excessive fat in the body. The BMI results for patients treated at Castañer General Hospital (see Table 5) show that the majority of the population is considered to be overweight or obese. In general, 75.96% of females and 76.03% of males in agricultural workers group were both overweight or obese according to the BMI metric. The same trend was found amongst non-agricultural workers, as 77.34% of males and 72.54% of females are also considered to be overweight or obese. Obesity has been related to a diversity of health conditions such as: high blood pressure, stroke, diabetes, osteoarthritis, depression, body pain, among others (Center for Disease Control and Prevention, 2015). In a 2016 study, it was found that obesity and high values of BMI were associated with early death rates, especially among men and with a higher risk of death related to obesity at a younger age (Angelantonio et al., 2016).

Table 5: Number and percentage (%) of patients according to BMI weight status, gender and occupation

	Male		**Female**	
Weight Status	**Agricultural**	**Non-agricultural**	**Agricultural**	**Non-agricultural**
Not available	43 (3.40%)	18 (2.59%)	29 (2.65%)	60 (3.67%)
Underweight	18 (1.42%)	8 (1.15%)	23 (2.10%)	32 (1.96%)
Normal/Heavy Weight	242 (19.15%)	131 (18.90%)	211 (19.29%)	357 (21.83%)
Overweight	495 (39.16%)	254 (36.65%)	349 (31.90%)	487 (29.79%)
Obese	466 (36.87%)	282 (40.69%)	482 (44.06%)	699 (42.75%)

In a study performed among 44,793 participants from The Netherlands, participants considered to be overweight or obese were at higher risk of suffering symptoms related to musculoskeletal conditions and suffered from slower recoveries from these discomforts (Viester et al., 2013). Another study also reported a relation between overweight/obese status and musculoskeletal pain in the area of the shoulders (Moreira-Silva, Santos, Abreu, & Mota, 2013). Interestingly, a different study mentioned that although high values of BMI can't be directly related to musculoskeletal pain, overweight or obese individuals are at risk of developing

metabolic syndrome. Metabolic syndrome is a combination of conditions that are directly related to heart conditions such as high blood sugar, high levels of cholesterol and triglycerides (Mayo Clinic Staff, n.d.). This syndrome can be felt in the body as musculoskeletal pain but in fact they are symptoms of more serious conditions related to heart health (Seaman, 2013).

The fact that the majority of the population is considered overweight or obese, raises a flag of the risk of developing MSD conditions and suffering discomforts associated to obesity, along with other health conditions. Obesity can be caused by diverse factors, including genetics, eating habits, emotional factors, lack of physical activity, among others (Thompson, Romito, & O'Brien, n.d.).

4.1.2.2 Most common MSD conditions and body areas affected

Table 7 and Table 8 show the most common MSD diagnostics among agricultural and non-agricultural workers who received medical services at the OPD Clinic at Castañer General Hospital. These tables include the conditions that comprise 80% of all the MSD diagnostics given to agricultural workers at the OPD Clinic. Among agricultural workers, 19.9% of all diagnostics related to MSD were for low back pain (M54.5), followed by cervicalgia (8%, pain in the neck-M54.2), and 4.7% of diagnostics for pain in the right shoulder (M25.511). These results are similar to a study performed by Xiao (2013) in which pain in the lower back area, shoulders, knee, and neck were the most common discomforts among Latino farm workers.

Similarly, as shown in Table 8, the three most common MSD conditions diagnosed among non-agricultural workers were low back pain (18.4%, M54.5), cervicalgia (8.7%, pain in the neck-M54.2), and pain in left knee (4.5%, M25.562). No association was found between the type of worker and the number of diagnostics of low back pain and cervicalgia (neck pain) diagnostics among agricultural and non-agricultural workers (X^2=1.118, P-value=0.29) (See Table 6).

Table 6: Chi-Square test for Low Back Pain and Cervicalgia among Agricultural and Non-agricultural workers

Chi-Square Test for Association: Occupation, Conditions			
Rows: Conditions	Columns: Type of worker		
	Agricultural Worker	Non-agricultural worker	All
Low Back Pain	305	235	540
	298.3	241.7	
Cervicalgia	122	111	233
	128.7	104.3	
All	427	346	773
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	1.118	DF=1	P-value=0.290
Likelihood Ratio Chi-Square=	1.116	DF=1	P-value=0.291

The complete list of MSD related diagnostics by occupation is described in Appendix C: Total number of primary and secondary MSD conditions by type of worker.

Table 7: Summary of most common primary and secondary MSD related diagnostics among agricultural workers

ICD10 Code	**Condition Description**	**Total number of diagnostics**	**%**	**Cumulative %**
M54.5	Low back pain	305	19.92%	19.92%
M54.2	Cervicalgia	122	7.97%	27.89%
M25.511	Pain in right shoulder	73	4.77%	32.66%
M15.0	Primary generalized osteoarthritis	65	4.25%	36.90%
M25.512	Pain in left shoulder	53	3.46%	40.37%
M62.838	Other muscle spasm	52	3.40%	43.76%
M25.561	Pain in right knee	51	3.33%	47.09%
M62.830	Muscle spasm of back	46	3.00%	50.10%
M25.562	Pain in left knee	45	2.94%	53.04%
M25.50	Pain in unspecified joint	33	2.16%	55.19%
G56.01	Carpal tunnel syndrome in right upper limb	24	1.57%	56.76%
M17.12	Unilateral primary osteoarthritis of the left knee	22	1.44%	58.20%
M25.551	Pain in right hip	21	1.37%	59.57%

ICD10 Code	Condition Description	Total number of diagnostics	%	Cumulative %
M51.26	Intervertebral disc displacement in the lumbar region	19	1.24%	60.81%
M54.16	Radiculopathy of the lumbar region	19	1.24%	62.05%
M05.79	Rheumatoid arthritis of multiple sites	16	1.05%	63.10%
M25.571	Pain in right ankle and joints of right foot	16	1.05%	64.14%
M17.11	Unilateral primary osteoarthritis of the right knee	15	0.98%	65.12%
M48.06	Spinal stenosis in the lumbar region	15	0.98%	66.10%
M25.531	Pain in right wrist	13	0.85%	66.95%
M06.9	Rheumatoid arthritis	12	0.78%	67.73%
M19.041	Primary osteoarthritis in the right hand	12	0.78%	68.52%
M25.572	Pain in left ankle and joints of left foot	12	0.78%	69.30%
M54.6	Pain in thoracic spine	12	0.78%	70.08%
G56.02	Carpal tunnel syndrome in the left upper limb	11	0.72%	70.80%
G56.03	Carpal tunnel syndrome in bilateral upper limbs	11	0.72%	71.52%
M54.31	Sciatica, right side	10	0.65%	72.18%
G56.00	Carpal tunnel syndrome in unspecified upper limb	9	0.59%	72.76%
M06.4	Inflammatory polyarthropathy	9	0.59%	73.35%
M25.522	Pain in left elbow	9	0.59%	73.94%
M54.41	Lumbago with sciatica in the right side	9	0.59%	74.53%
M19.011	Primary osteoarthritis, right shoulder	8	0.52%	75.05%
M19.012	Primary osteoarthritis of the left shoulder	8	0.52%	75.57%
M19.042	Primary osteoarthritis of the left hand	8	0.52%	76.09%
M25.552	Pain in left hip	8	0.52%	76.62%
M45.9	Ankylosing spondylitis of unspecified sites in spine	8	0.52%	77.14%
M51.37	Other intervertebral disc degeneration, lumbosacral region	8	0.52%	77.66%

ICD10 Code	Condition Description	Total number of diagnostics	%	Cumulative %
M54.17	Radiculopathy of lumbosacral region	8	0.52%	78.18%
M54.89	Other dorsalgia	8	0.52%	78.71%
M25.532	Pain in left wrist	7	0.46%	79.16%
M47.812	Spondylosis without myelopathy or radiculopathy, cervical region	7	0.46%	79.62%
M51.06	Invertebral disc disorders with myelopathy, lumbar region	7	0.46%	80.08%

Table 8: Summary of most common primary and secondary MSD related diagnostics among non-agricultural workers

ICD10 Code	Condition Description	Total number of diagnostics	%	Cumulative %
M54.5	Low back pain	235	18.40%	18.40%
M54.2	Cervicalgia	111	8.69%	27.09%
M25.562	Pain in left knee	58	4.54%	31.64%
M15.0	Primary generalized osteoarthritis	57	4.46%	36.10%
M25.511	Pain in right shoulder	57	4.46%	40.56%
M25.512	Pain in left shoulder	57	4.46%	45.03%
M62.830	Muscle spasm of back	57	4.46%	49.49%
M25.50	Pain in unspecified joint	43	3.37%	52.86%
M25.561	Pain in right knee	43	3.37%	56.23%
M62.838	Other muscle spasm	32	2.51%	58.73%
M51.26	Other intervertebral disc displacement in the lumbar region	21	1.64%	60.38%
M25.552	Pain in left hip	18	1.41%	61.79%
M06.9	Rheumatoid arthritis, unspecified	16	1.25%	63.04%
M48.07	Spinal stenosis in the lumbosacral region	14	1.10%	64.13%
G56.02	Carpal tunnel syndrome in left upper limb	13	1.02%	65.15%
M25.551	Pain in right hip	13	1.02%	66.17%
M25.572	Pain in left ankle and joints of left foot	12	0.94%	67.11%
G56.01	Carpal tunnel syndrome in right upper limb	11	0.86%	67.97%

ICD10 Code	Condition Description	Total number of diagnostics	%	Cumulative %
M05.79	Rheumatoid arthritis of multiple sites	11	0.86%	68.83%
M54.16	Radiculopathy, lumbar region	11	0.86%	69.69%
M17.0	Bilateral primary osteoarthritis of knee	10	0.78%	70.48%
M54.6	Pain in thoracic spine	10	0.78%	71.26%
M51.37	Other intervertebral disc degeneration, lumbosacral region	9	0.70%	71.97%
M54.31	Sciatica, right side	9	0.70%	72.67%
G56.00	Carpal tunnel syndrome in unspecified upper limb	8	0.63%	73.30%
M48.02	Spinal stenosis, cervical region	8	0.63%	73.92%
M62.81	Muscle weakness (generalized)	8	0.63%	74.55%
M06.00	Rheumatoid arthritis without rheumatoid factor, unspecified site	7	0.55%	75.10%
M15.8	Other polyosteoarthritis	7	0.55%	75.65%
M17.11	Unilateral primary osteoarthritis of right knee	7	0.55%	76.19%
M17.12	Unilateral primary osteoarthritis, left knee	7	0.55%	76.74%
M25.531	Pain in right wrist	7	0.55%	77.29%
M25.571	Pain in right ankle and joints of right foot	7	0.55%	77.84%
M54.17	Radiculopathy of the lumbosacral region	7	0.55%	78.39%
M06.211	Rheumatoid bursitis, right shoulder	6	0.47%	78.86%
M13.0	Polyarthritis, unspecified	6	0.47%	79.33%
M50.33	Other cervical disc degeneration, cervicothoracic region	6	0.47%	79.80%
M51.16	Invertebral disc disorders with radiculopathy, lumbar region	6	0.47%	80.27%
M54.41	Lumbago with sciatica in the right side	6	0.47%	80.74%

For both male and female patients, low back pain (M54.5) and cervicalgia (neck pain-M54.2) were found to be the most common MSD diagnostics, independent of occupational status (See Appendix C: Total number of primary and secondary MSD conditions by type of worker).

MSD conditions that affect all patients who received medical services can be classified in four main groups to summarize findings (See Appendix D: Classification of MSD conditions):

a) Pain: Condition in which patient suffer from discomfort in a specific area of the body.
b) Arthritis: All conditions related to arthritis such as Rheumatoid arthritis, osteoarthritis, etc.
c) Muscle conditions: Conditions related to the muscles.
d) Discs and nerves conditions: Conditions associated to spine discs or nerves around the body.

As shown in Table 9, 67.12% of the MSD related diagnostics for agricultural workers are in the category of Pain, while conditions related to arthritis are the second most common among agricultural workers with 15.58% of the diagnostics.

Table 9: Classification of most common primary and secondary MSD diagnostics

Classification	**Agricultural workers**		**Non-agricultural workers**	
	# of Diagnostics	**% of total diagnostics**	**# of diagnostics**	**% of total diagnostics**
Pain	788	67.12	671	65.08
Arthritis	183	15.58	134	13.00
Discs and nerves conditions	157	13.37	129	12.51
Muscle Conditions	46	3.91	97	9.4

For non-agricultural workers, the same pattern as for agricultural workers was found. As can be seen in Table 9, the category of Pain has the highest percent of diagnostics with 65.08%, followed by conditions related to arthritis with 13.00%. Additional statistical tests were

performed to determine if there was any difference in the proportions of the number of diagnostics in each category among agricultural and non-agricultural workers. The following comparisons were made: a) Pain vs Muscle Conditions, b) Arthritis vs Muscle Conditions, c) Discs and nerves conditions vs Muscles Conditions, d) Pain vs Arthritis conditions, e) Pain vs Discs and nerves conditions, and f) Arthritis vs Discs and nerves conditions. Given the fact that multiple comparisons were made (6 comparisons), a correction to the α-value was made by using the Bonferroni correction method. The original α-value=0.05 was divided by 6 (number of comparisons) to obtain a more conservative α-value=0.008. As can be seen in Table 10 and Table 11, the Chi-Square test show that there is dependence between the type of worker and the conditions in the classification of "Pain" and "Muscle Conditions" (X^2=24.894, P-value=0.000).

Table 10: Type of worker vs Pain and Muscle Conditions

	Pain (# of conditions)	**Muscle Conditions (# of conditions)**	**% Pain**
Agricultural worker	788	46	94.48
Non-agricultural worker	671	97	87.37

Table 11: Chi-Square Test for Type of worker vs Pain and Muscle Conditions

Chi-Square Test for Association: Occupation, Conditions			
Rows: Occupation	Columns: Type of Diagnostic		
	Pain	Muscle Conditions	All
Agricultural Worker	788	46	834
	759.55	74.45	
Non-agricultural worker	671	97	768
	699.45	68.55	
All	1459	143	1602
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	24.894	DF=1	P-value=0.000
Likelihood Ratio Chi-Square=	25.268	DF=1	P-value=0.000

While performing a Two-Sample Proportions Test (Table 12), it was confirmed that the proportions of Pain Conditions among agricultural workers (AW) is higher than among non-agricultural workers (NAW) (P-value=0.000).

Table 12: Two-Sample proportions Test: Type of worker vs Pain and Muscle Conditions

Two-Sample proportions test		
Null hypothesis	H_0: AW-NAW=0	
Alternative hypothesis	H_1: AW-NAW>0	
Method	Z-Value	P-value
Normal approximation	4.95	0.000
Fisher's exact		0.000

There was also a relationship between the type of workers and conditions classified as Arthritis and Muscle conditions (X^2=25.755, P-value=0.000) (See Table 13 and Table 14).

Table 13: Type of worker vs Arthritis and Muscle Conditions

	Arthritis (# of conditions)	**Muscle Conditions (# of conditions)**	**% Arthritis**
Agricultural worker	183	46	79.91
Non-agricultural worker	134	97	58.01

Table 14: Chi-Square Test for Type of worker vs Arthritis and Muscle Conditions

Chi-Square Test for Association: Occupation, Conditions			
Rows: Occupation	Columns: Type of Diagnostic		
	Arthritis	Muscle Conditions	All
Agricultural Worker	183	46	229
	157.81	71.19	
Non-agricultural worker	134	97	231
	159.19	71.81	
All	317	143	460
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	25.755	DF=1	P-value=0.000
Likelihood Ratio Chi-Square=	26.191	DF=1	P-value=0.000

A Two-Sample proportions Test (See Table 15) confirmed that agricultural workers (AW) suffered more for conditions in the classification of Arthritis than Muscle conditions when compared with non-agricultural workers (NAW).

Table 15: Two-Sample proportions Test: Type of worker vs Arthritis and Muscle Conditions

Two-Sample proportions test		
Null hypothesis	H_0: AW-NAW=0	
Alternative hypothesis	H_1: AW-NAW>0	
Method	Z-Value	P-value
Normal approximation	5.23	0.000
Fisher's exact		0.000

Finally, the Chi-square test (X^2=19.754, P-value=0.000) showed that there also exists a relationship between the type of worker and conditions in the classification of Discs and Nerves Conditions and Muscle Conditions (Table 16 and Table 17).

Table 16: Type of worker vs Discs and nerves conditions and Muscle Conditions

	Discs and nerves (# of conditions)	**Muscle Conditions (# of conditions)**	**% Discs and nerves**
Agricultural worker	157	129	54.89
Non-agricultural worker	46	97	32.16

Table 17: Chi-square test for Type of worker vs Discs and nerves conditions and Muscle Conditions

Chi-Square Test for Association: Occupation, Conditions			
Rows: Occupation	Columns: Type of Diagnostic		
	Discs and Nerves	Muscle Conditions	All
Agricultural Worker	157	129	286
	135.33	150.67	
Non-agricultural worker	46	97	143
	67.67	75.33	
All	203	226	429
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	19.754	DF=1	P-value=0.000
Likelihood Ratio Chi-Square=	20.107	DF=1	P-value=0.000

The Two-Sample proportions test (Table 18) confirmed that agricultural workers (AW) suffered more of Discs and Nerves conditions than Muscle Conditions when compared with non-agricultural workers (NAW).

Table 18: Two-Sample proportions Test: Type of worker vs Discs and Nerves Conditions and Muscle Conditions

Two-Sample proportions test		
Null hypothesis	H_0: AW - NAW =0	
Alternative hypothesis	H_1: AW- NAW >0	
Method	Z-Value	P-value
Normal approximation	4.65	0.000
Fisher's exact		0.000

On the other side, no significant differences were found while comparing the proportion among agricultural and non-agricultural workers for Pain and Arthritis conditions, Pain and Discs and nerves conditions, and Arthritis and Discs and nerves conditions.

The body areas with the highest number of different diagnostics among agricultural workers are Hands/Wrists/Arms and Lower Back. As shown in Table 19, 42 different

diagnostics were attributed to the Hands/Wrists/Arms, while 30 unique diagnostics affected the lower back area among this group. The Category "General" includes conditions that can affect the whole body (Ex. arthritis).

Table 19: Total number of unique diagnostics per body area by worker group

	Agricultural worker	**Non-agricultural worker**
Hands/Wrists/Arms	42	35
Lower Back	30	29
General	29	25
Knees	25	21
Neck	19	18
Ankles	11	9
Shoulders	9	9
Elbows	8	6
Feet	7	1
Legs	6	9
Upper Back	6	4
Hips	6	7
Back	3	4

For non-agricultural workers, the same pattern is observed in which 35 different diagnostics were related to the Hands/Wrists/Arms and 29 unique conditions to the lower back area (See Table 19).

4.1.2.3 Primary and Secondary MSD Diagnostics

A primary diagnostic is the one that arises from the initial symptom which motivates the patient to attend the medical provider. A secondary diagnostic is an additional diagnostic determined during the medical evaluation within the same visit to the medical provider. In order to reduce the family-wise error rate in the statistical tests of this section, a Bonferroni correction analysis was performed to the P-values. Bonferroni correction is used to reduce the family-wise error. This effect is caused by performing multiple statistical comparisons in the same set of data, causing posible false positives in the analysis (McDonald, 2014b). To perform a

Bonferroni correction, the original α-value is divided by the number of statistical tests to be performed. The result will be the new α-value. In other words, $corrected\ \alpha - value = \frac{\alpha - value}{\#\ of\ statistical\ tests}$. The P-value that will be used as comparison in this section will be P-value=0.005. A Chi-square test was used in order to determine if there was any difference among the proportions of primary and secondary MSD diagnostics recorded among the different occupations and gender. Table 20 shows the total number of primary and secondary MSD diagnostics of agricultural and non-agricultural workers treated at the OPD clinic. It is important to notice that secondary MSD diagnostics comprise 35% of the MSD diagnostics in agricultural workers and 36% in non-agricultural workers. This information is relevant as this is a significant percent of MSD diagnostics that are only treated after being identified during a medical examination related to a primary MSD diagnostic. Otherwise, the diagnostic and treatment for these MSD conditions will be unexistent to the patient, affecting the quality of life of the worker. As found in the literature, in occasions agricultural workers consider that pain is part of the job in the farm and avoid receiving treatment for possible MSD conditions related to their job (Arcury et al., 2012; Estill et al., 2002).

Table 20: Total number of Primary and Secondary MSD diagnostics for patients at the OPD clinic

Type of worker	# Primary Diagnostics	# Secondary Diagnostics
Agricultural workers	990	542
Non-agricultural workers	823	465

The results of the Chi-Square Tests described in *Table 21* (X^2=0.160, P-value=0.689) showed that there are no significant differences in terms of the total number of primary and secondary MSD diagnostics received by each type of worker.

Table 21: Chi-Square Test for Primary and Secondary diagnostics for occupation

Chi-Square Test for Association: Occupation, Type of Diagnostic			
Rows: Occupation	Columns: Type of Diagnostic		
	Primary Diagnostics	Secondary Diagnostics	All
Agricultural Worker	990	542	1532
	984.9	547.1	
Non-agricultural worker	823	465	1288
	828.1	459.9	
All	1813	1007	2820
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	0.160	DF=1	P-value=0.689
Likelihood Ratio Chi-Square=	0.160	DF=1	P-value=0.689

With respect to gender, there were no significant differences between the number of primary and secondary MSD diagnostics among agricultural and non-agricultural workers (See *Table 22* and *Table 23*).

Table 22: Chi-Square test for Male workers: Primary and Secondary MSD Diagnostics

Chi-Square Test for Association: Male Worker, Type of Diagnostic			
Rows: Type of worker	Columns: Type of Diagnostic		
	Primary Diagnostics male	Secondary Diagnostics male	All
Male Ag. Worker	510	261	771
	507.5	263.5	
Male Non-ag. worker	218	117	335
	220.5	114.5	
All	728	378	1106
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	0.120	DF=1	P-value=0.730
Likelihood Ratio Chi-Square=	0.119	DF=1	P-value=0.730

Table 23: Chi-Square test for Female workers: Primary and Secondary MSD Diagnostics

Chi-Square Test for Association: Female Worker, Type of Diagnostic			
Rows: Type of worker	Columns: Type of Diagnostic		
	Primary Diagnostics female	Secondary Diagnostics female	All
Female Ag. Worker	480	281	761
	481.7	279.3	
Female Non-ag. worker	605	348	953
	603.3	349.7	
All	1085	629	1714
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	0.030	DF=1	P-value=0.861
Likelihood Ratio Chi-Square=	0.030	DF=1	P-value=0.861

Overall, there is no evidence to suggest that there is a significant difference between the total number of primary and secondary MSD diagnostics based on occupation or gender of the patients who received medical services at the OPD clinic.

4.1.2.4 Total number of MSD and Non-MSD diagnostics

Chi-Square Test was also used to determine if there exist any significant difference between the total number of MSD and Non-MSD diagnostics among agricultural workers and non-agricultural workers. Table 24 shows the total number of MSD and Non-MSD diagnostics for each worker group. In this analysis, the number of diagnostics includes primary and secondary diagnostics. A corrected α-value=0.005 will be used to reduce the family-wise error rate in the statistical tests. Results show that agricultural workers show a slightly higher percent of MSD diagnostics in comparison with non-agricultural workers.

Table 24: Proportion of diagnostics by type of condition and occupation

Type of patient	MSD (# of diagnostics)	Non-MSD (# of diagnostics)	% of MSD diagnostics
Agricultural worker	1,538	13,873	9.98%
Non-agricultural worker	1,289	13,274	8.85%

In fact, the Chi-Square Test (X^2=11.167, P-value=0.001) demonstrates that there is significant difference in the proportions between the groups (*Table 25*).

Table 25: Chi-Square Test for proportion of diagnostics and occupation

Chi-Square Test for Association: Occupation, Type of conditions			
Rows: Occupation	Columns: Worksheet columns		
	MSD	No-MSD	All
Agricultural Worker	1538	13873	15411
	1453	13958	
Non-agricultural worker	1289	13274	14563
	1374	13189	
All	2827	27147	29974
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	11.167	DF=1	P-value=0.001
Likelihood Ratio Chi-Square=	11.184	DF=1	P-value=0.001

A Two-sample proportions test (See Table 26) confirmed that in fact, the proportion of MSD diagnostics among agricultural workers (AW) is higher than non-agricultural workers (NAW).

Table 26: Two-sample proportion test for number of diagnostics among agricultural and non-agricultural workers

Two-Sample proportions test		
Null hypothesis	H_0: AW-NAW=0	
Alternative hypothesis	H_1: AW-NAW>0	
Method	Z-Value	P-value
Normal approximation	3.35	0.000
Fisher's exact		0.000

With respect to gender, male agricultural workers have a higher proportion of MSD diagnostics in comparison with non-agricultural workers (Table 27).

Table 27: Proportion of diagnostics by type of condition and occupation for males

Male Workers	**MSD (# of diagnostics)**	**Non-MSD (# of diagnostics)**	**% of MSD diagnostics**
Male agricultural worker	775	6,567	10.56%
Male non-agricultural worker	335	3,097	9.76%

However, the Chi-square test results (X^2=1.598, P-value=0.206) concluded that there is no significant difference among both groups (Table 28). Therefore, there is no evidence to conclude that there exists an association between the male gender and the number of MSD diagnostics.

Table 28: Chi-Square test for male workers and type of diagnostic

Chi-Square Test for Association: Occupation, Type of Condition			
Rows: Male worker	Columns: Type of Condition		
	MSD	Non-MSD	All
Male Agricultural Worker	775	6567	7342
	756.4	6585.6	
Male Non-agricultural worker	335	3097	3432
	353.6	3078.4	
All	1110	9664	10774
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	1.598	DF=1	P-value=0.206
Likelihood Ratio Chi-Square=	1.612	DF=1	P-value=0.204

The pattern among female workers is like that of male workers in which the percent of female agricultural workers that have been diagnosed with MSD conditions is higher than for female non-agricultural workers, as shown in Table 29. The Chi-square test (X^2=4.502, P-value=0.034), showed that as in male workers, there is no association between female gender and number of MSD diagnostics (Table 30).

Table 29: Proportion of diagnostics by type of condition and occupation for females

Female Workers	MSD (# of diagnostics)	Non-MSD (# of diagnostics)	% of MSD Diagnostics
Female agricultural worker	763	7,306	9.46%
Female non-agricultural worker	954	10,177	8.57%

Table 30: Chi-Square test for female workers and type of diagnostic

Chi-Square Test for Association: Occupation, Type of Condition			
Rows: Female worker	Columns: Type of Condition		
	MSD	Non-MSD	All
Female Agricultural Worker	763	7306	8069
	721.6	7347.4	
Female Non-agricultural worker	954	10177	11131
	995.4	10135.6	
All	1717	17483	19200
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	4.502	DF=1	P-value=0.034
Likelihood Ratio Chi-Square=	4.483	DF=1	P-value=0.034

On the other hand, when comparing male and female agricultural workers, a higher percent of male agricultural workers are diagnosed with MSD conditions (Table 31). However, a Chi-square test ($X2$=5.175, P-value=0.023) showed no relationship between gender and the number of MSD diagnostics among both groups (See *Table 32*)

Table 31: Proportion of diagnostics by type of condition for male and female agricultural workers

Agricultural Workers	MSD (# of diagnostics)	Non-MSD (# of diagnostics)	% of MSD Diagnostics
Male agricultural worker	775	6567	10.56%
Female agricultural worker	763	7306	9.46%

Table 32: Chi-square test for type of diagnostic among male and female agricultural workers

Chi-Square Test for Association: Occupation, Type of Condition			
Rows: Agricultural worker	Columns: Type of Condition		
	MSD	Non-MSD	All
Male Agricultural Worker	775	6567	7342
	732.7	6609.3	
Female Non-agricultural worker	763	7306	8069
	805.3	7263.7	
All	1538	13873	15411
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	5.175	DF=1	P-value=0.023
Likelihood Ratio Chi-Square=	5.170	DF=1	P-value=0.023

Some publications have found that the tasks performed by minorities in family-owned farms, such as women who do not considered themselves agricultural workers, are in fact directly related to agricultural work (Reed et al., 1999). Our data shows that agricultural workers show a higher percent of MSD (Table 33) when compared to dependents of agricultural workers. In this case, the Chi-square test (X^2=8.773, P-value=0.003) show significant statistical difference in the proportions of MSD diagnostics among these two groups (Table 34).

Table 33: Proportions of Agricultural workers and dependents of agricultural workers with MSD diagnostics

Type of patient	**MSD (# of diagnostics)**	**Non-MSD (# of diagnostics)**	**% of MSD Diagnostics**
Agricultural worker	1,538	13,873	9.98%
Dependent of agricultural worker	292	3,209	8.34%

Table 34: Chi-square test for dependent of agricultural workers and agricultural workers

Chi-Square Test for Association: Occupation, Type of Condition			
Rows: Occupation	Columns: Type of Condition		
	MSD	Non-MSD	All
Agricultural Worker	1538	13873	15411
	1491	13920	
Dependent of agricultural worker	292	3209	3501
	339	3162	
All	1830	17082	18912
Cell Contents:	Count		
	Expected count		
Pearson Chi-Square=	8.773	DF=1	P-value=0.003
Likelihood Ratio Chi-Square=	9.074	DF=1	P-value=0.003

The Two-sample proportion test confirmed that the proportion of MSD diagnostics among agricultural workers (AW) is higher than among dependents of agricultural workers (DAW) (See Table 35).

Table 35: Two-sample proportion test for number of diagnostics among agricultural workers and dependents of agricultural workers

Two-Sample proportions test		
Null hypothesis	H_0: AW-DAW=0	
Alternative hypothesis	H_1: AW-DAW>0	
Method	Z-Value	P-value
Normal approximation	3.12	0.001
Fisher's exact		0.001

4.1.2.5 Median number of MSD diagnostic per worker

Considering both primary and secondary MSD diagnostics, in this section the median number of MSD diagnostics per agricultural and non-agricultural workers will be compared. As

shown in Figure 4, agricultural workers tend to have a higher median number of MSD diagnostics (2.25 diagnostics) when compared with non-agricultural workers (1.94 diagnostics).

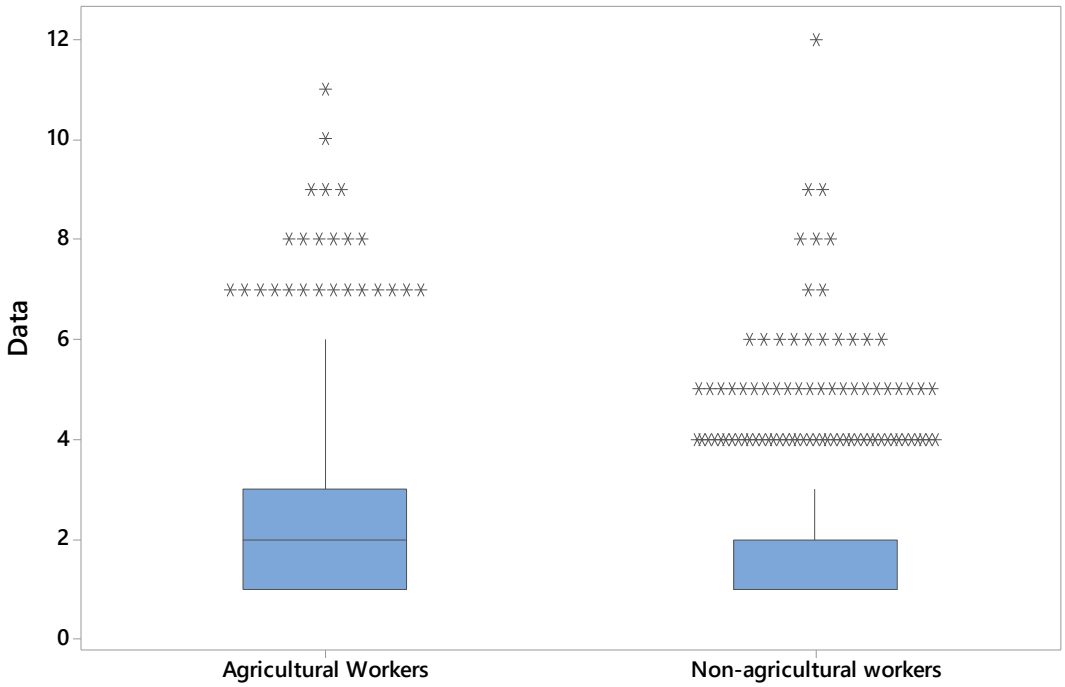


Figure 4: Median number of diagnostics per type of worker

A Kruskal-Wallis Test was used to compare the difference of the median and it was found that in fact, agricultural workers have a statistically significant higher median number of MSD diagnostics when compared with non-agricultural workers (H=8.22, p=0.004) (Table 36).

Table 36: Kruskal-Wallis Test for median number of diagnostics per occupation

Kruskal-Wallis Test: Total Diagnostics vs Workers difference				
Workers Difference	N	Median	Ave Rank	Z
Agricultural worker	684	2.000	703.4	2.87
Non-agricultural worker	662	1.000	642.6	-2.87
Overall	1346		673.5	
H=8.22	DF=1	P=0.004		
H=9.51	DF=1	P=0.002 (adjusted for ties)		

The same behavior was found for male workers, in which agricultural workers had a higher median number of MSD diagnostics than male non-agricultural workers. As shown in Figure 5, the mean number of MSD diagnostics of male agricultural workers was 2.13, while for male non-agricultural workers the median was 1.85. However, with a P-value=0.041 in the Kruskal-Wallis test (H=4.18) and compared with the Bonferroni correction P-value=0.005, there is no statistically significant difference in the median number of MSD diagnostics among both groups. It cannot be concluded that male agricultural workers have a higher median of MSD conditions than male non-agricultural workers (Table 37).

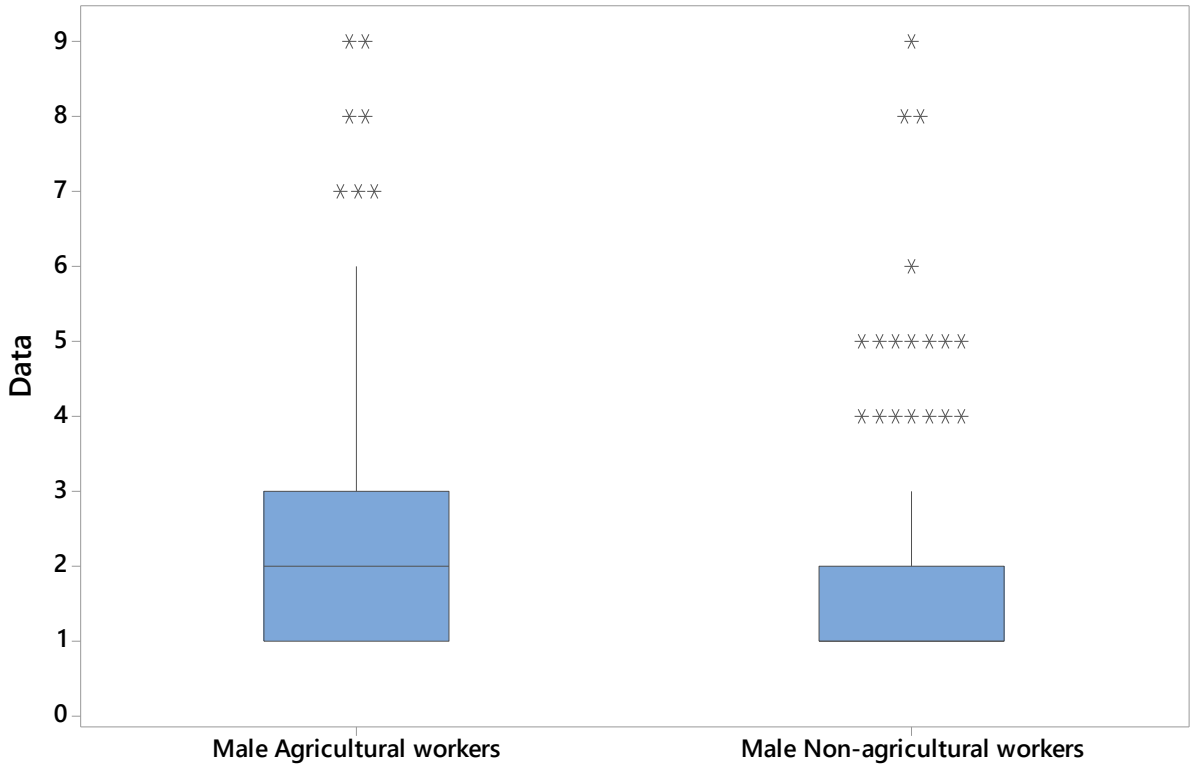


Figure 5: Male median number of MSD diagnostics by work group

Table 37: Kruskal-Wallis Test for median number of diagnostics per type of male worker

Kruskal-Wallis Test: Total diagnostics Male vs Male worker				
Workers Difference	N	Median	Ave Rank	Z
Agricultural worker	363	2.000	282.2	2.04
Non-agricultural worker	181	1.000	253.0	-2.04
Overall	544		272.5	
H=4.18	DF=1	P=0.041		
H=4.89	DF=1	P=0.027 (adjusted for ties)		

The interval plot for female workers also suggested that female agricultural workers have a higher median number of MSD diagnostics (2.38 MSD diagnostics) when compared with female non-agricultural workers (1.98 MSD diagnostics).

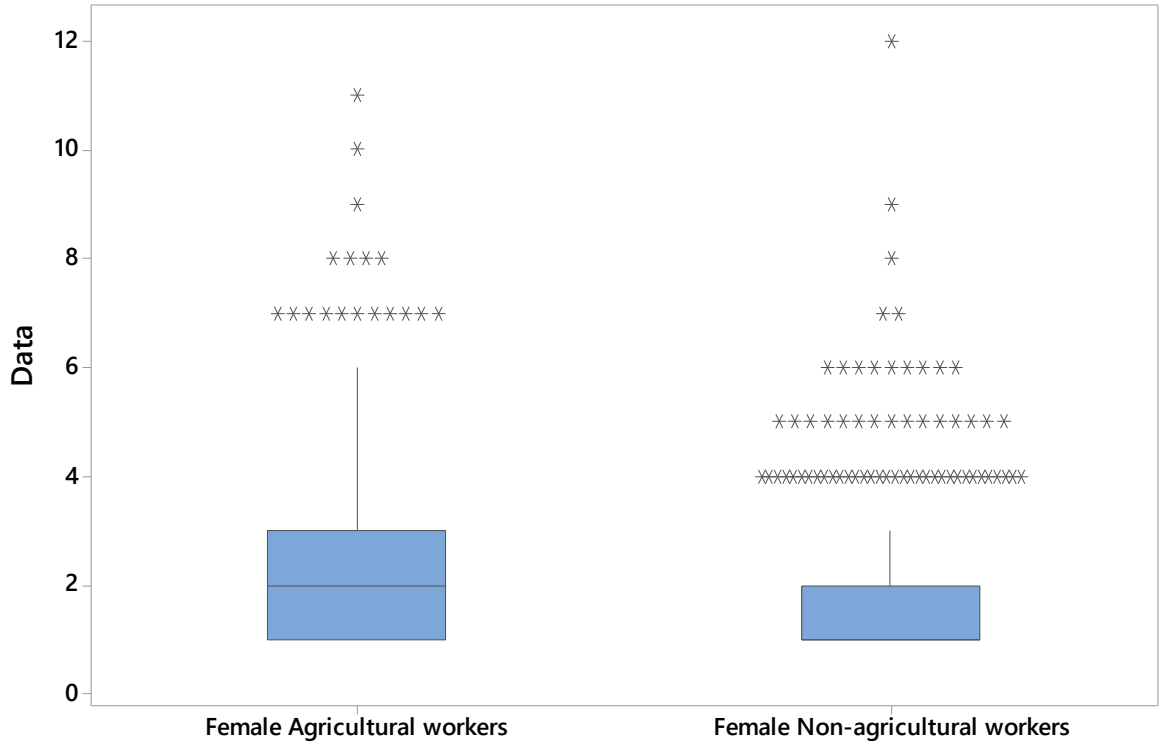


Figure 6: Female median number of MSD diagnostics by work group

The Kruskal-Wallis test (H=6.31, P=0.012) concluded that there is no evidence that female agricultural workers have a higher median number of MSD diagnostics when compared with female non-agricultural workers (See Table 38).

Table 38: Kruskal-Wallis Test for median number of diagnostics per type of female worker

Kruskal-Wallis Test: Total Diagnostics females vs Female worker				
Workers Difference	N	Median	Ave Rank	Z
Agricultural worker	321	2.000	426.7	2.51
Non-agricultural worker	481	1.000	384.7	-2.51
Overall	802		401.55	
H=6.31	DF=1	P=0.012		
H=7.26	DF=1	P=0.007 (adjusted for ties)		

4.1.3 Phase II: Musculoskeletal Discomforts, Health, and Safety Practices Questionnaire

4.1.3.1 Demographics of the sample

The first part of the Questionnaire gathered demographic information of the convenience sample of 100 participants. Table 39 shows a summary of the demographic characteristics for the agricultural worker sample.

Table 39: Demographic Characteristics of the sample (Average and Standard Deviation (SD))

	Male	**Female**
Sex	95%	5%
Average Age (years) (SD)	39.30 (12.61)	50.60 (7.02)
Average Height (cm) (SD)	171.30 (8.23)	157.28 (3.96)
Average Weight (kg) (SD)	81.76 (15.45)	80.29 (13.01)
Average years in agriculture (SD)	12.94 (10.15)	14 (3.32)
Average hours/day at work (SD)	7.43 (1.32)	8 (0)
Average days/week at work (SD)	5.22 (0.49)	4.6 (0.89)

The majority of the sample was comprised of men (95%), while 5% were women. This same phenomenon is also found through literature in which women are presented as a minority group among agricultural workers (Frank et al., 2004; McCoy, Carruth, & Reed, 2001). Other publications stated that the labor of women among farms, especially those that are family-owned, is not normally considered as farm work, although they support the direct labors of the farm (Reed et al., 1999; Singh & Vinay, 2013). However, another study reported a sample of 66% women working in coffee harvesting (Navarro et al., 2008).

As mentioned before, participants were selected among farms in which the process to harvest their main products was similar. The distribution of participants among the different crops is shown in Table 40.

Table 40: Distribution of participants per type of crop

Crops	# of Participants
Coffee	6
Plantain	15
Fruit Trees	19
Mango	21
Banana	39

Height and weight of the participants was used to determine their Body Mass Index (BMI). Overall, 71% of the sample was considered to be obese or overweight, as shown in Table 41 and Figure 7, 26% of the sample had a Normal/Heavy Weight BMI, 30% were considered obese, 41% overweight, and 1% underweight (2% of the data was not available).

Table 41: Weight status of participants according to BMI

Weight Status	# of Participants
Not Available	2
Underweight	1
Normal/Heavy weight	26
Overweight	41
Obese	30

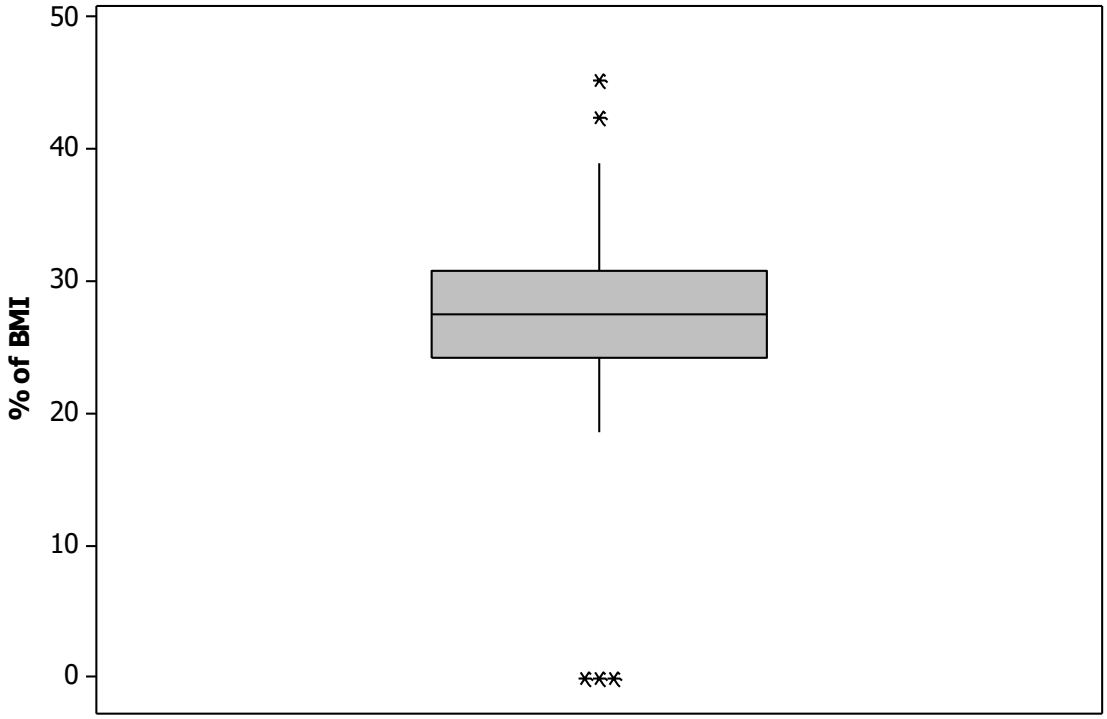


Figure 7: Boxplot for % of BMI for the questionnaire participants

The average years in agriculture for the participants of the study was 13 and 14 years for male and female participants, respectively. Although during the visits to the farms, the majority of farm workers shared that they worked around 5 hours a day in their principal job, most of them also worked in agriculture at home or at other farms, working a total of 8 hours/day. The average farm worker spent mostly 5 days/week working in agriculture related activities.

With respect to level of schooling, as shown in Figure 8, 33% of participants did not complete high school, while 48% participants completed high school. In review, 81 of the participants hadn't completed advanced studies, while the other 19 either completed a technical or bachelors degree.

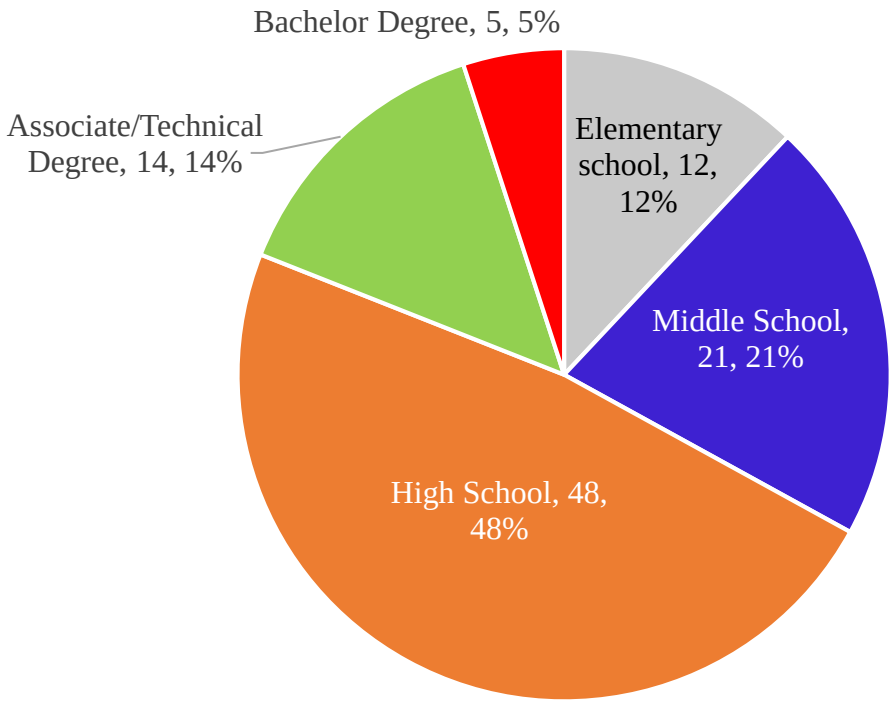


Figure 8: Level of Schooling among participants

Low levels of literacy have been mentioned in literature as a safety issue because the workers are at risk of performing tasks without the required information or understanding to avoid injuries or diseases (Kar & Dhara, 2007). In conversations with some of the farm administrators, it was noted that although some of the participants mentioned that they had a high school diploma, some of them did not even know how to read or write. It was also found that some of the participants attended Special Education Program while in school. Although no specialized skills are required for farm workers, low literacy levels of this population highlights the risk of missinformation related to musculoskeletal disorders and other injuries related to their job. Also, low socioeconomic status can be related to health and nutrition problems among farm workers (Kar & Dhara, 2007).

4.1.3.2 Nordic Modified Questionnaire Descriptive Statistics

A summary of the number of participants that reported pain in the different parts of the body is presented in Table 42, along with the percent of participants who received some type of treatment to relieve the pain. For the period of 12 months (Table 42), lower back area was the most reported pain among farm workers with 66 participants, followed by the shoulders with 51, and hands/wrists in the third position with 43 participants. In the period corresponding to the last 7 days, lower back was also the top offender with 58 participants, followed by hands/wrists with 38, and shoulders with 32 participants. In the same way, 74% of participants who reported lower back pain, as well as 56% of participants who reported pain in the hands/wrists received some type of treatment to relieve the pain. In the following sections, the descriptive statistics of the data obtained from the different parts of the body is presented in more detail.

During the interviews, it was noted that some of the participants chosed a combination of medical and home treatment and this was tabulated separately. Various participants reported not having time or a health insurance plan to cover the costs related to receive proper medical treatment for their pain or discomfort. Also, some participants shared that pain was part of the job and for that reason many of them kept working while ignoring the pain. The perception of pain or risk as part of the daily job was also reported in a study performed among migrant farm workers from North Carolina in which 94.9% of the participants reported that risks were part of the job in the farms (Arcury et al., 2012). In other publications it has been reported as well that the perception of working with pain in the farms was part of the job because of economic related issues or cultural beliefs (Estill et al., 2002). Participants were also asked if the pain, if any, affected their daily tasks in the farm such as leaving early from work, missing out a day or avoiding certain tasks because of pain.

Table 42: Number of participants reporting discomforts by body area and period (n=100)

Body Area	Period		% who received treatment
	12 months	7 days	
Lower Back	66	58	74
Shoulders	51	32	35
Hands/wrists	43	38	56
Upper Back	39	26	54
Knees	38	27	42
Neck	36	24	42
Ankles	26	20	42
Hips	20	17	40
Elbows	15	15	33

4.1.3.2.1 Neck

From the 100 participants, 36 reported to have suffered from some type of neck pain in the last 12 months while 24 reported it for the period of 7 days (Table 42).

Figure 9 shows a histogram of the level of pain reported by the participants of the study. The histogram confirms that most of the participants did not report pain in the neck area for any of the periods. The average level of pain for those who reported neck pain during the last 12 months was 4.22 (SD=2.43), described as "Moderate discomfort in the area". Furthermore, 24 participants reported to have an average level of pain of 5.16 (SD=2.94) in the period of 7 days, which can be considered a "Moderate pain in the area".

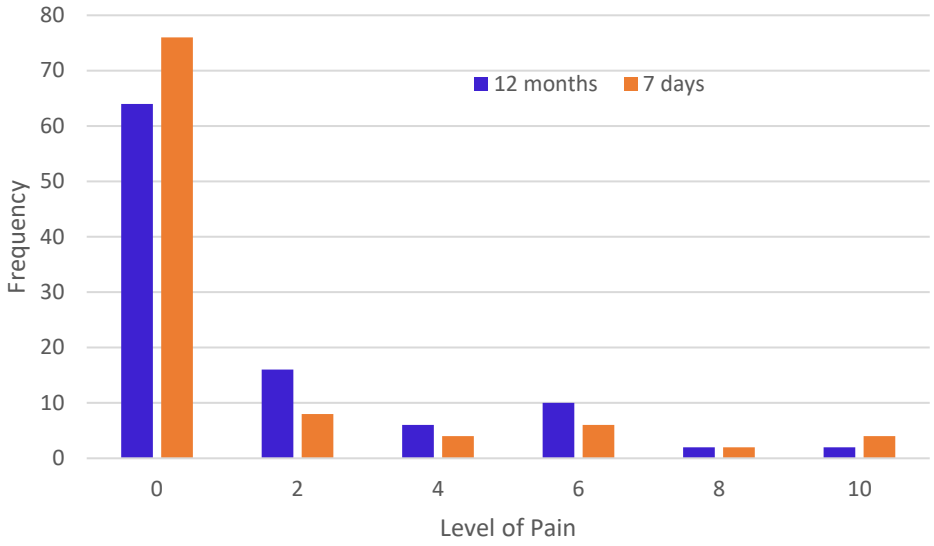


Figure 9: Histogram of participants' reported level of pain in the neck

For neck pain (See Table 42), 42% of the participants that reported pain in the neck area received some type of treatment to relieve the pain (Figure 10). Thirty-three percent only received home treatment while the rest 67% of the participants received proper medical treatment or a combination with home treatment. Although 36 participants reported pain during the last 12 months and 24 reported pain for the last 7 days, only 15 participants received some type of treatment to relieve the pain in the neck and 25% of them reported that it had affected their daily job.

The results of neck pain reported for the last 12 months was considerably higher than the findings of Walker-Bone et al. in which 4% of the participants reported pain in the neck in the last 12 months (Walker-Bone & Palmer, 2002) (See Table 43). Although the publication from Walker-Bone et al. (2002) does not specify the type of crops that the participants of that study normally worked, neck extension and flexion for long periods of time has been associated to musculoskeletal disorders (Davis & Kotowski, 2007). In general, most of the tasks performed by all farm workers require these types of movements. Faucett et al. (2001) carried out a study of

213 California workers, were 10% reported pain in the neck and shoulder, in contrast with 36% and 24% for periods of 12 month and 7 days respectively of our study. Of a sample of 143 participants that worked in oil palm plantations, 32.2% reported to have suffered pain in the neck in a period of 12 months, similar result to our study (Ng, Tamrin, Yik, Yusoff, & Mori, 2014). On the other hand, 11.2% of these oil palm plantation workers reported pain in the neck in the past 7 days; which is less than half of the results of our study. However, the level of pain registered by the participants of the study performed by Faucett et al. is like the one reported by our sample. The average level of pain reported by farm workers of Puerto Rico was 4.22 (SD=2.43), this can be considered Level 4 or "Moderate discomfort in the area", as described in Table 1. Sixteen percent of the participants reported a Level 4 pain while 14% of farm workers of California reported a level of pain described as "aching" which is a discomfort in the area.

Table 43: Publications related to neck pain among agricultural workers

Author	Sample size	% who reported pain	Period of pain
(Walker-Bone & Palmer, 2002)	N/A	4	12 months
(Faucett et al., 2001)	213	10	12 months
(Ng et al., 2014)	143	32	12 months
(Ng et al., 2014)	143	11.2	7 days
(Faucett et al., 2001)	213	14	7 days

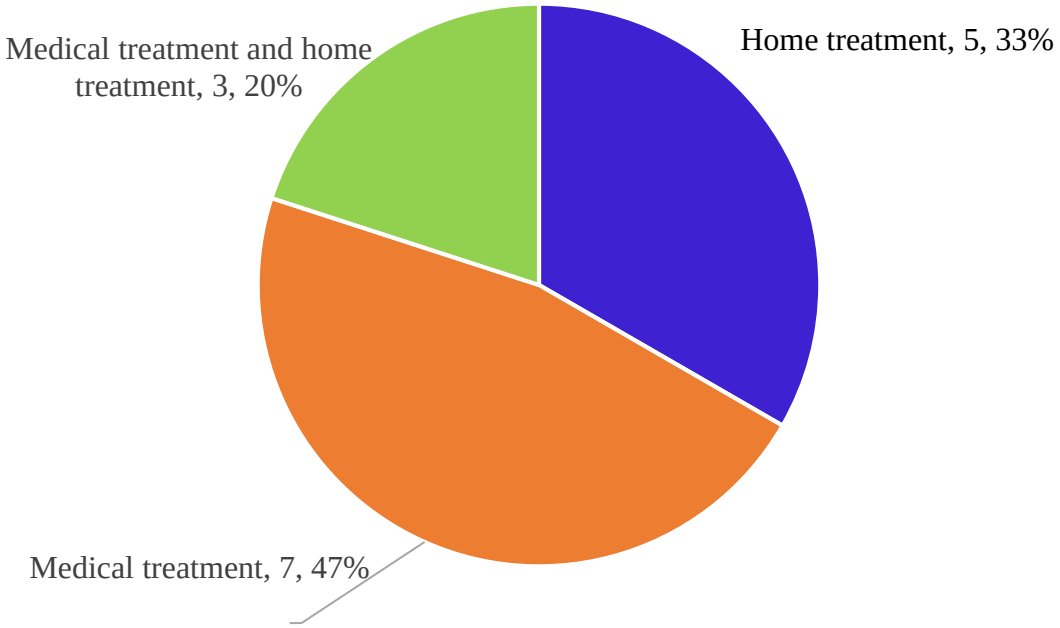


Figure 10: Type of medical treatment for neck's pain

4.1.3.2.2 Shoulders

In the last 12 months, participants reported a moderate discomfort in the area (mean=4.74, SD=2.33). According to Table 42, 51 participants reported to have suffered from neck pain during the last 12 months. Of the 100 participants, 32 reported shoulders pain during the last 7 days with an average level of pain of 4.63 (SD=2.61) which is also considered a moderate discomfort in the area.

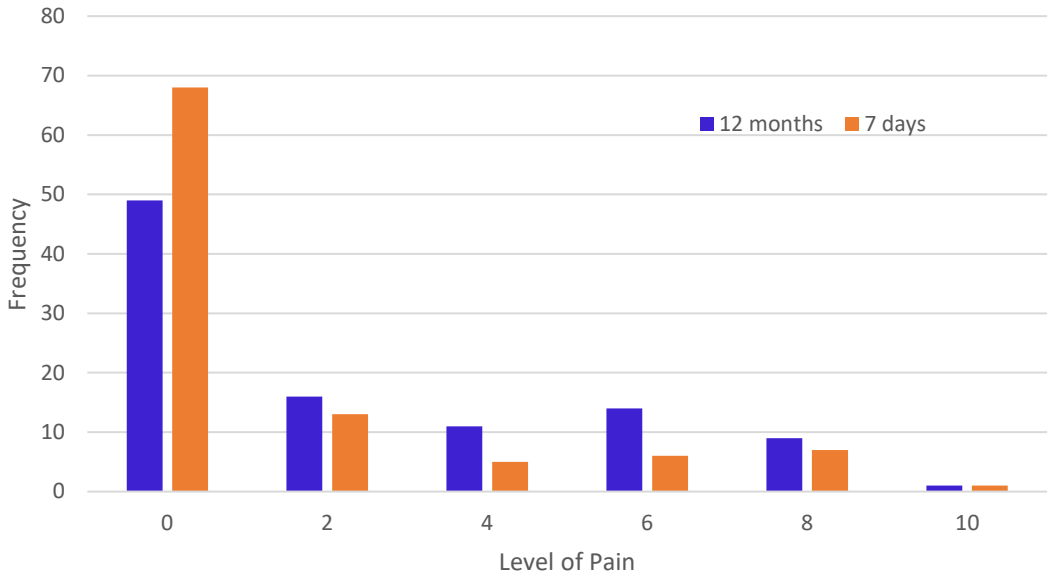


Figure 11: Histogram of participants' reported level of pain in the shoulders

As per Figure 12, 35% of the participants that reported pain in the shoulders received some type of treatment. Of the 51 participants who reported pain in the period of 12 months, 22 reported that their daily job was affected because of pain in the shoulders.

In a study performed in Brazil among 44 farm workers involved in coffee harvesting, 70% reported to have suffered pain in the shoulders in the last 12 months (Navarro et al., 2008). The number of participants that reported shoulder pain in Puerto Rico for the last 12 months was 51. However, Faucett et al. (2001) reported that 10% of the 213 participants suffered pain in the neck/shoulders in the past 12 months. The results of Faucett et al. (2001) are like the ones from Walker-Bone & Palmer, (2002) in which 11.8% of the 122 participants reported to have suffered pain in the shoulders. Pain in the shoulders for the last 12 months was third (tied with neck pain in the same period) among farm workers of oil palm plantations with 32.2% reporting it, a percentage slightly lower than our study. However, a significant difference was found in the period of 7 days in which our study reported 32% of participants with pain in the shoulders, while Ng et al. (2014) reported only 9.8%. In the case of Irish farmers, 25% of participants of

600 participants reported to have suffered pain in the neck/shoulders area (Osborne et al., 2010). As can be seen through literature, the number of farm workers that reported suffering pain in the shoulders varies among the different studies, however, our participants are among the most affected by pain in this area.

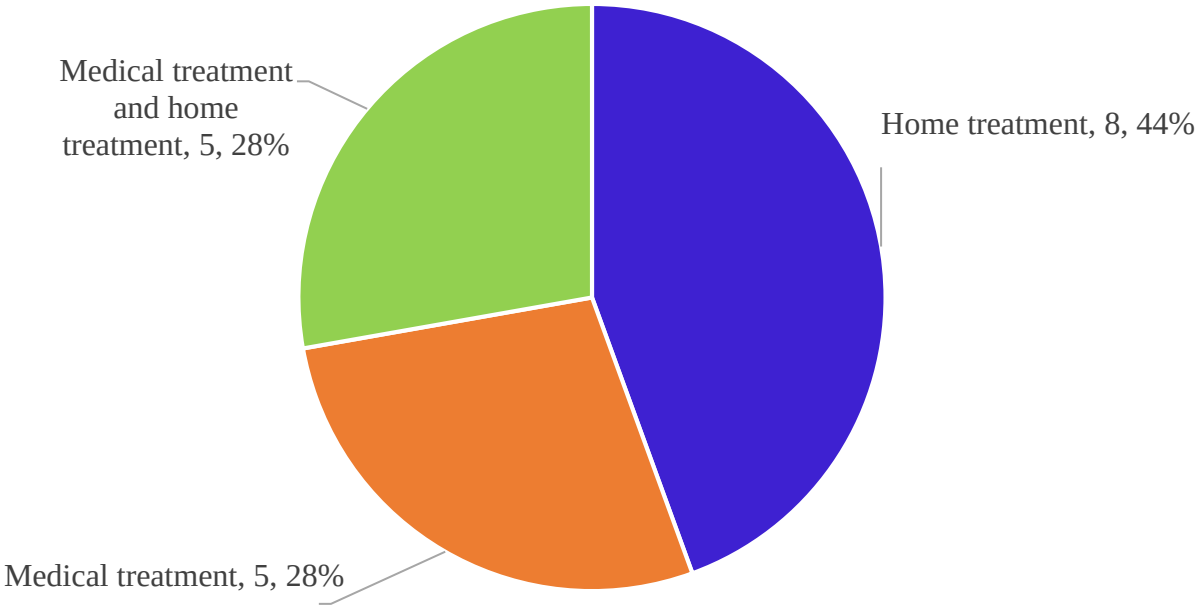


Figure 12: Type of medical treatment for shoulder's pain

4.1.3.2.3 Upper Back

A total of 39 participants reported suffering pain in the upper back during the last 12 months (See Table 42) reporting a moderate pain in the area with an average of 5.54 (SD=2.92). Of the 100 participants, only 26 reported to have suffered upper back pain during the last 7 days. The average level of pain for this period was 5.77 (SD=2.90) which according to *Table* 1, is also considered as moderate pain in the area.

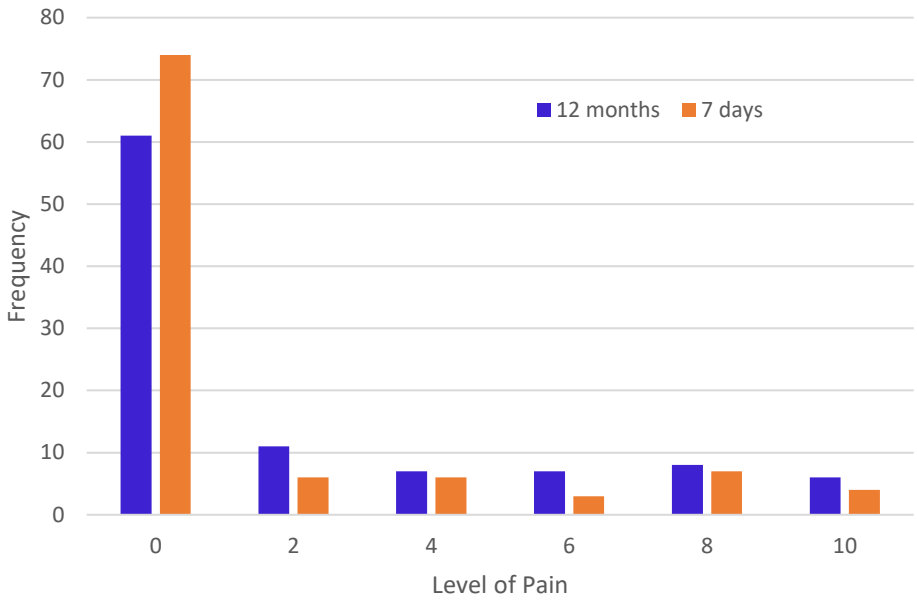


Figure 13: Histogram of participants' reported level of pain in the upper back area

For those who reported pain in the upper back area (39), 54% received some type of medical treatment. According to Figure 14, 81% of those who received some type of treatment for pain in the upper back area visited a medical provider, and 56% of the participants that suffered pain in the upper back area reported that their job had been affected because of this discomfort.

In our study, 39% of the participants reported some type of pain in the upper back area in the past 12 months, a higher percentage in comparison with previous publications (see Table 44). For the 7 days period, 26% of our participants reported to have suffered upper back pain in comparison with 15.7% and 9.8% of Palmer (1996) and Ng et al. (2014) (See Table 44). Davis & Kotowski (2007) reported that there is not much information related to upper back pain among farm workers but confirmed that pain in this area is very common among this group with around 25% of the population reporting it. A higher percentage of Puerto Rico's farm workers reported

to have suffered from upper back pain in comparison with other studies for farm workers in the literature.

Table 44: Publications related to upper back pain among agricultural workers

Author	Sample size	% who reported pain	Period of pain
(Huiyun Xiang et al., 1999)	742	26.1	12 months
(Palmer, 1996)	108	28.7	12 months
(Ng et al., 2014)	143	28	12 months
(Tonelli, Culp, & Donham, 2014)	N/A	16.7	12 months
(Palmer, 1996)	108	15.7	7 days
(Ng et al., 2014)	143	9.8	7 days

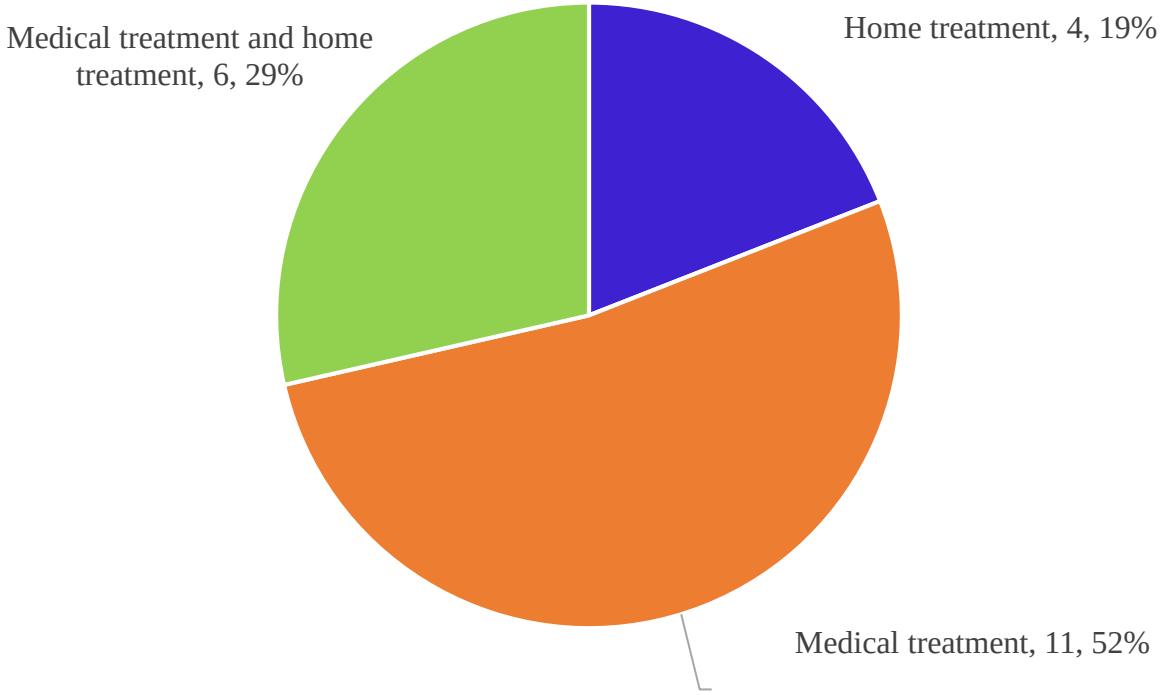


Figure 14: Type of treatment for upper back's pain

4.1.3.2.4 Lower Back

Lower back pain had the highest number of participants reporting it. For the past 12 months, 66 participants reported suffering low back pain with an average pain of 6.39 (SD=2.79) (Table 42). For those who reported pain in the lower back during the last 7 days (58

participants), the average level of pain was 6.72 (SD=2.53). For both periods of time, participants reported a moderate pain in the lower back.

Lower back pain in both periods of time was the most common pain registered among participants of this study. It also had the highest average level of pain reported among the different areas of the body. Figure 15 shows that the frequency for higher level of pain increased among participants.

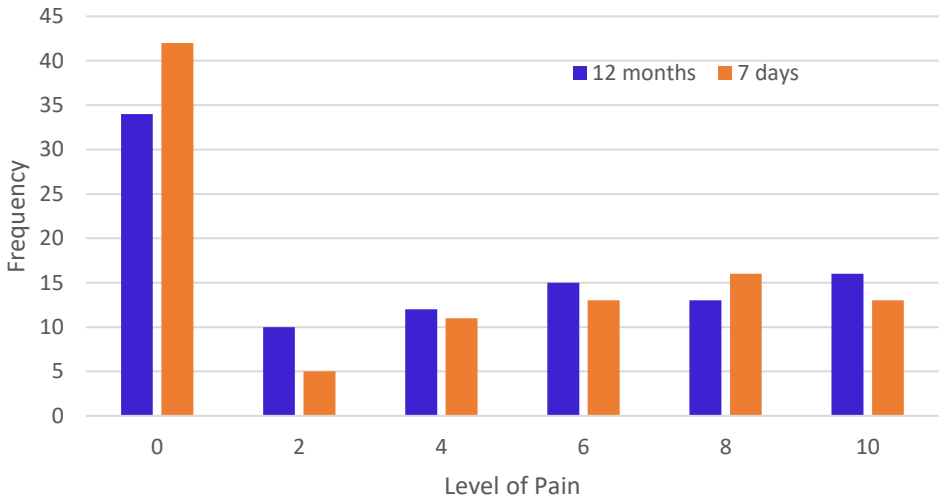


Figure 15: Histogram of participants' reported level of pain in the lower back area

Of the participants who reported suffering pain in the lower back area, 74% received some type of pain relieving treatment. This finding is the highest among all the areas of the body in this study. Around 33% of those who reported receiving treatment visited some hospital or medical personnel for the issue, being the highest percent of participants seeking medical help for pain in a specific body area. It is also important to mention that 59% of the participants suffering lower back pain reported that it had affected their daily work.

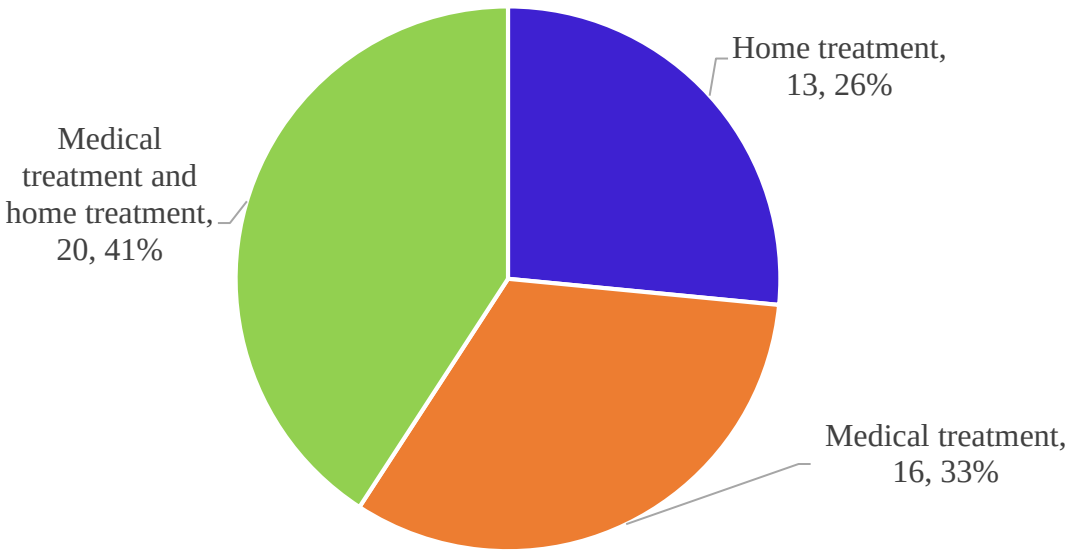


Figure 16: Type of treatment for lower back's pain

A total of 66% of participants reported to have suffered lower back pain in the last 12 months. This was the most common pain among participants in the given time lapse of this study. A similar result was found in a study performed among 122 farm workers in which 48% of them reported to have suffered lower back pain, the most common among the participants (Walker-Bone & Palmer, 2002). As cited in Walker-Bone & Palmer (2002), a study performed among farm workers in California concluded that 37% reported that lower back pain affected their daily work in the farm. In our study, 59% of the participants reported that their work was affected because of pain in this area. Another study published that 18% (n=742) of the participants reported to have suffered lower back pain (Huiyun Xiang et al., 1999). Although there is a considerable difference in the percent of participants who suffered pain in this area, lower back was the most affected part of the back for these participants. In a study performed among workers of oil palm plantation, 58% (n=143) reported to have suffered lower back pain in the last 12 months, being also the most common affected body part among the participants (Ng et

al., 2014). However, our study found that 58% of the participants had suffered lower back pain in the last 7 days while Ng et al. (2014) reported that 24.5% of their participants suffered pain in this area during the same period. As in this study, lower back pain during the last 7 days was the most common pain in the area among oil palm plantation workers, as reported by Ng et al. (2014).

4.1.3.2.5 Elbows

The average level of pain for the periods of 12 months and 7 days was 4.13 (SD=2.97) and 3.87 (SD=2.56), respectively. In Table 42, 15 participants reported to have suffered pain in the elbows in both periods of time. In Figure 17 it can be observed that most participants reported no pain in the elbows, and of those who reported pain in the elbows for both periods, the majority reported to be Level 2 which is considered "Light Discomfort in the Area" as described in Table 1.

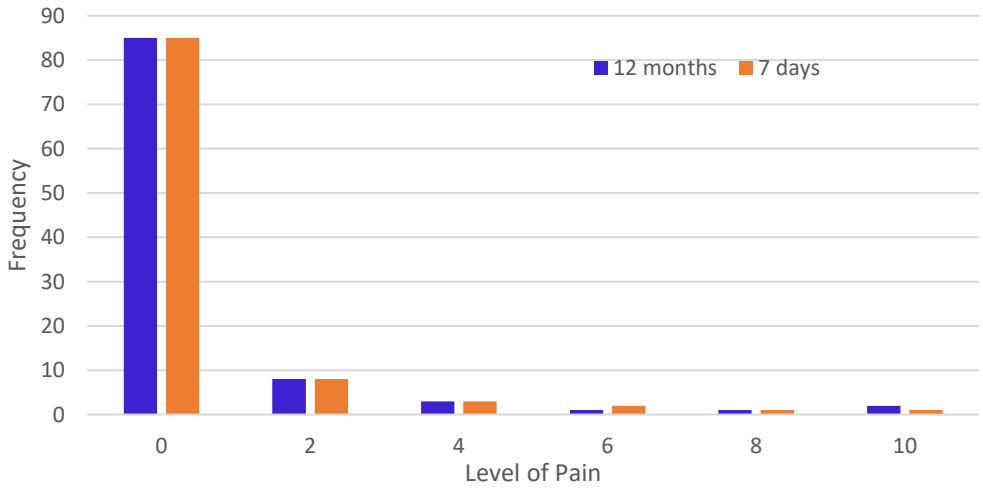


Figure 17: Histogram of participant's reported level of pain in the elbows

From the 15 participants who reported suffering pain in the elbows in both periods of time, 33% reported to have received some type of treatment (See Figure 18) and from that group 60% received home treatment while 40% received a combination of home and medical treatment. Of those who suffered pain in the elbows, 27% reported that pain in the elbows did affect their daily job.

In the last 12 months, only 15 participants reported to have suffered some type of pain in the elbows with an average level of pain of 4.13. Rosecrance et al. (2006) (as cited in (Tonelli et al., 2014)), reported that 5.8% of Kansas farm workers suffered from pain in the elbows in the past 12 months, lower prevalence than our study. This result is very similar to one performed among farm workers of the tomato industry in which 6.5% of the participants (n=108) reported pain in the elbows in the last 12 months but in the period of 7 days, only 0.9% of the participants reported pain (Palmer, 1996). In another study among 122 farm workers, also 0.9% of the participants reported pain in the elbows (Walker-Bone & Palmer, 2002). However, in a study performed among oil palm plantations workers, 20.3% of the participants (n=143) reported to have suffered pain in the elbows, similar to our result (Ng et al., 2014). On the other hand, only 6.3% of oil palm plantation workers reported to have suffered pain in the last 7 days.

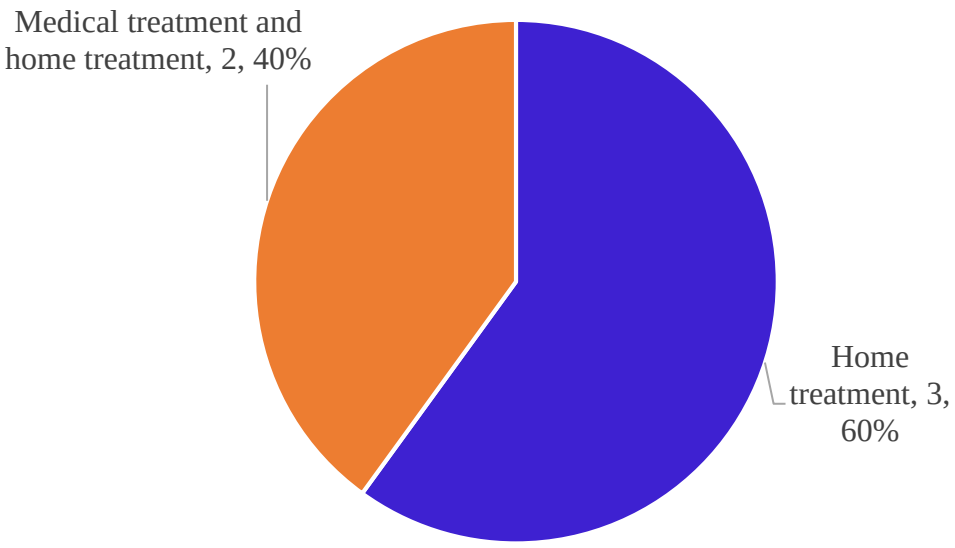


Figure 18: Type of treatment for elbow's pain

4.1.3.2.6 Knees

Thirty-eight participants reported suffering pain in the knees during the last 12 months as can be seen in Table 42. The average level of pain for this group was 4.68 (SD=2.80) which is a moderate discomfort in the area. On the other hand, 27 participants reported pain in the knees during the last 7 days with an average of 5.41 (SD=2.87) which is a moderate pain in the area.

The histogram of the data in Figure 19, showed that most of the participants reported no pain in the knees.

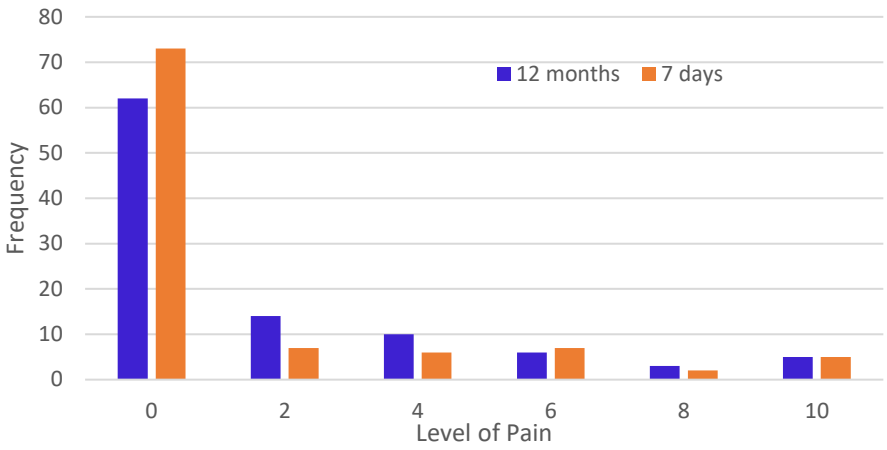


Figure 19: Histogram of participant's reported level of pain in the knees

Around 42% of the participants who reported pain in the knees received some type of treatment to relieve the pain, and half of the participants that received treatment, reported to have received a combination of medical and home treatment. Only 13% of the participants that suffered pain reported that their daily job had been affected because of pain in the knees.

Unlike our study, were 38% of the participants reported pain in the knees in the past 12 months, Palmer (1996) reported that 18.2% of workers in the tomato industry suffered pain in the knees during the same period. The same occurred for 7 days in which 27% of our participants suffered pain in the knees, while Palmer reported that 6.5% of his participants reported pain in the same area. However, in a study among oil palm plantation workers, pain in the knee was the second most common pain among this group with 45.5% of the participants (n=143) reporting it (Ng et al., 2014). The same was true for the period of 7 days among oil palm plantation workers in which 14% of the participants reported to have suffered pain in the knees, almost half than our study.

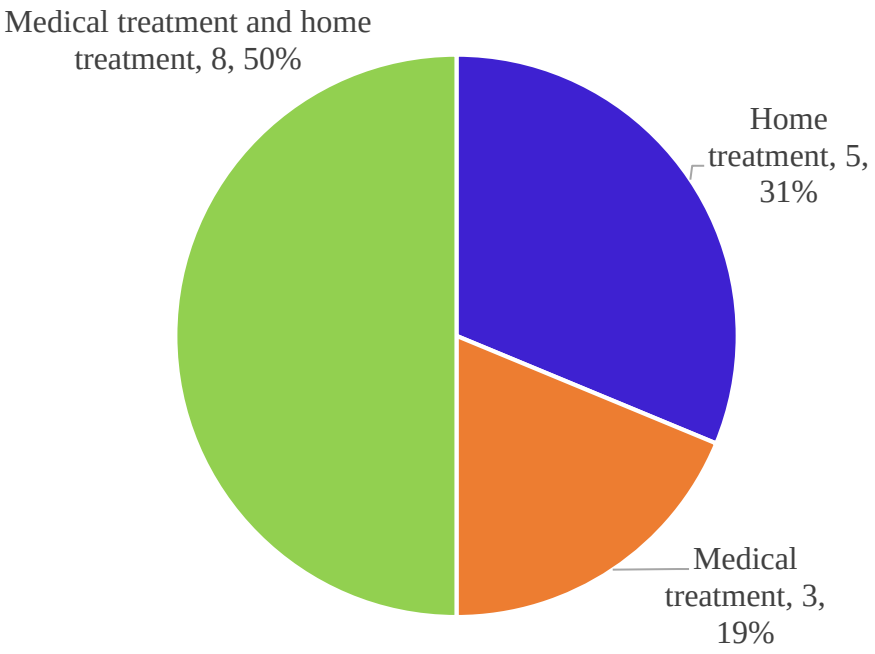


Figure 20: Type of treatment for knee's pain

4.1.3.2.7 Hips

For the hips area (Table 42), 20 participants reported having suffered pain in the hip during the last 12 months while 17 participants reported pain during the last 7 days. The average level of pain for 12 months and 7 days was 5.40 (SD=3.19) and 6.00 (SD=3.22), respectively. As per Table 1, this is a moderate pain.

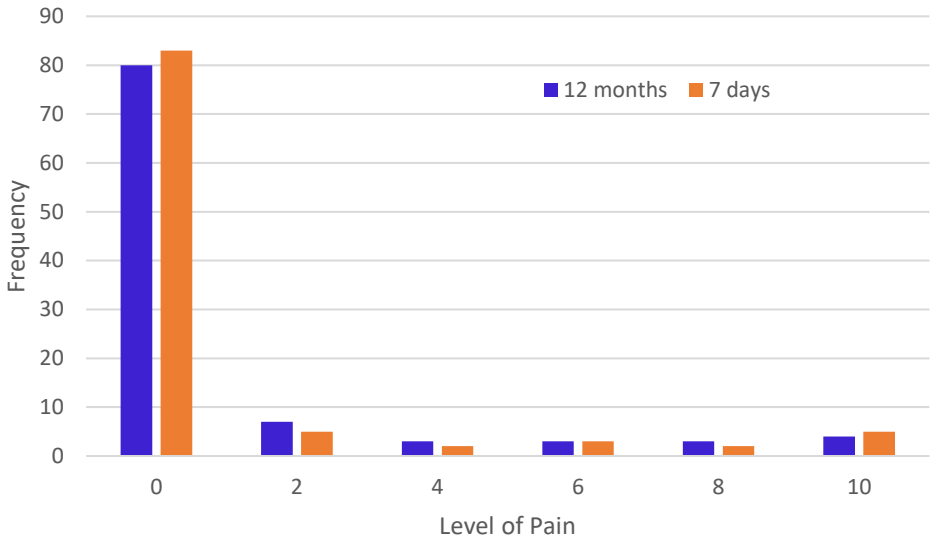


Figure 21: Histogram for participants 'reported level of pain in the hips

According to Figure 21, most of the participants reported no pain in the hips during both periods. The second most reported level of pain was 2, with 7 and 5 participants in the periods of 12 months and 7 days, respectively.

For those that reported pain, 40% received treatment for hip's pain. Thirty percent of the participants with pain reported that their daily job was affected by pain in the hips. Another study found that hip pain was common among farm workers because of the tasks that required them to be stoop or bend for long periods of time (Xiao, 2011). While Palmer (1996) reported that 14.8% of the participants suffered from hip pain in the past 12 months, only 5.6% reported it in a period of 7 days. The number of participants that reported pain in the hip in the last 7 days for our study was considerably higher than that of Palmer (1996) with 17% of the participants. However, in other studies, participants did not report any type of pain in the area of the hips (Gangopadhyay et al., 2008). As cited by Tonelli et al. (2014), 10.4% of Kansas farmers reported pain in the hip/thighs. This result is similar to one performed with Irish farmers (n=585) in which 8% of the participants reported to have suffered pain in this area (Osborne et

al., 2010). Fifteen percent of farmers in the United States suffered from hip pain (Davis & Kotowski, 2007). They also mentioned that hip pain was associated with heavy lifting and movements associated to farming tasks.

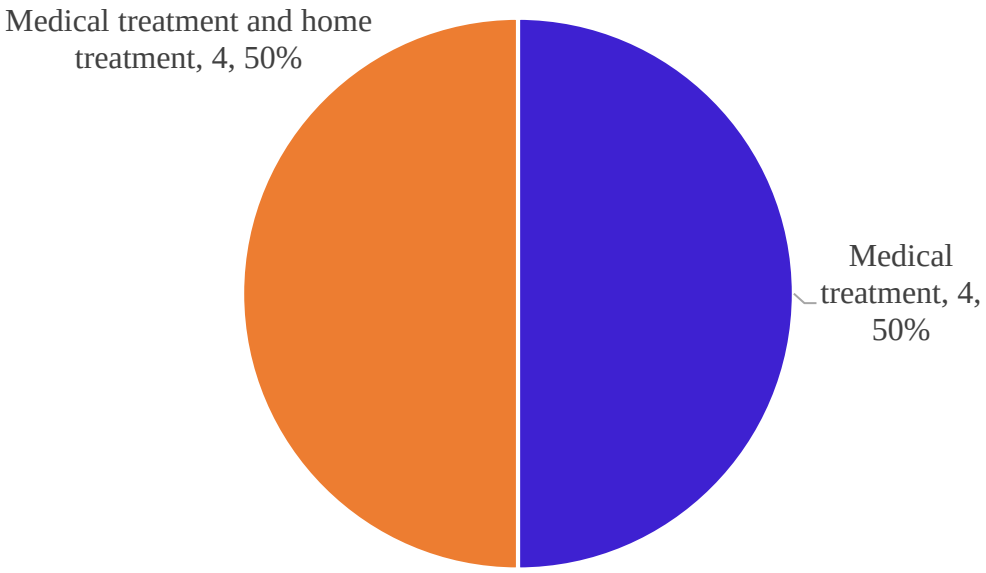


Figure 22:Type of treatment for hip's pain

4.1.3.2.8 Hands/Wrists

Pain in the hands/wrists in the last 12 months was reported by 43 participants and by 38 participants for the period of 7 days (See Table 42). The average level of pain for the 12 months' periods was of 4.65 (SD=2.38) and for the 7 days' period was 4.58 (SD=2.18) which is a moderate discomfort in the area.

More than half of the participants reported not suffering pain in this area during any of the periods (Figure 23). For both periods of time, Level 2 was the most reported among participants. No participant reported a Level 10 pain in the period of 7 days.

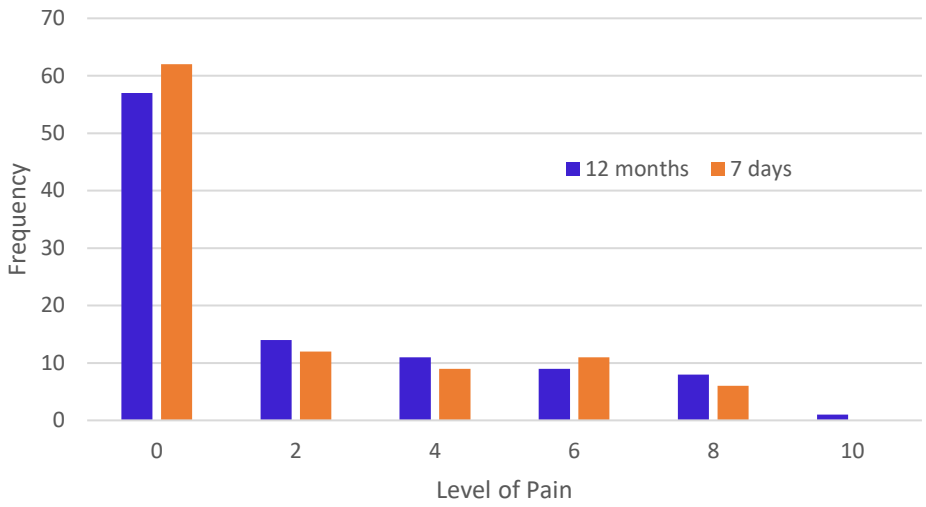


Figure 23: Histogram for participants' reported level of pain in the Hands/Wrists

Of the 43 participants that suffered pain, 56% of the participants reported to have received some type of treatment for pain in the hands/wrists. Most of them (46%), received only home treatment to deal with the pain, and thirty percent of the participants with pain had seen their daily jobs affected because of pain in the hands/wrists.

Gangopadhyay et al. (2008) reported pain in the hands and wrists as separated areas, different to our study in which both body parts were considered together. However, it can be noted that 50% of the participants (n=46) reported suffering pain in the wrists while 41% reported pain in the hands, slightly higher in comparison to our research in which 43 participants reported pain in the last 12 months and 38 in the past 7 days. Moreover, Ng et al. (2014) reported that 26.6% of the participants suffered pain in the past 12 months and 6.3% in the last 7 days. These results are considerably lower than ours and those reported by Gangopadhyay et al (2008). Davis & Kotowski (2007) cited that 28% of farmers (n=1700) in the United States suffered pain in the hands/wrists. Some of the tasks related to pain in the hands/wrists as

mentioned by Davis & Kotowski (2007) are repetitive movements and pinch forces, all related to the different tasks performed by the farm workers in our study.

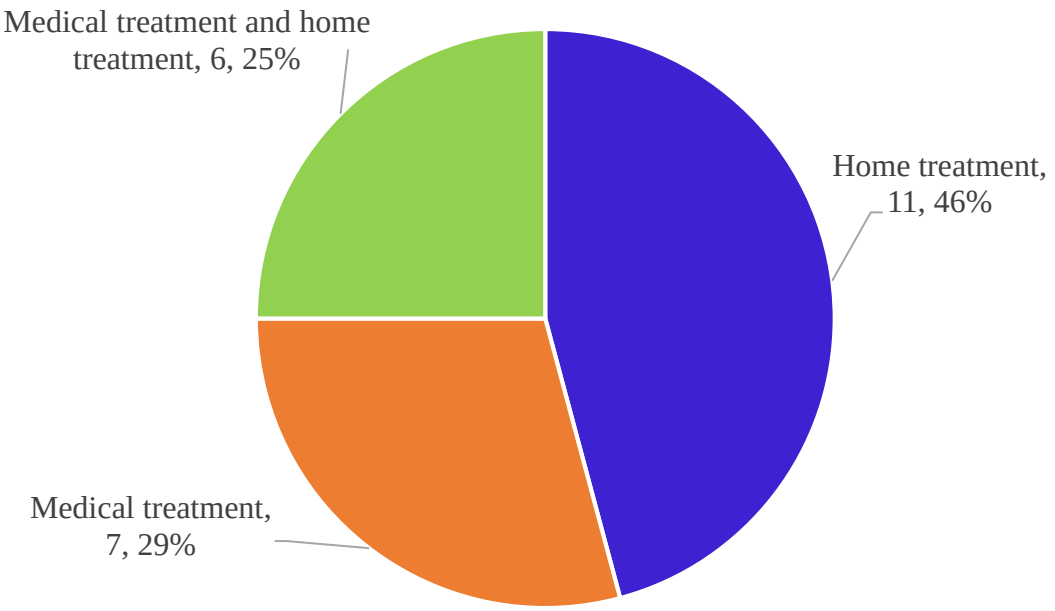


Figure 24: Type of treatment for hands/wrists' pain

4.1.3.2.9 Ankles

As shown in Table 42, 26 participants reported suffering pain during the last 12 months while 20 reported suffering pain in the ankles during the last 7 days.

The average level of pain for the last 12 months was of 4.31 (SD=2.69) while the average level of pain for the last 7 days was of 4.74 (SD=2.92). For both periods of time, this is considered a moderate discomfort in the area.

Figure 25 shows that most participants reported not suffering pain in the ankles. Of those that reported pain in the ankles, the majority reported a Level 2 pain, described as “Light Discomfort in the area”.

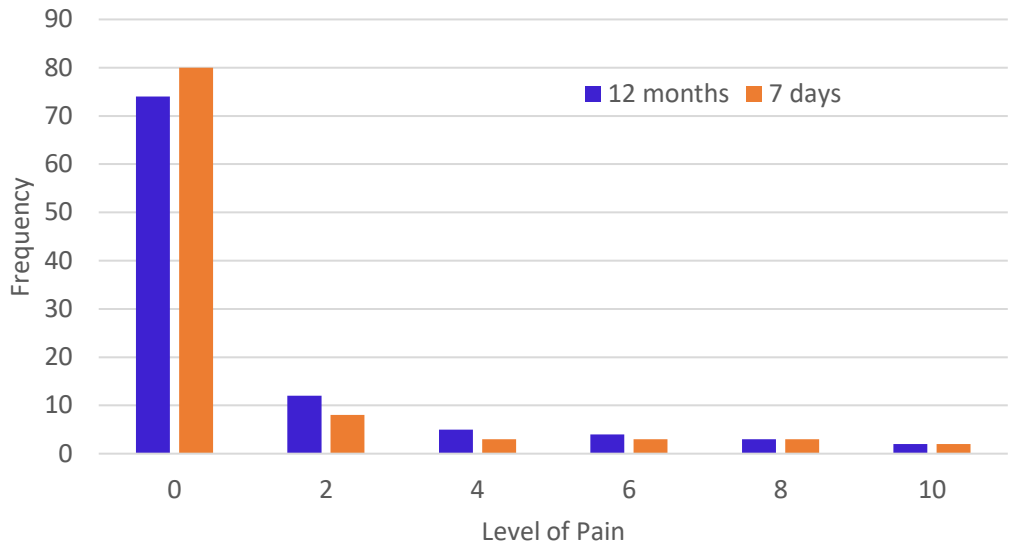


Figure 25: Histogram of participants' reported level of pain in the ankles

While 26 participants reported suffering from pain in the ankles for the last 12 months and 20 for the last 7 days, 42% of the participants reported having received treatment for the pain. Around 31% of the participants who suffer pain in the ankles said that their job was affected because of the pain.

Pain in the ankles was reported by 63% of the participants in a study performed by Gangopadhyay among prawn seed collectors, in comparison with 26% and 20% in periods of 12 months and 7 days of this study (Gangopadhyay et al., 2008). However, our results are like those cited by Singh et al. (2013) of the University of Agricultural Sciences in India in which 23% of the participants reported to have suffered pain in the ankles.

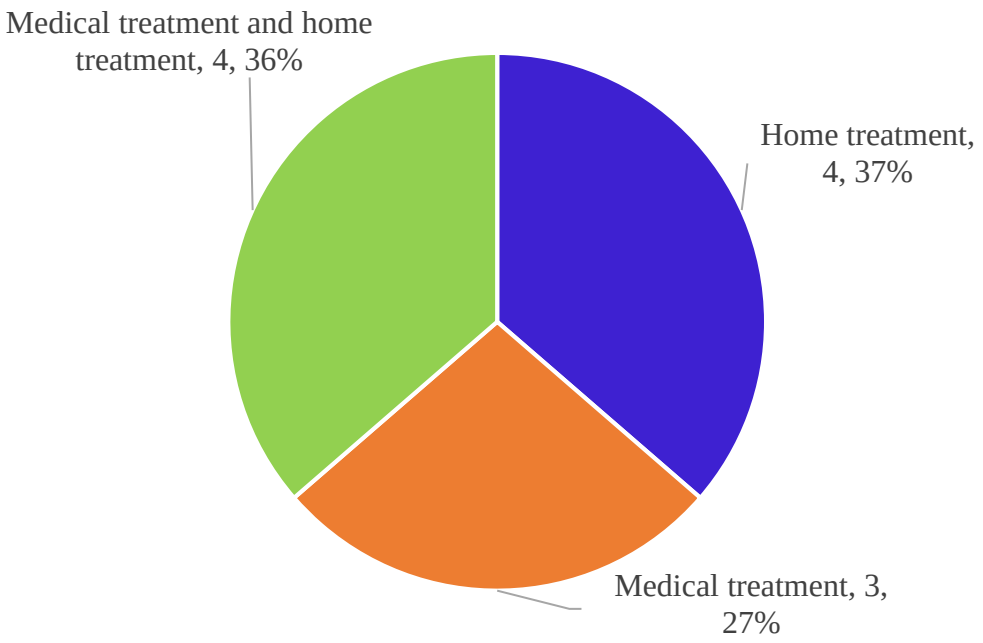


Figure 26: Type of treatment for ankle's pain

4.1.3.3 Statistical Analysis for the Nordic Modified Questionnaire Results

4.1.3.3.1 Level of pain difference among periods

As mentioned before, the level of pain was evaluated by participants in different parts of the body in periods of 7 days and 12 months. Fisher's Exact Test was used to determine if there was a significant difference in the level of pain reported among both periods of time. In order to perform this calculation, R Statistical Software (R) (R Core Team, 2017) was used.

Table 45: Fisher's exact test to determine the difference in reported level of pains between the 7 days and 12-month periods

Body area	P-value
Neck	0.3202
Shoulders	0.0821
Upper Back	0.4406
Lower Back	0.6609
Elbows	1
Knees	0.4750
Hips	0.9723
Hands/wrists	0.9107
Ankles	0.8995

Table 45 shows the P-values obtained in each of the Fisher's Exact Test performed per each body area. At a 95% confidence level, no significant difference was found in the reported level of pain between both periods of pain for any body area. Although no publications have been found in which the reported level of pain among both periods were compared, some studies revealed that the prevalence of pain is higher in the period of 12 months. This was the case of a study performed among oil palm plantations workers in which the prevalence of pain was higher in the period of 12 months (Ng et al., 2014). In another publication focused in coffee farm workers in Brazil, the prevalence of pain in the shoulders for the last 12 months was the highest reported (Navarro et al., 2008).

4.1.3.3.2 Relation of study variables to reported Level of pain

Random Forest consists of several parameters such as number of variables to be used at each split and number of trees to be constructed. In this work, the function *tuneRF* determined the optimum number of variables that were used at each split of the Random Forest model. This function suggested the use of 10 variables at each split to reduce the classification error in the algorithm. An iterative method was used to determine the number of trees that gave the lowest

classification error. It was found that at 500 trees, the error rate was stable. After this, the algorithm created a total of 500 trees and used 10 variables at each split to perform the Random Forest analysis. Sampling with replacement was used to reduce the probability error in the algorithm. By evaluation of the response variable data, it was noted that the data set was highly imbalanced. For this reason, a classification weight was added to each class of the response variable. The classification weight for each class was determined by the proportion of each class in the data set (See Table 46).

Table 46: Classification weight for RF model

Level of pain	Number of each class	Classification weight
2	180	30.51%
4	117	19.83%
6	123	20.85%
8	96	16.27%
10	74	12.54%

Figure 27 shows the predictor variables that had relevance in the result of the response variable which is Level of pain based in the Mean Decrease Accuracy (MDA). Variables were displayed vertically with the most relevant on top and the least relevant on the bottom of Y-axis. As shown in Figure 27, “Age”, “Body.Area”, “Years.Experience”, and “Academic.Degree” had the highest MDA values, meaning that these are the most relevant variables in the model and are more related to the response variable.

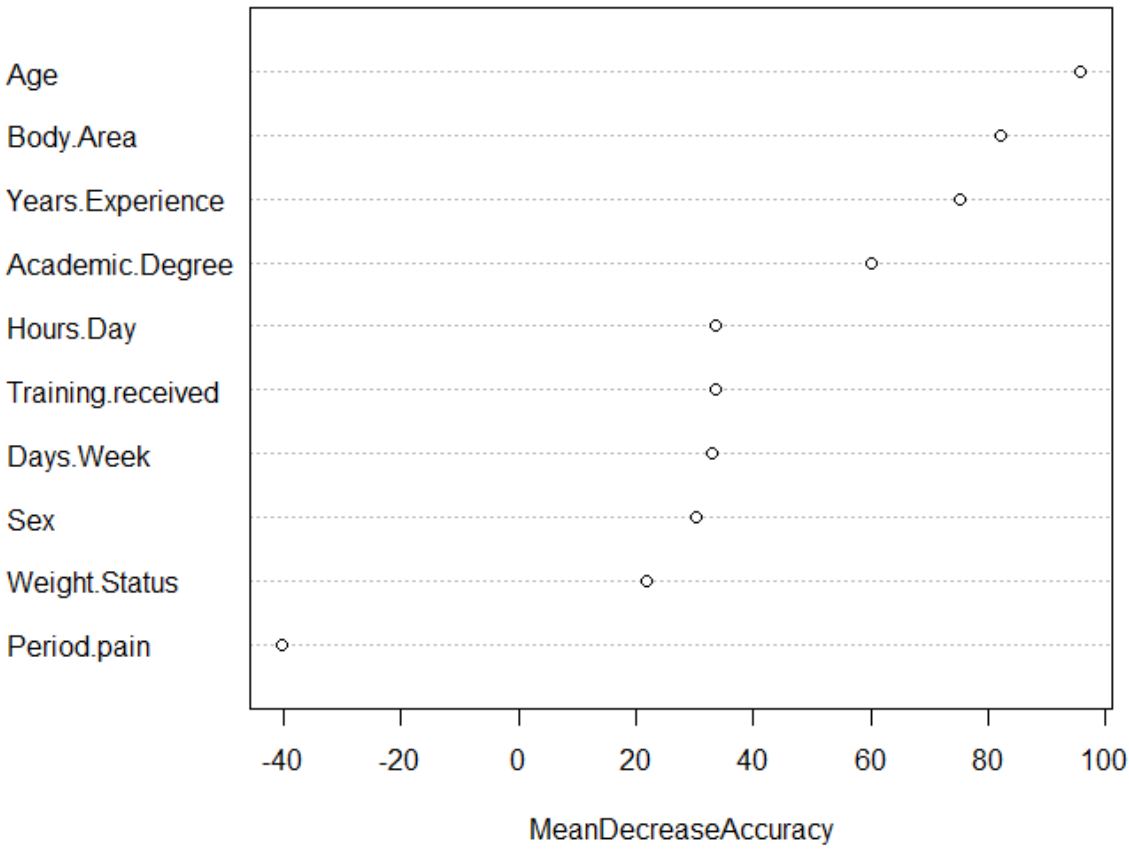


Figure 27: Mean Decrease Accuracy of study variables

The results of the *MDA* are confirmed by the results of the *Mean Decrease Gini (MDG)* as can be seen in Figure 28. The variables "Body.Area", "Age", "Years.Experience", and "Academic Degree" resulted with the higher values of MDG.

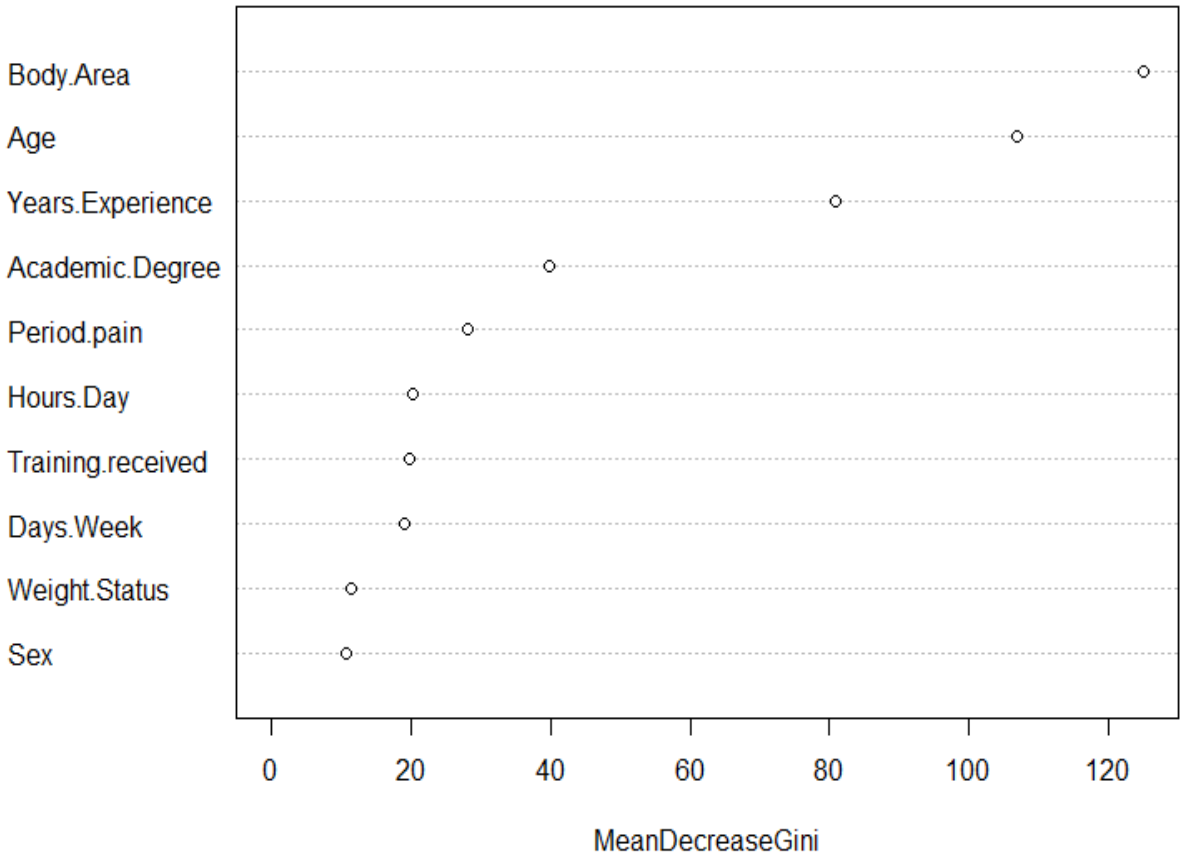


Figure 28: Mean Decrease Gini of study variables

Many publications mentioned that the techniques to perform specific agricultural tasks are related to pain in different parts of the body. One of these publications was related to Hispanic farm workers in California were the author concluded that the pain in different parts of the body is related to the positions in which each task is performed in the field (Xiao, 2011). This can be related to our variable of "Body.Area" in which the reported level of pain will be affected depending on which body part is located. Another factor mentioned through literature was the age of the farmers, as older farmers are more likely to suffer from conditions related to MSD like arthritis and thus by continuing working in the farm at an old age are at higher risk of suffering work-related injuries (Tonelli et al., 2014). Another research found that farm workers older than 40 years of age had a pain prevalence more than double of younger participants (Xiao,

2011). In a study performed among farm workers in China, it was found that those between the age of 40-49 were more likely to suffer injuries related to their job at the farm (H. Xiang et al., 2000). Although Xiang et al. (1999) cited that there was a relationship with increasing age and back pain, he reported that back pain decreased as age increased. In terms of years of experience, Xiang et al. also reported that there was no significant difference among workers of different age but same amount of years of experience as farm workers, in contrast with our results in which years of experience was found to be related to the level of pain reported by the participants. Ng et al. (2014) cited a study performed among oil palm plantation workers that states that age and years of experience in agricultural industry are directly related to MSD.

Also, low literacy levels are commonly associated with risk factors in the agricultural industry. As mentioned in a study performed among Hispanic farmworkers, populations with low literacy level are considered at risk in terms of injuries and MSD (Faucett et al., 2001). The Center for Disease Control and Prevention also consider low literacy as a risk factor for agricultural workers, meaning that more emphasis to improve this area should be addressed (Center for Disease Control and Prevention, 2012). As can be seen in Figure 27 and Figure 28, Academic Degree of the participants of our study was found to be an important variable in the Random Forest model.

In a study performed among 300 farm workers in India, it was found that age and years of experience were the most related to the development of MSD among the participants (Hemalatha et al., 2017). However, no relation was found between the development of MSD and the sex of the participants or the BMI.

The Out-of-Bag (OOB) estimate of error rate is internally calculated by using a third of the samples selected to construct each tree (Breiman, 2001). This third of the data is not used in the construction of the trees, however it is evaluated in the trees and aggregated through all the

model to bring a percentage of error. The estimate of error among this third of the data can be used to estimate the error of the model under study. The OOB estimate of error is useful in Random Forest as it is used as an internal validation method of the model. For this model, the OOB was approximately 24%. In Figure 29, the OOB decreased as the number of trees in the model increased, reaching a stable value at around 500 trees in the model.

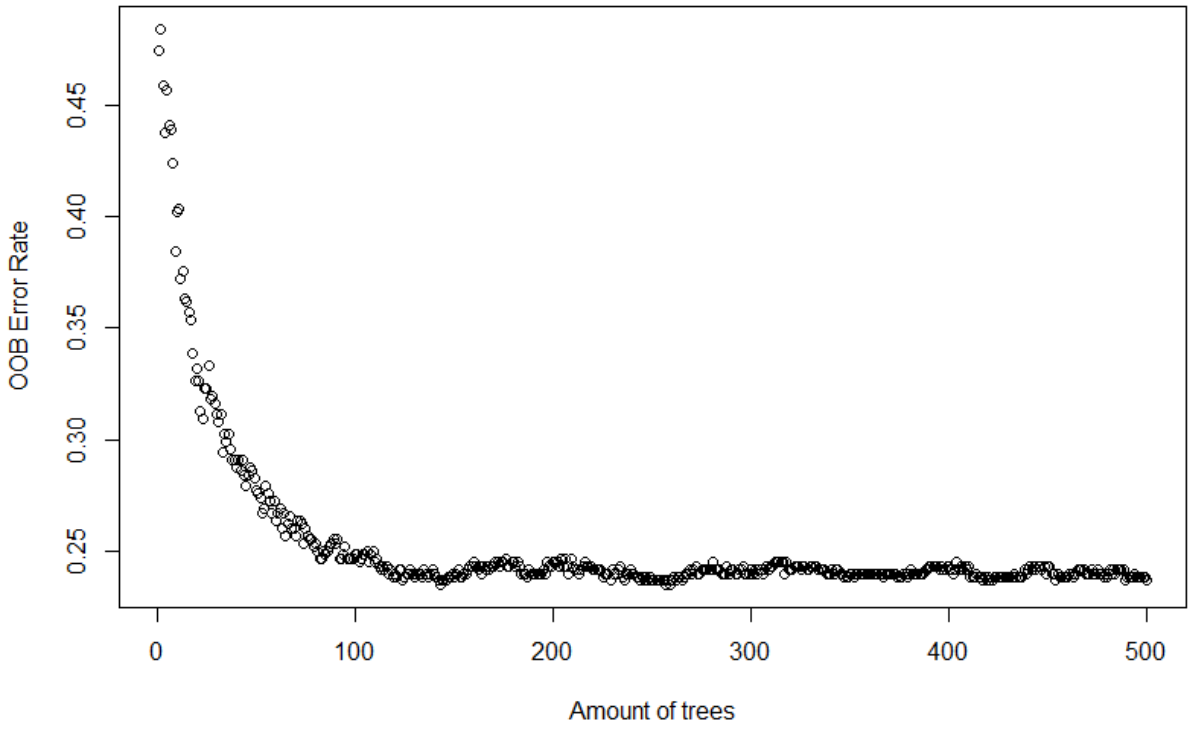


Figure 29: Out of Bag (OOB) error rate

Partial dependence plots are useful to understand the relevance of a variable on the probability of a class (R Core Team, 2017). In partial dependence plots, the Y-axis corresponds to the logit of the probability, which is defined as the natural logarithm of the odds while the X-axis corresponds to the variable that is being evaluated. A positive logit value means that the variable is more associated to the value of the variable that is being evaluated. In contrast, a negative value will imply that the variable is less associated to the value of the variable.

By using partial dependence plots to evaluate the variable “Body.Area”, the areas of the body that were most related to each Level of pain were identified. Figure 30 demonstrates that mostly all of the areas of the body are positively related to a level of pain of 2, however, lower back has a negative relationship with it. This means that it is very improbable that a participant who suffered from lower back pain reported a level of pain=2. Figure 31 shows that all parts of the body are related to a level of pain of 4 which means that most of the participants that reported pain in any part of the body, reported a level of 4. Pain in the hands/wrists and in the shoulders had a stronger association with a level of pain of 4 when compared with other areas of the body. This same behavior was observed in Figure 32 in which hands/wrists, knees and shoulders are strongly related to a level of pain of 6, however, upperback had a negative relationship with level of pain of 6. Almost the opposite to what can be seen in Figure 30 was observed in Figure 33 where most of the areas of the body had a negative relationship to a level of pain of 8 with the exception of lower back and ankles. Figure 34 shows that only lower back area had a relationship to a level of pain of 10, whereas hand/wrists and shoulders showed the most negative logit values in this graph. In general, the area of the body variable was most related to levels of pain of 2, 4, and 6, but not so relevant to level of pain of 8 and 10.

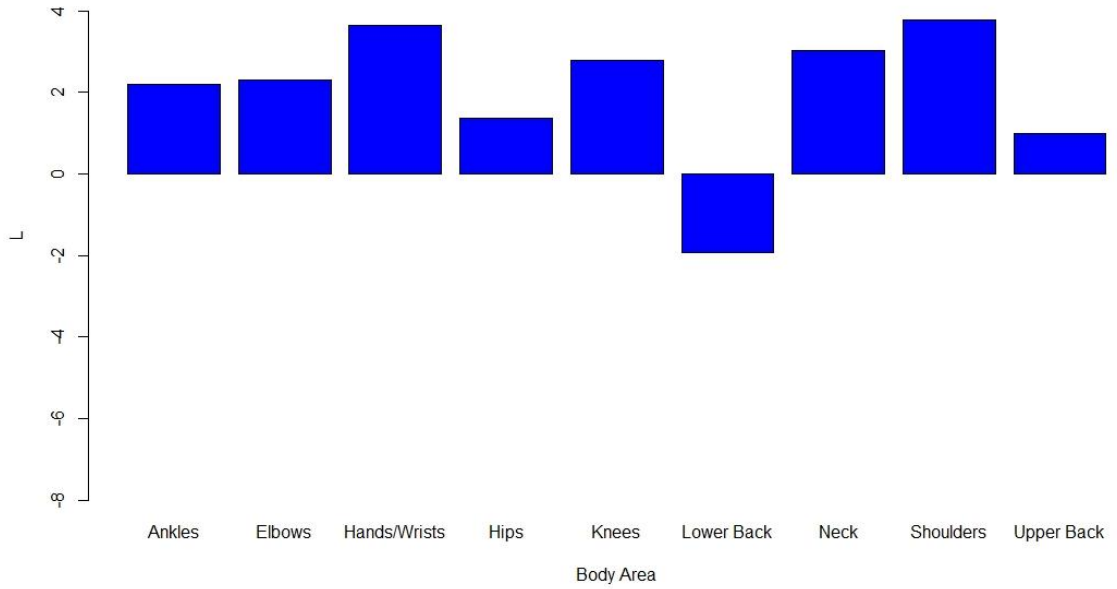


Figure 30: Partial dependence plot for Body Area: Level of Pain =2

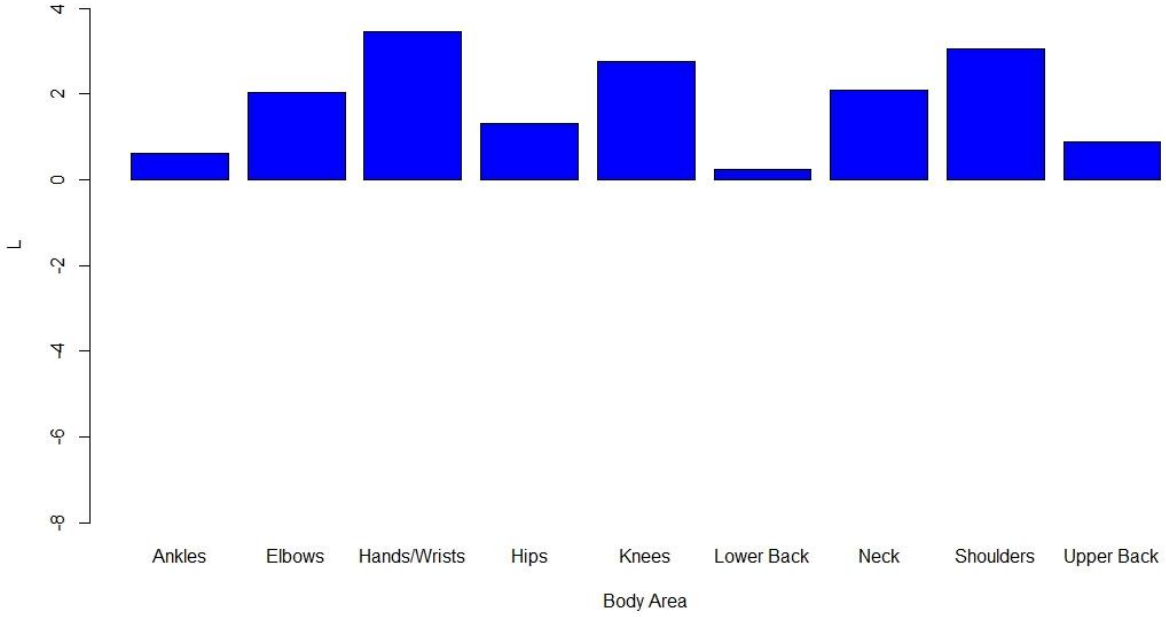


Figure 31: Partial dependence plot for Body.Area: Level of Pain =4

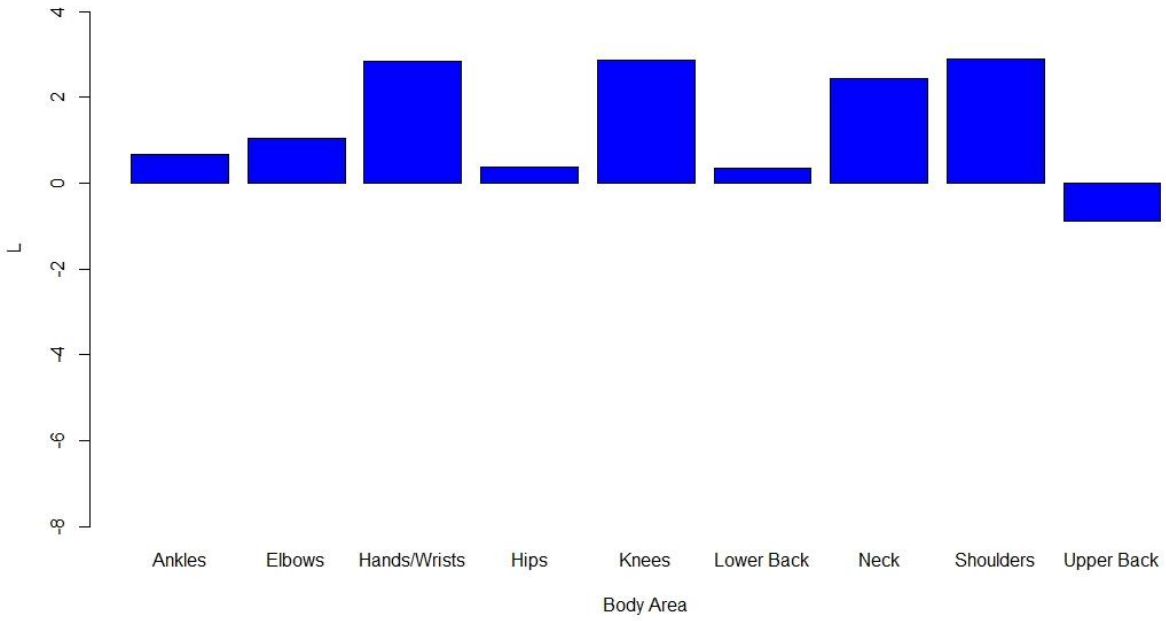


Figure 32: Partial dependence plot for Body.Area: Level of Pain =6

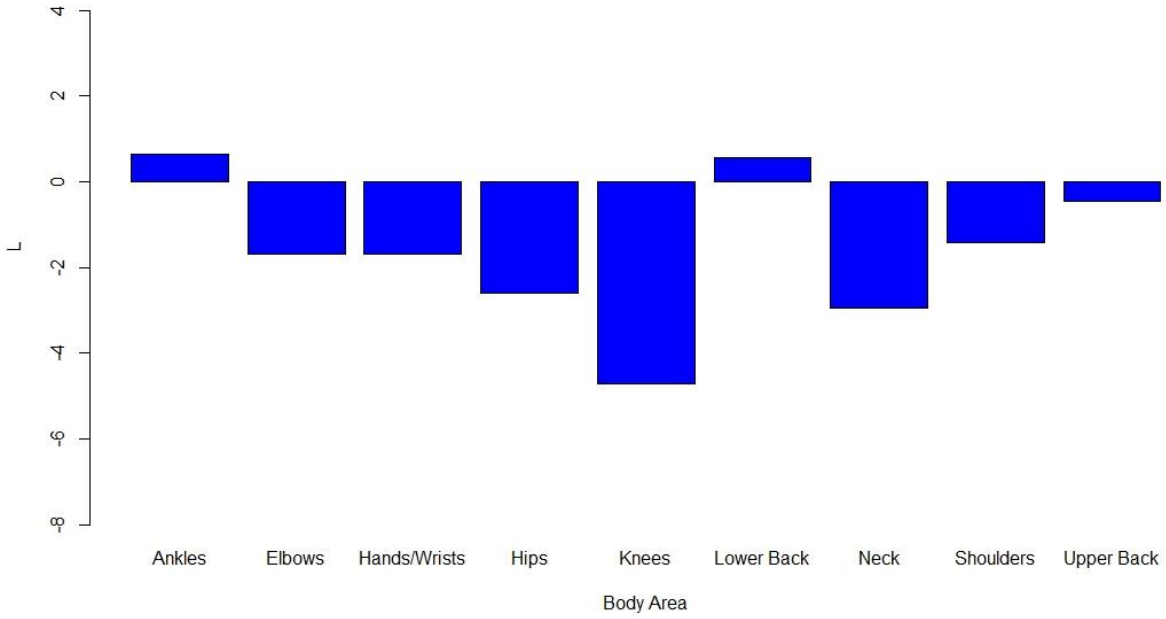


Figure 33:Partial dependence plot for Body.Area: Level of Pain =8

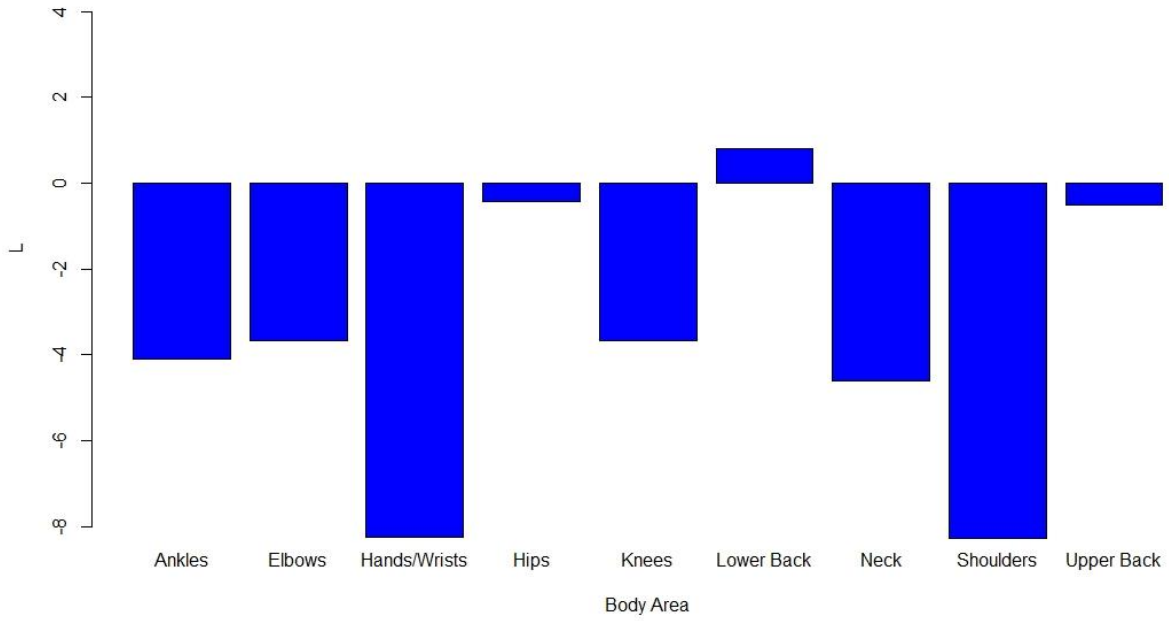


Figure 34:Partial dependence plot for Body.Area: Level of Pain =10

The partial dependence plots for the variable "Academic Degree" are presented from Figure 35 to Figure 39. As can be seen in Figure 35, participants with an academic degree of High School are more related to levels of pain of 2, followed by those that completed Intermediate School, Associate/Technical degrees, and bachelor's degree. Those that only completed Elementary School were the least to report a level of pain of 2.

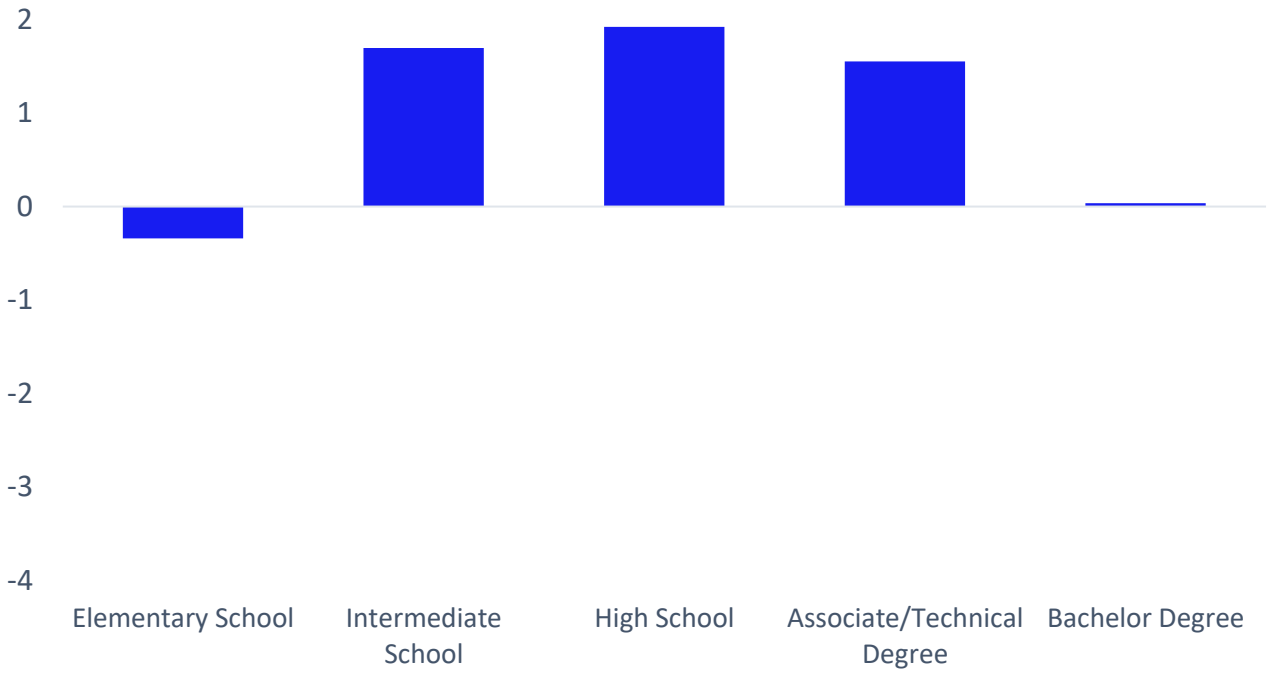


Figure 35: Partial dependence plot for Academic degree: Level of Pain=2

According to Figure 35, participants with a High School degree and Intermediate School degree are more likely to report a level of pain of 2. According to Figure 36 and and Figure 37, participants with a High School degree and Associate/Technical Degree are more likely to report level of pain of 4 and 6. Participants with a bachelor's degree and those that had only completed Elementary School had similar reporting patterns for level of pain 4 and 6.

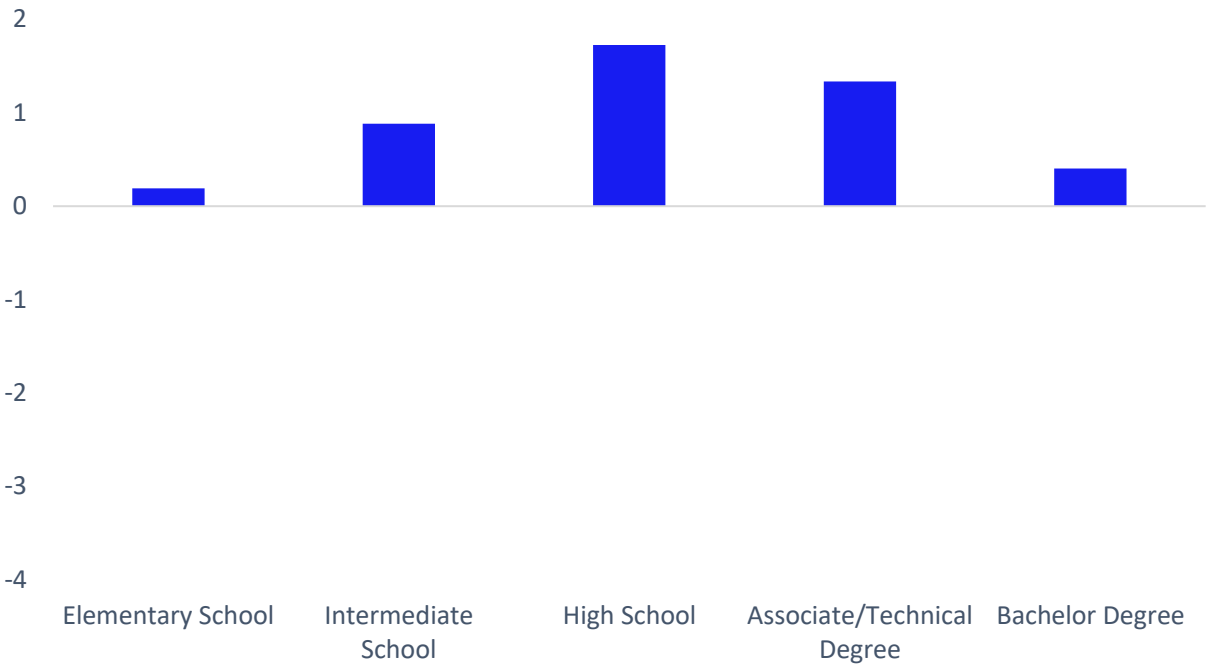


Figure 36: Partial dependence plot for Academic degree: Level of Pain=4

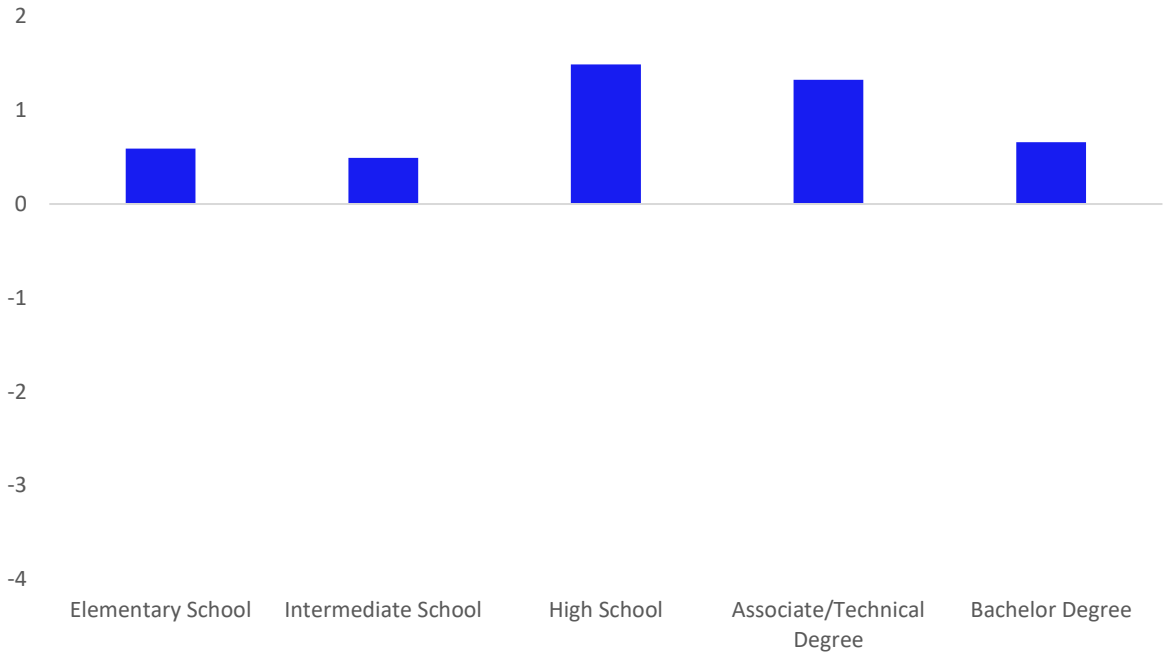


Figure 37: Partial dependence plot for Academic degree: Level of Pain=6

For a level of pain of 8 (See Figure 38), the only group that had a positive relationship was for those that completed Elementary School or bachelor's degree. None of the groups were associated to a level of pain of 10 as can be seen in Figure 39

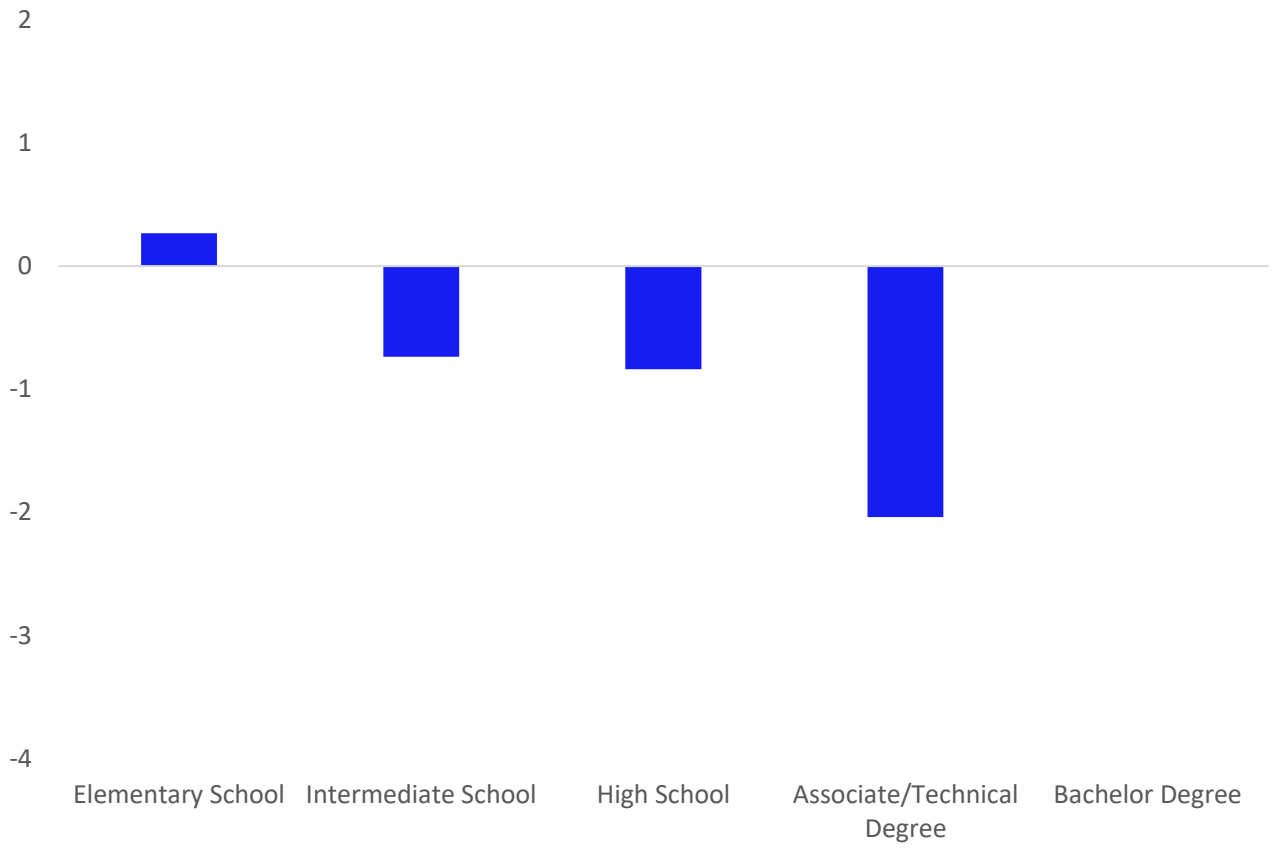


Figure 38: Partial dependence plot for Academic degree: Level of Pain=8

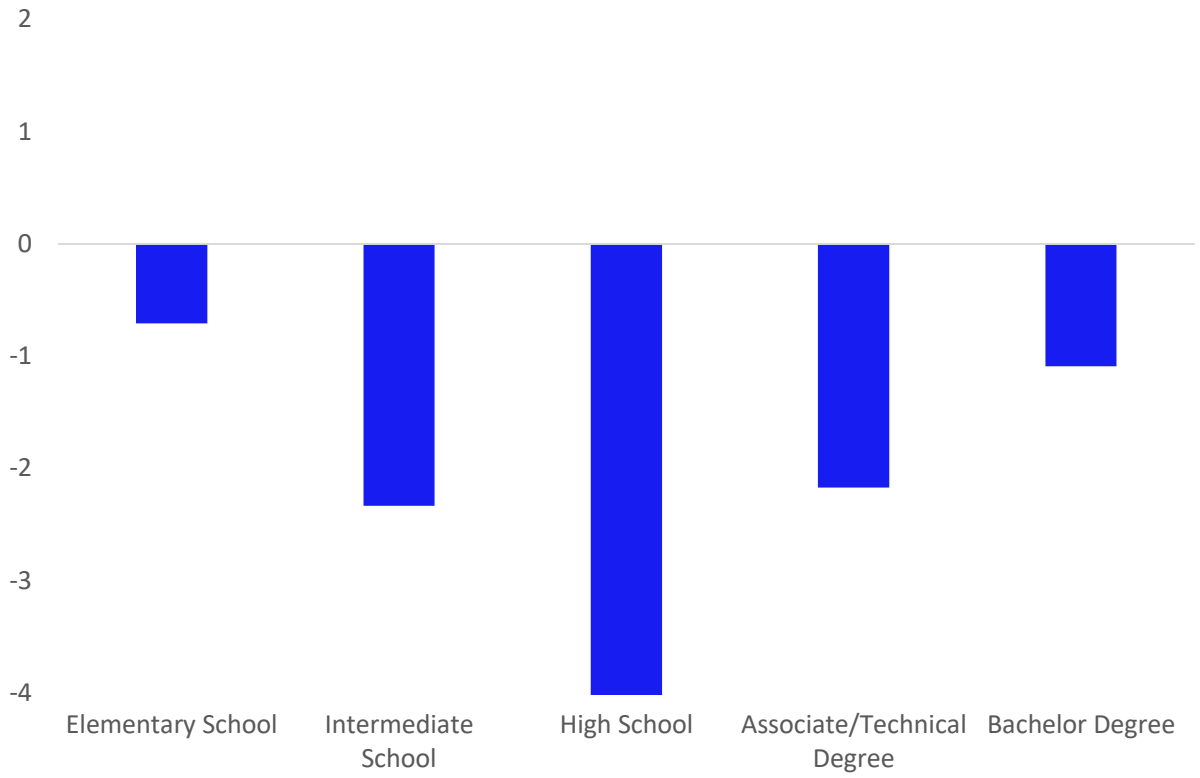


Figure 39: Partial dependence plot for Academic degree: Level of Pain=10

Age of the participants was also a variable that resulted with a high MDA according to the Random Forest Model. The minimum age for a person to be participant of the project was 21 years, there was no restriction in the maximum age of the participants. Partial dependence plots for Age are presented from Figure 40 to Figure 44. In Figure 40, for a level of pain of 2, between 30 to 40 years of age, participants are less likely to report that level of pain. But, from that point on, the likelihood to report a level of pain increased with age of the participants. For a level of pain of 4, no visible trend was detected in the partial dependence plot presented in Figure 41, as there seems to be no influence in the age of the participants to the chance of reporting a level of pain of 4. A similar pattern of that from a level of pain of 2 occurred for level of pain of 6 (Figure 42) whereas the age increased up to around 50 years of age, the likelihood to report a level of pain of 6 decreased. However, after 50 years of age, there is an increase of the

likelihood of participants reporting a level of pain of 6. As shown in Figure 43, as age increases, the negative relationship between age and a level of pain of 8 reduces to a value of almost zero. For a level of pain of 10, as age increased, the more negative the likelihood to report a level of pain of 10 (See Figure 44). After visualization and analysis of all the plots, the youngest and the oldest of the participants are more likely to report suffering pain, however, age of the participants is more related to a reporting level of pain of 2.

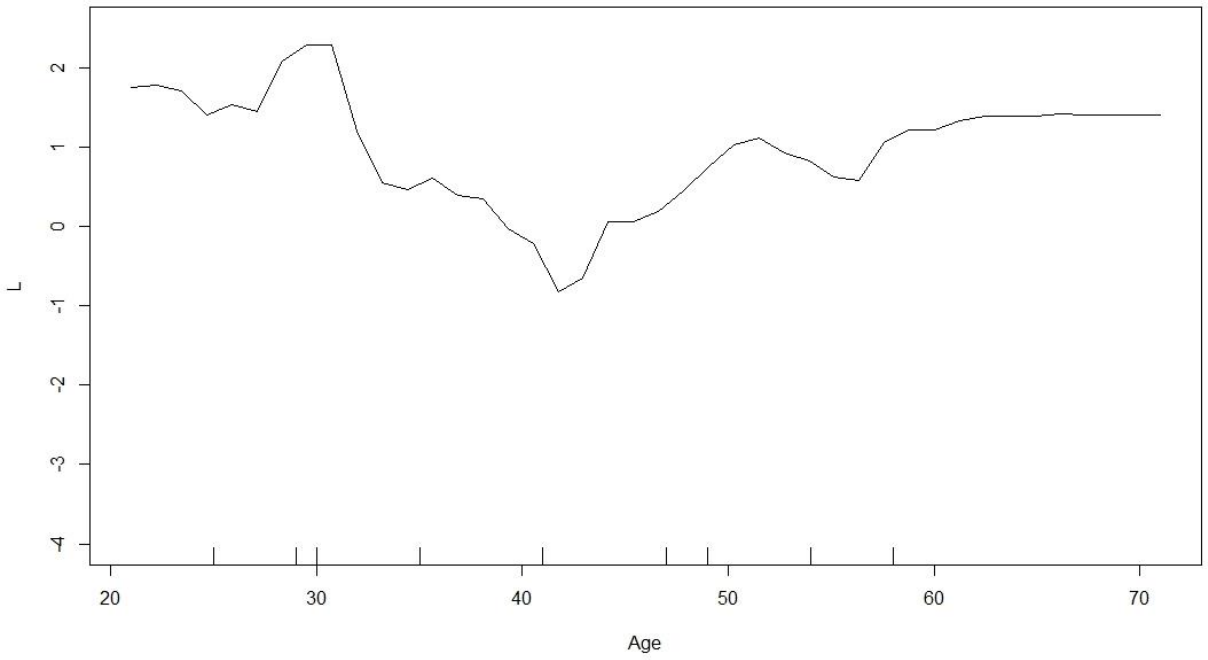


Figure 40:Partial dependence plot for Age: Level of pain=2

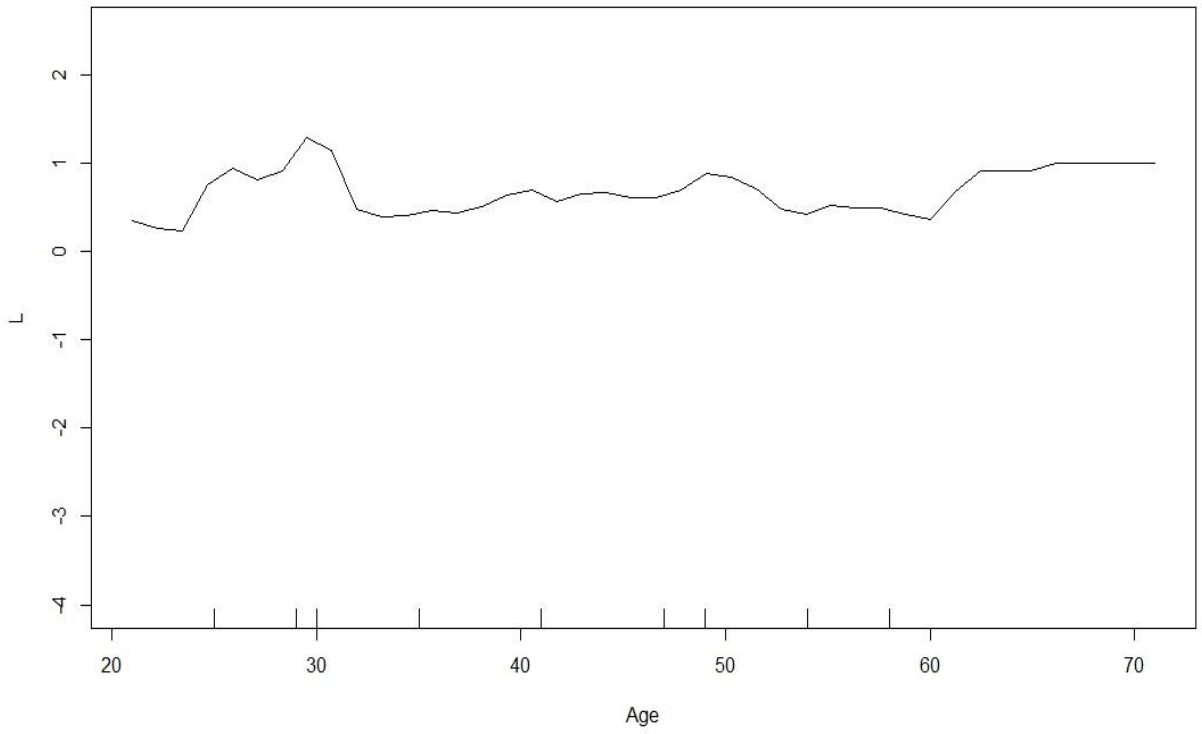


Figure 41: Partial dependence plot for Age: Level of pain=4

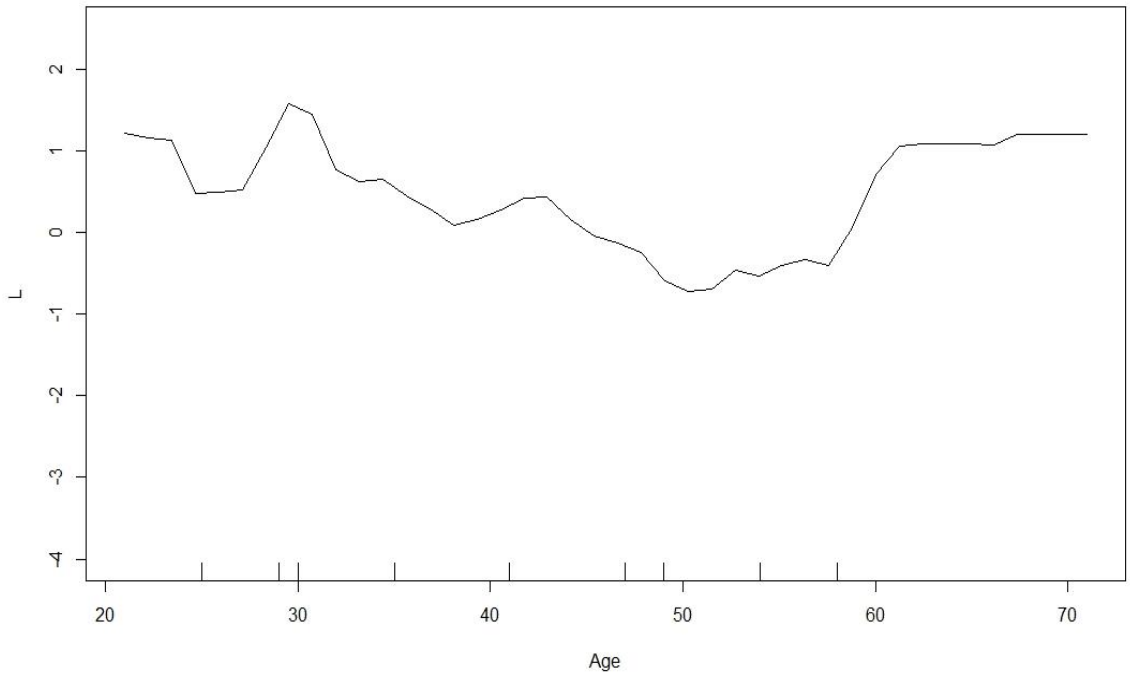


Figure 42: Partial dependence plot for Age: Level of pain=6

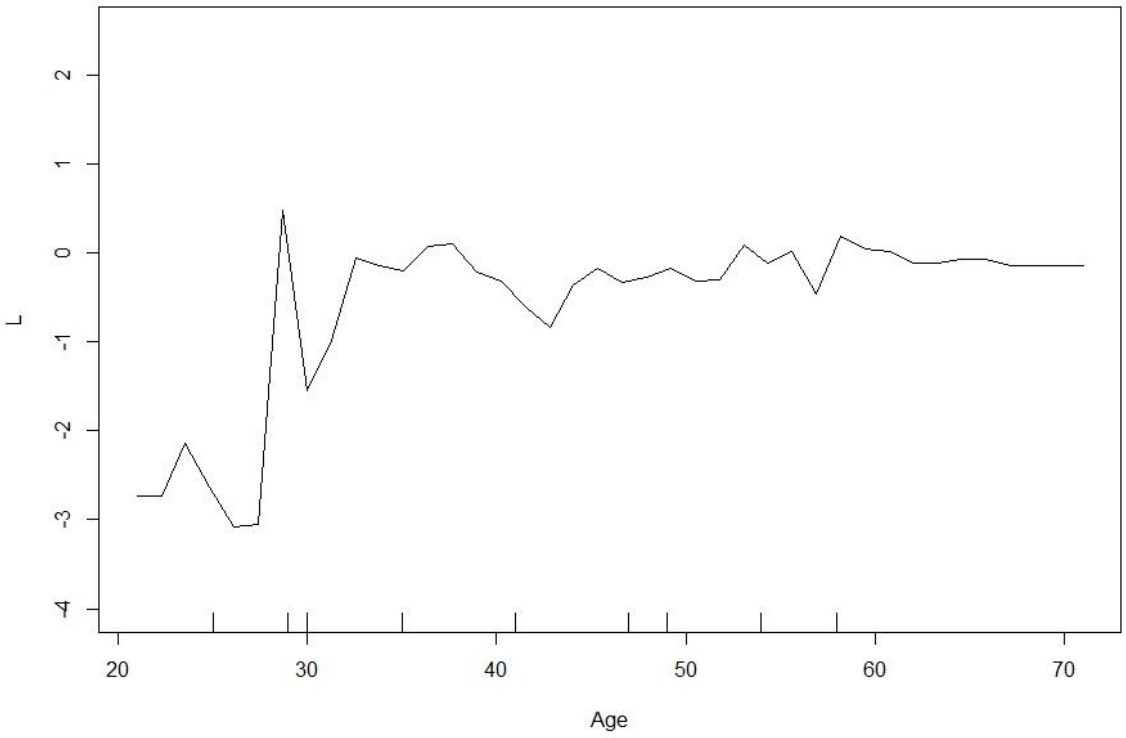


Figure 43: Partial dependence plot for Age: Level of pain=8

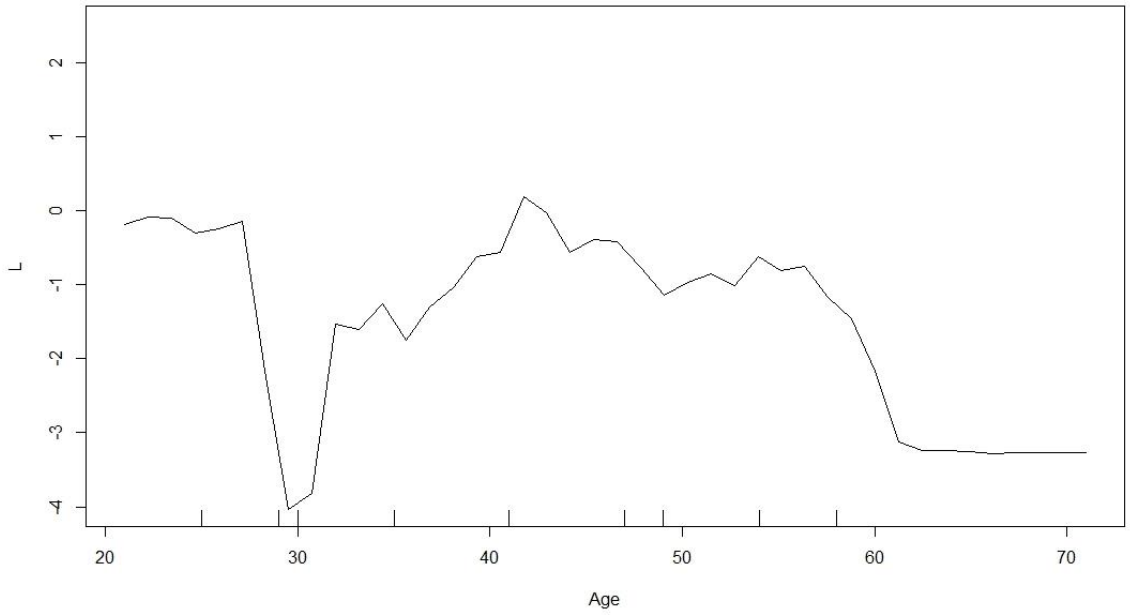


Figure 44: Partial dependence plot for Age: Level of pain=10

Another important variable according to the Random Forest model was the years of experience of the agricultural worker. A minimum of 1 year of experience was asked for the participants to be part of the research. As can be seen in Figure 45 and Figure 46, as the number of years of experience increased, the likelihood to report levels of pain of 2 and 4 suffered a slight decreased. With the same reasoning, for a level of pain of 6 (Figure 47), as the amount of years of experience increased up to around 15 years, the chances to reporting a level of pain of 6 are positive but between 15-20 years there is a negative relationship with level of pain. After 20 years of experience, the likelihood of reporting a level of pain of 6 increases. On the other side, and as can be concluded from Figure 48, as the years of experience increased, participants are more likely to report a level of pain of 8. Figure 49 shows that there is not a strong relationship among years of experience and a level of pain of 10. In general, participants with more years of experience in the agricultural industry are more prone to report a level of pain of 8 in comparison to other workers.

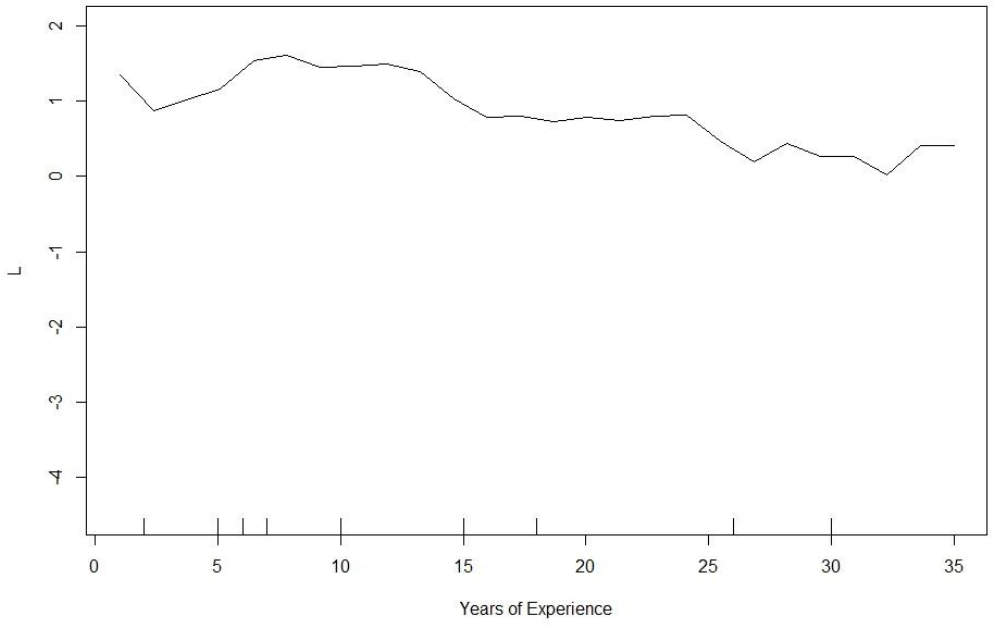


Figure 45:Partial dependence plot for Years of Experience: Level of pain=2

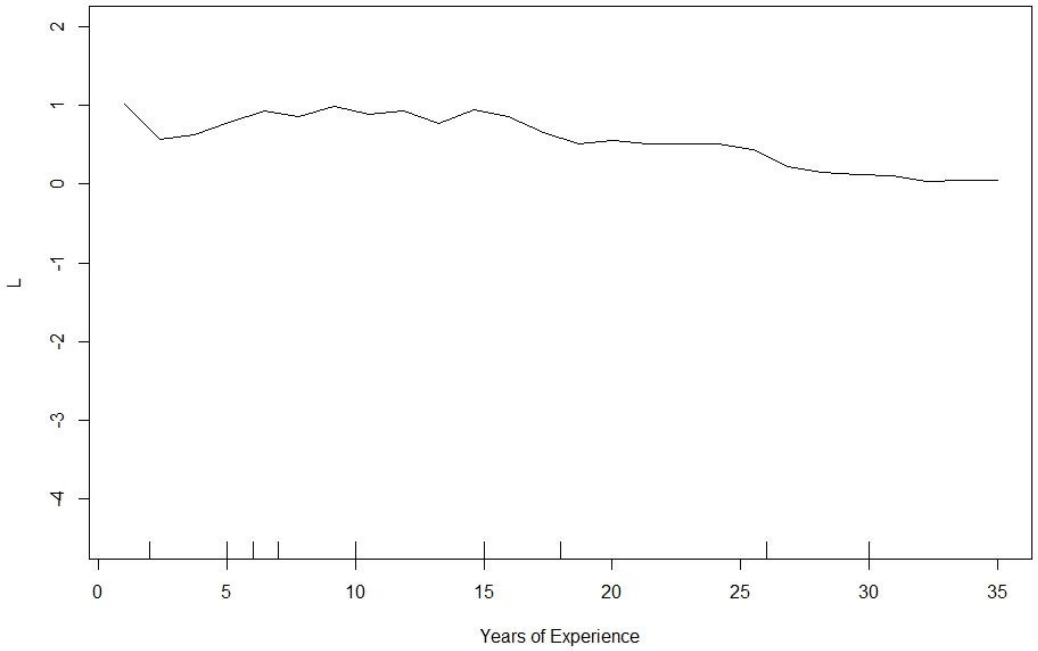


Figure 46: Partial dependence plot for Years of Experience: Level of pain=4

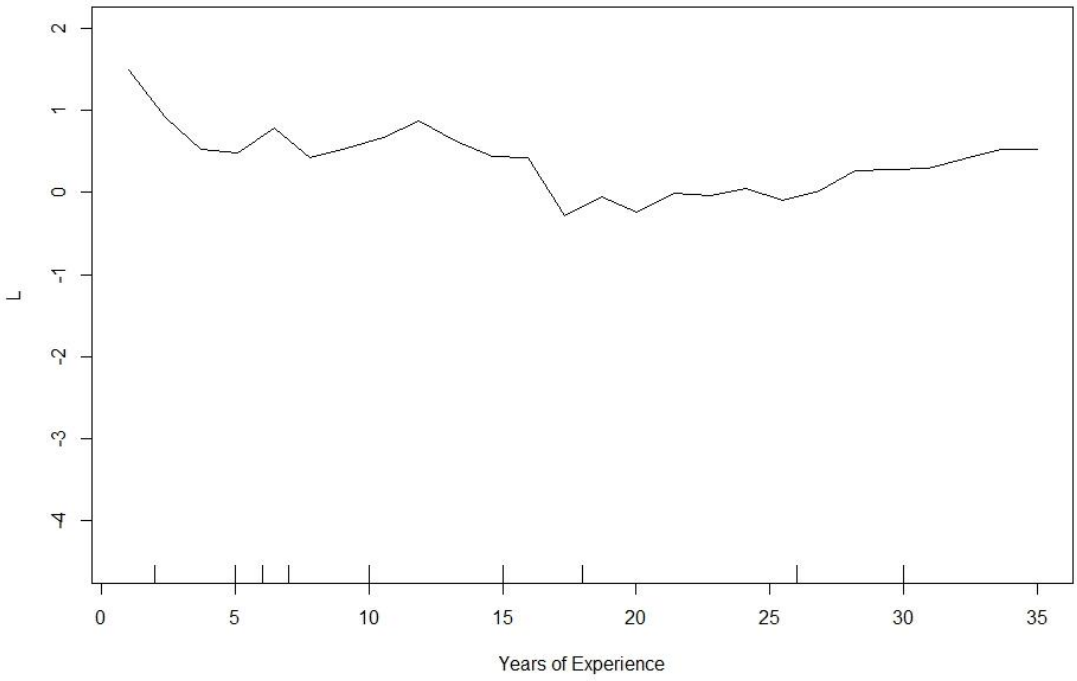


Figure 47: Partial dependence plot for Years of Experience: Level of Pain=6

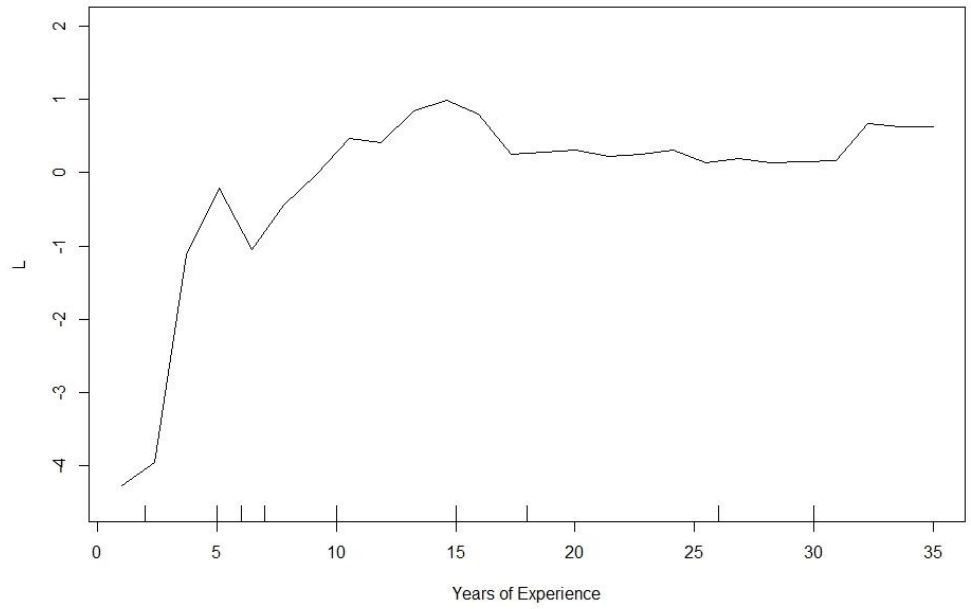


Figure 48: Partial dependence plot for Years of Experience: Level of Pain=8

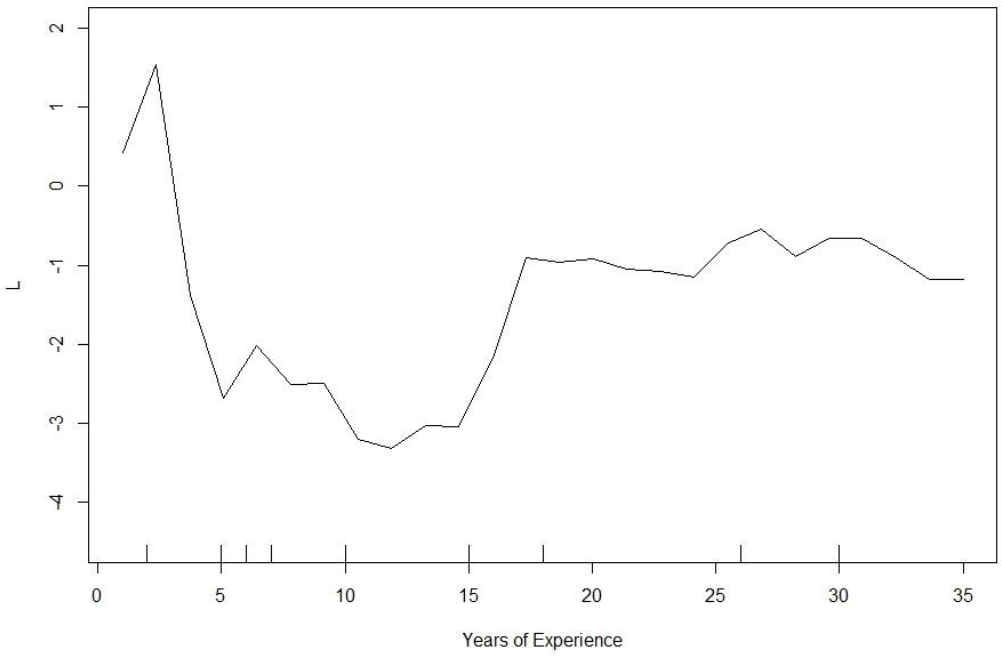


Figure 49: Partial dependence plot for Years of Experience: Level of Pain=10

4.1.3.4 Safety Practices at Work and Health Condition

4.1.3.4.1 Personal Protective Equipment

Agriculture has been constantly considered a hazardous industry to work due to the nature of its tasks (Sadeghi, Karuppiah, Bahri, & Dalal, 2014), and farm workers are at constant risk of developing work-related diseases and injuries. The use of Personal Protective Equipment (PPE) is helpful to reduce the risk of work-related injuries. Results shows that 99% of the participants in our study used at least one PPE to perform daily tasks. As part of the questionnaire, participants were asked about their usage of different types of PPE (See Table 47). Ninetythree percent of participants confirmed that they use Security Shoes. However, in order for a shoe to be considered a Security Shoe, it must comply with the requirements established in the ASTM F2413-11 from the American Society for Testing and Materials (ASTM International, 2011). After observation and further asking the participants, it was confirmed that rubber boots without safety toe cap were the ones that are mostly used on the farms. Although this kind of shoe does not give protection to impact or compression, they are commonly used among farm workers for their low sales price and as a mechanism to keep their feet dry from water and mud in the farm. Of the 100 participants, 25 reported to have suffered from some type of accident at work.

Table 47: Use of PPE

PPE	% of participants that use PPE
Safety Shoes (Rubber Boots)	93%
Gloves	86%
Security Glasses	58%
Dust Mask	53%
Apron	26%
Respirator	26%
Helmet	9%
Earmuffs	6%
Other	3%

4.1.3.4.2 Work under direct sun exposure

In Figure 50, it is evident that farm workers spend most of their time performing tasks under direct sunlight. Around 67% of the participants spend an average 6-8 hours under direct sunlight, while 24% spend 3-5 hours. Tasks at the farm start normally early in the morning to avoid high temperatures at the field that could negatively affect the performance of the workers.

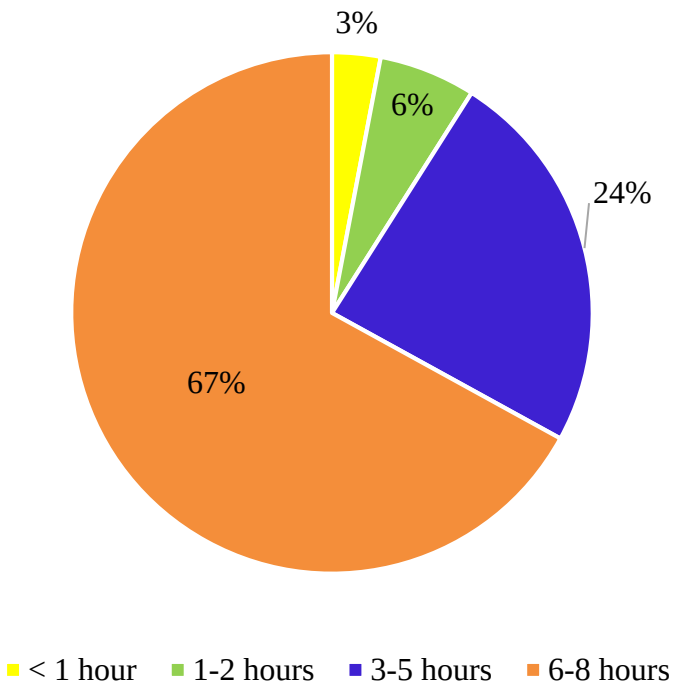


Figure 50: Number of hours under direct sunlight

The vast majority of participants (97%) indicated they used some type of apparel for protection of direct sunlight. Most use multiple gears to protect themselves from direct exposure to the sun, and only 15% reported using sunscreen lotion for protection (see Figure 51). Also, only 4% of participants reported having sunburns caused during their work at the farm (Figure 53).

Direct sun exposure for long periods of time has been associated with different types of diseases such as skin cancer (Xiao, 2011). The most common types of cancer among agricultural workers are basal cell carcinoma, lip cancer, and squamous cell carcinoma (S. G. Von Essen et al., 1998). Direct exposure is also related to heatstroke and heat exhaustion (Department of Labor and Human Resources of Puerto Rico, 2013).

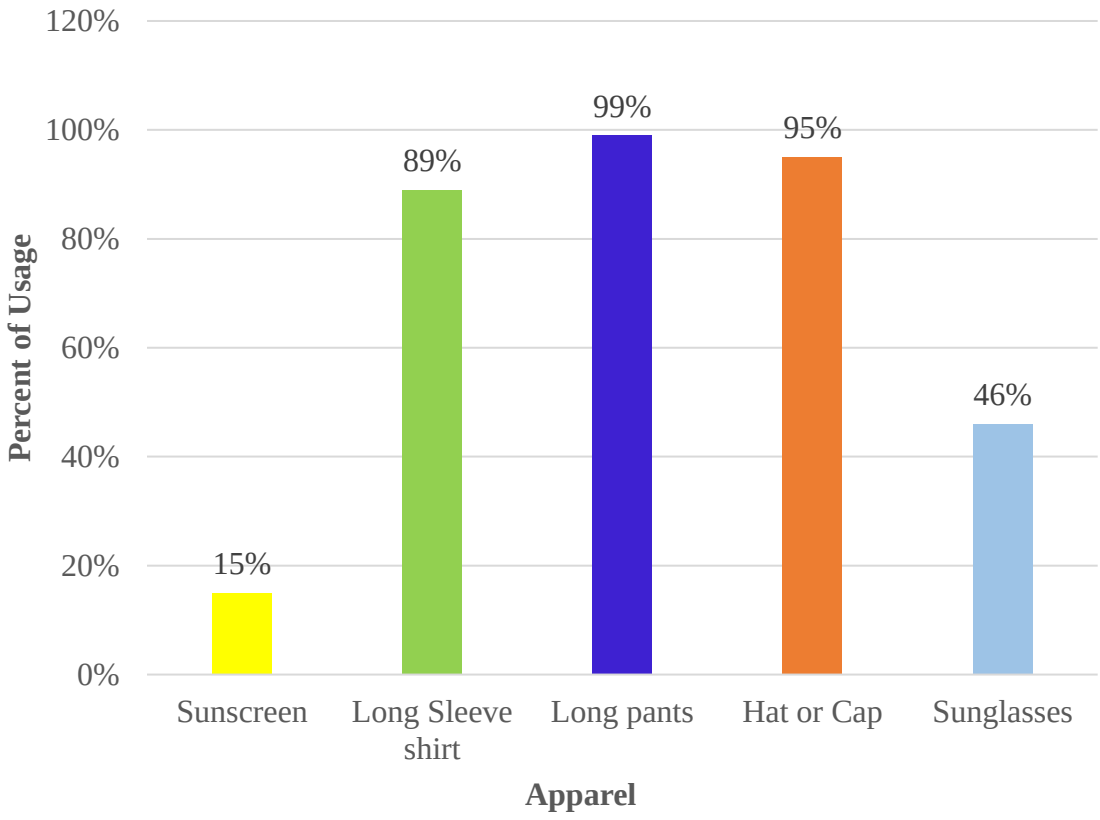
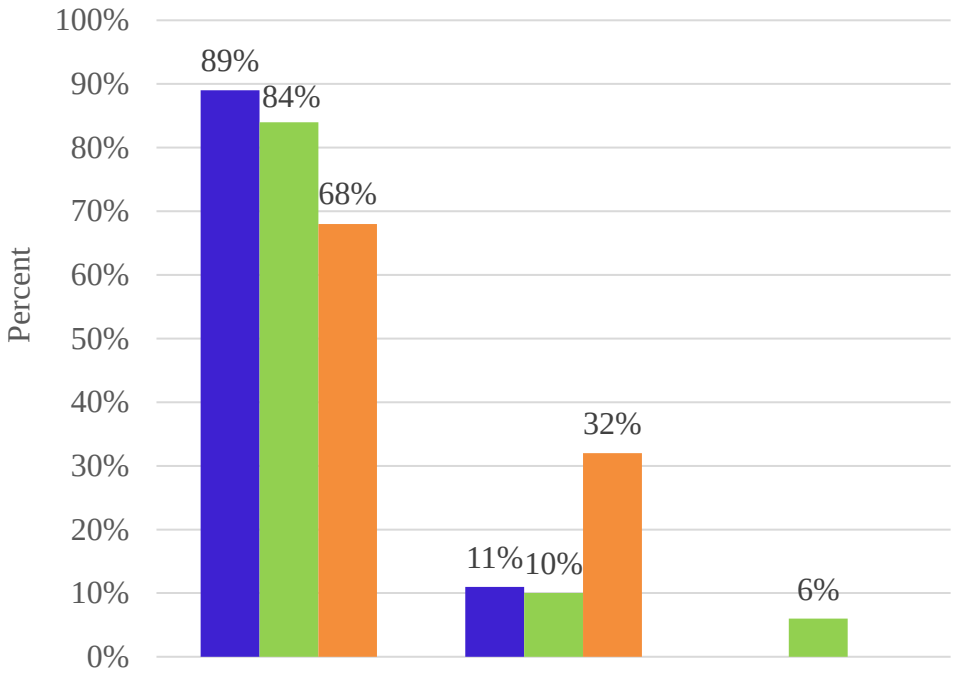


Figure 51: Reported use of sun protection apparel

4.1.3.4.3 Safety Awareness and Education

In terms of safety education among farm workers (Figure 52), 84% assured to know the risks associated to the different tasks in the farm, 10% were not aware, and 6% knew basic information about the subject. Although 89% of the participants reported that safety was a priority in the work environment, 36% of them claimed that no training was received to perform their tasks in a safely manner. During the interview, it was noticed that those who confirmed to have received some training related to performing their tasks in a safely manner (68%) were making references mostly about trainings related to pesticide awareness to avoid poisoning, but not neccesarily about how to perform tasks in a safely manner to avoid injuries or discomforts. It can be concluded that agricultural workers are not aware of information and trainings that can help them reduce discomforts that can be potentially caused by their daily tasks. These results have some similarity with a study performed in North Carolina among 300 farmers, in which 70.1% of farm workers assured that safety was important for their employers, however, 54.2% reported that no safety training was given to them, 85.2% reported lack of safety equipment, and 54.2% said that working safely was not rewarded (Arcury et al., 2012). Sadeghi et al. (2014) reported that the combination of the type of movements related to agricultural work in combination with a lack of knowledge related to safety by farm workers had as result situations that could be detrimental to the health of the workers.



	Yes	No	I have basic knowledge
Is safety a priority in the work environment?	89%	11%	N/A
Do you know the risks related to the tasks at the farm?	84%	10%	6%
Have you received training to perform the tasks in a safely manner?	68%	32%	N/A

Figure 52: Safety at the work environment

A Fisher's exact test was performed to analyze the relationship between level of pain and training received by the workers to perform the tasks in a safely manner. As can be seen in the P-values listed in Table 48, with a corrected α-value=.005, that no significant difference was found in any of the areas of the body and periods in the reported level of pain among those who replied receiving training and those who don't. As mentioned before, knowing that agricultural

workers are not clear in the difference of trainings related to avoid pesticide poisoning and trainings to avoid injuries and discomforts at work, more emphasis should be given to this type of information for this population. Along with trainings, tools to facilitate the tasks and avoid injuries should also be required in the work area.

Table 48: P-values for Level of pain vs training received

Body area	7 days	12 months
Ankles	0.13	0.21
Elbows	0.01	0.59
Hands/Wrists	0.99	0.53
Hips	0.94	0.71
Knees	0.65	0.67
Lower back	0.25	0.46
Neck	0.70	0.79
Shoulders	0.55	0.66
Upper back	0.80	0.76

4.1.3.4.4 Health conditions among farm workers

Results show that hypertension, allergies, and sinusitis are the most common diseases among farm workers (Table 49). As can be seen in Figure 53, these conditions comprised around 50% of the reported conditions of the participants. Hypertension was reported by 29 participants, while allergies and sinusitis were reported by 18 participants respectively. Hypertension has been widely associated with kidney diseases, which place this population of agricultural workers at risk (Valcke, Levasseur, Soares da Silva, & Wesseling, 2017). Respiratory and cardiovascular conditions such as hypertension have been widely associated with obesity and as seen in the demographic information of our sample, most of the individuals were overweight or obese. The obesity among agricultural workers was also found among the patients of the OPD Clinic in Castañer General Hospital. As mentioned before, high BMI values have been associated with metabolic syndrome, which although is not considered to be

an MSD, it reflects in the body as musculoskeletal pain that can negatively affect the working conditions of the agricultural workers (Seaman, 2013).

Allergies were the second most common diseases among participants. Some of the common allergies that were mentioned by the participants were nasal and insects bite. These two types of allergies are quite common among agricultural workers due in fact to the nature of the tasks at the farm. None of the participants reported to have suffered of pesticide poisoning, which reinforce the fact that the correct safety measures are taken at the farms for this task as mentioned before. As agricultural workers are considered a disadvantaged group within the overall population, their risk of developing medical conditions without the proper treatment is high.

Table 49: Health conditions among participants

Medical Conditions	Men	Women	Total
Hypertension	27	2	29
Allergies	17	1	18
Sinusitis	17	1	18
Asthma	11	2	13
Diabetes	12	1	13
Other	11	2	13
Cataracts	10	1	11
Depression	9	1	10
Kidney Conditions	4	2	6
Sunburn	4	0	4
Heart Conditions	2	1	3
Cancer	1	0	1
Pesticide Poisoning	0	0	0

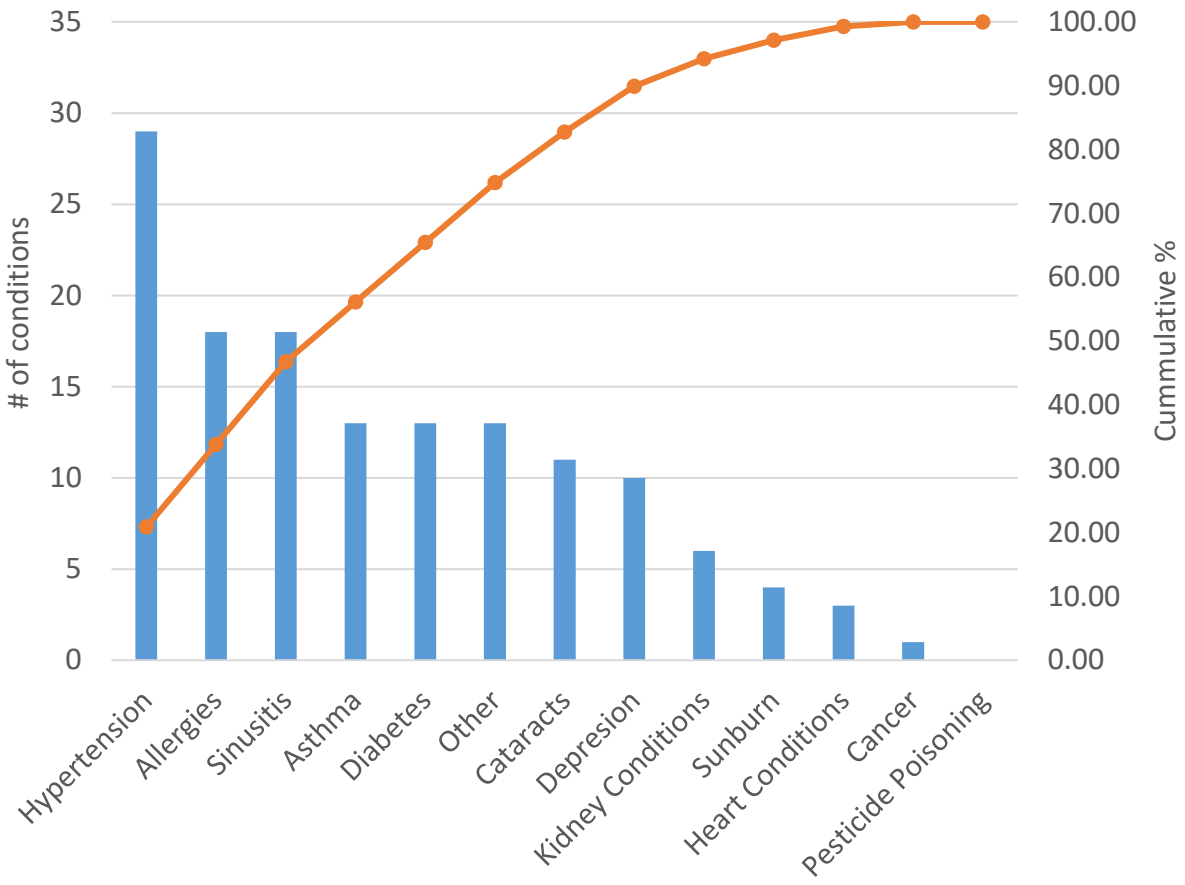


Figure 53:Health conditions among agricultural workers

Chapter 5

In this chapter, the final conclusions related to the findings of this research study will be presented as well as future work that can be developed based on the results from this study.

5.1 Conclusions

As mentioned before, the agricultural industry has always been considered a hazardous industry because of the diverse tasks performed by the workers. The main purpose of this research was to develop a profile related to MSD and discomforts among agricultural workers and to obtain information related to health and safety issues at the farms. From the data of the OPD Clinic of Castañer General Hospital, it was found that in proportion, agricultural workers suffered more from MSD conditions than non-agricultural workers. However, no statistical difference was found within gender variables. This finding is supported by the results cited by Chapman and Meyers (2001) in the National Health Interview Survey of 1988 in which the agriculture, forestry, and fishing workers reported the highest percentage of musculoskeletal conditions. Fadi (2010) also mentioned that MSD conditions are the most common illnesses/injuries among farm workers. In this study, the most common MSD conditions among agricultural and non-agricultural workers were: low back pain and cervicalgia (neck pain) and agricultural workers suffered more from pain in the right shoulder, whereas non-agricultural workers had more diagnostics of pain in the left knee. These results are similar to a study performed in Latino farm workers in which back pain was the most common discomfort among farm workers (Xiao, 2011). Lower back pain was also found to be the most common discomfort among workers in rice farms (Kar & Dhara, 2007). After classifying the MSD conditions per type, it was found that most of the MSD diagnostics of agricultural workers are related to pain or discomfort, whereas the second most common type of MSD diagnostics in both groups were

conditions of arthritis. Pain and arthritis in different parts of the body among agricultural workers has been widely mentioned in literature. For example, Walker-Bone et.al (2002) cited studies performed in Finland, Sweden, and France in which there was found a higher rate of hip osteoarthritis on agricultural workers than in non-agricultural workers. They also mentioned that agricultural workers were at higher risk of developing rheumatoid arthritis when compared with other occupations. Pain is also one of the side effects related to arthritis. Vieser et al. (2013) mentioned that osteoarthritis and rheumatoid arthritis has been associated with musculoskeletal symptoms in agricultural workers with high BMI. Considering that most agricultural workers in Puerto Rico were found to be overweight or obese, it makes sense that both Pain and Arthritis conditions are the most common ones on our population.

The results from the Nordic Modified Questionnaire, show that for both periods of 7 days and 12 months, lower back pain was the most common reported pain among agricultural workers with 66% and 58% respectively. For the period of 12 months, pain in the shoulders was the second most common discomfort among agricultural workers. On the other hand, pain in the hands/wrists was the second most common in the period of 7 days. Lower back pain was also reported to have the highest average level of pain in both periods of time for agricultural workers with 6.39 (SD=2.79) for the period of 12 months and 6.72 (SD=2.53) for the 7 days' period. Lower back pain also had the highest percent of participants reporting to have received some type of treatment to relieve the pain (74%) followed by upper back pain in which 54% of those that reported it received some type of treatment. These results are consistent with the findings of the data of the OPD clinic of Castañer General Hospital and with literature in which pain in the back is in the top offender list among agricultural workers (See Table 7). Lower back pain among agricultural workers is common ground throughout literature. In a study among farm workers in Colorado, lower back pain was the most common discomfort among this population

(Huiyun Xiang et al., 1999). Also, 37% of farmers in Ireland reported suffering from lower back pain (Osborne et al., 2010). No significant difference was found in the reported level of pain in the different parts of the body among both periods of time. The highest percent of participants that reported that their job was affected because of pain were those who suffered upper back and lower back pain with 56% and 59% of the participants, respectively. As per these findings, appropriate trainings and tools to help reduce the presence of lower back pain should be made more accessible to agricultural workers as this discomfort is the most common and with more negative effects among this population.

As per the Random Forest algorithm developed as part of the data analysis of the questionnaire, the area of the body, age of the workers, years of experience in the agricultural industry, and academic degree were the most influential variables in the level of pain reported by the agricultural workers.

Questionnaire responses and OPD Clinic of Castañer General Hospital records, both show that 71% and 74.95% of the individuals are overweight or obese. As mentioned before, individuals considered to be overweight or obese are at a higher risk of developing musculoskeletal pain and suffer from lower recovery of these symptoms.

The questionnaire also revealed that 99% of participants reported to use at least one PPE while performing their tasks at the farm. For sun protection, 97% of them reported to use some type of protection to avoid sunburns, such as long pants and long sleeve shirts, and most of them use multiple items to protect themselves from the sun. This is important given the fact that 67% of participants spend in average 6-8 hours under direct sun exposure and 24% of them spend 3-5 hours under direct sun.

Related to safety education, 84% of the participants reported to know the risks related to the tasks in the farm, 89% assured that safety was a priority in the work environment, and 68%

reported that they have received some type of training to perform their tasks in a safely manner. However, no evidence was found of a relationship between the training received by the workers and the reported level of pain in the different parts of the body. From the interviews, the perception was that the safety training received by the participants was related to pesticide awareness and not necessarily in techniques to perform the tasks in a safely manner that helped them avoid injuries.

Cardiovascular conditions were the most common diseases reported by agricultural workers. Hypertension was widely spread among farm workers with 29% of the participants reporting it. Asthma and sinusitis, both classified as respiratory conditions were the second most common diseases among farm workers in Puerto Rico. Frank et al. (2004) mentioned that bronchitis was the most common respiratory disease among farm workers, however it also mentioned that 25% of animal feeding operators suffered from sinusitis. Although in our study it was found that asthma was the third most common respiratory disease among agricultural workers, Frank et al (2004) cited that the prevalence of asthma among this population is lower than the general population of workers.

Although a convenience sample like the one used in Phase II of our study can't be used to obtain definitive conclusions about a group, the data of the OPD Clinic at Castañer General Hospital can be used to validate the results obtained with the questionnaire of Phase I. It can be concluded that: a) there is a higher proportion of agricultural workers with MSD conditions than non-agricultural workers (P-value=0.001), b) the median of MSD diagnostic for each agricultural worker (2.25 MSD diagnostic/worker)is significantly higher than for non-agricultural workers (1.94 MSD diagnostic/worker; P-value=0.004), c) lower back pain was reported with the highest level of pain in the periods of 7 days and 12 months and the discomfort that lead to more people

to seek for medical assistance, d) age, years of experience, body area, and education are the most relevant variables related to level of pain.

Based on the findings of this research and the evidences found through literature, the following recommendations can be implemented to improve the quality of life of this population:

- Implementation of local regulations and policies for the prevention of occupational risks in our agricultural industry. The Puerto Rico Occupational Safety and Health Agency (PROSHA) can establish specific rules, standards, regulations and procedures for the protection and well-being of the agricultural workers.
- Strengthening the promotion and participation in wellness programs as well as occupational health coaching and counseling without any cost to agricultural workers to help reduce the obesity problem in the agricultural and working population. These programs can be provided by the Puerto Rico Department of Health, PROSHA and the Agricultural Extension Service, as well as nonprofit organizations.
- Develop educationally appropriate and participatory safety and health trainings that consider health literacy. These trainings must include all specific topics regarding safety and health issues that occurs in the agricultural industry such as:
    - Ergonomics
    - Heat stress
    - Pesticides management
    - Importance and use of PPE at the farms
    - Machine safety and guarding

  Also, the inclusion of overweight/obesity prevention and education would be helpful for the adoption of healthy lifestyles among agricultural workers.

- Invest in research to develop tools and machinery that facilitate the manual labors at the farm to avoid or reduce repetitive movements, lifting heavy loads, among others.
- Develop a surveillance system related to MSDs and other occupational diseases to address and track the risks of injuries and illness occurring in the agriculture workers to improve the occupational environment of this population.
- Require and enforce a recordkeeping program specifically for the agricultural populations related to MSDs and injuries in addition to OSHA Injury and Illness Recordkeeping (OSHA-300) regardless of the number of workers at the farm.

As cited by Davis and Kotowski (2007), MSD conditions are responsible of $167 million in losses every year in the agricultural industry in the United States. In addition, MSD among agricultural workers has been increasing throughout the years. These factors highlight the relevance of taking concrete actions in favor of reducing the incidence of MSD conditions among agricultural workers. Some of the benefits that can be obtained by the implementation of public policy to control, prevent, and reduce MSD cases in the agricultural industry are: a) reduction of economic losses due to these conditions, b) encourage the participation in the agriculture industry to the general population as it became a safer industry to work, c) have a stronger agricultural industry in Puerto Rico that can contribute to a better economy in the Island.

5.2 Future Work

The tasks performed by the agricultural worker are in constant daily change and depend heavily on the type of crop. To obtain a better insight of the musculoskeletal problems suffered by agricultural workers, future work in this area could expand on the:

- Evaluation on the prevalence of MSDs and other occupational risks factors and conditions among other agricultural workers working at different types of crops not considered in this study. This would reduce the variance related to the high variety of tasks performed by the workers that highly depends on the crops in which they are dedicated. Also, it will provide insights into best practices and specific ergonomic measures targeted to each type of crop in respect to its work methods.
- Analysis to determine the economic losses to the local agricultural industry that are caused by work-related MSD conditions in agricultural workers. This is an important factor to assure that employers consider the economic effects to their business because of this issue. Public policy to enhance working conditions for the agricultural workers can also be supported with this type of information. As most of the agricultural workers are under the level of poverty, medical expenses related to their treatment are covered by government subsidized medical plan. Better working conditions can be translated in reduction of medical expenses and improved well-being.
- Development of educational material to raise awareness related to MSD in the agricultural industry among workers and farm owners as well.
- Use of the Ovako Working Analysis System (OVAKO) (Karhu, Kansi, & Kuorinka, 1977) to better understand the specific tasks among agricultural workers that are more likely to cause discomforts or MSDs.

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Appendix A: IRB Approval Letter

Institutional Review Board
CPSHI/IRB 00002053
University of Puerto Rico – Mayagüez Campus
Dean of Academic Affairs
Call Box 9000
Mayagüez, PR 00681-9000

November 21, 2016

Julio Martin Marantes
Industrial Engineering
RUM

Dear student:

As Director of the Institutional Review Board of the University of Puerto Rico - Mayagüez Campus, I have considered your application for the project titled ***Survey of Muscolosketal Disorders among Agricultural Workers in Puerto Rico*** (Protocol num. 20160903). Since your research deals with a sensitive topic, your application required a full IRB Board review.

The IRB Board reviewed your application on November 18. After evaluating your research protocol and supporting documents, the Board requested some modifications, which you addressed in your response to the Board. Therefore, your application is approved effective today and expiring November 20, 2017. We also remind you that our approval does not exempt you from complying with other institutional and governmental requirements related to your research topic and/or funding source.

Federal regulations demand that our office supervise all active research projects. We consider a research project to be active if participants are still being recruited or if recruitment has ceased but data gathering and analysis are not yet complete. If you anticipate that your project will be active beyond the approval expiration date, we ask that you submit an application of extension no later than one month before your approval expires.

Attached please find a copy of your consent form stamped with our committee's official seal of approval. We ask that you used this document during your research project. We remind you that you need to hand a copy of the signed consent form to all research participants.

Any modifications or amendments to the approved protocol or its methodology must be reviewed and approved by the IRB before they are implemented, except in cases where the change is necessary to reduce or eliminate a potential risk for participants. The IRB must be informed immediately if an adverse event or unexpected problem arises related to the risk to human subjects. The IRB must likewise be notified immediately if any breach of confidentiality occurs.

We appreciate your commitment to uphold the highest standards of human research protections and remain.

Sincerely,

Dr. Rafael A. Boglio Martínez
President, Institutional Review Board (IRB)
University of Puerto Rico, Mayagüez Campus
Office: Celis 108
Tel.: (787) 832-4040 Ext. 6277
Web Page: http://www.uprm.edu/cpshi/

Telephone: (787) 832 - 4040 x 6277, 3807, 3808 – **Fax:** (787) 831-2085 –**Webpage:** www.uprm.edu/cpshi
Email: cpshi@uprm.edu

Appendix B: Questionnaire of musculoskeletal discomforts, health, and safety practices at work among agricultural workers in Puerto Rico

Universidad de Puerto Rico
Recinto Universitario de Mayagüez
Colegio de Ingeniería
Departamento de Ingeniería Industrial

Estudio descriptivo sobre dolores musculares, seguridad en el ambiente de trabajo y condiciones de salud en trabajadores agrícolas de Puerto Rico

Hoja Informativa

El propósito de esta investigación es recoger información relacionada a dolores musculares en diferentes partes del cuerpo, seguridad en el trabajo y condiciones de salud de los trabajadores agrícolas en Puerto Rico. Este trabajo es realizado por Julio Martin, estudiante graduado del Departamento de Ingeniería Industrial de la Universidad de Puerto Rico, Recinto Universitario de Mayagüez como parte de los requisitos para la tesis de maestría.

Como parte de la investigación y de manera voluntaria, se le pedirá contestar un cuestionario que tiene tres partes: a) Información personal, b) dolor/molestias en diferentes partes del cuerpo y c) seguridad en el ambiente de trabajo y condiciones de salud. Este estudio no representa ningún tipo de riesgo para usted. Se estima que tomará cerca de 20 minutos completar todas las preguntas del cuestionario. No se ofrecerá ningún tipo de recompensa por su participación en esta investigación.

Toda la información relacionada a su identidad será manejada de manera privada y anónima. En el cuestionario no se recogerá ningún tipo de información que pueda identificarlo. Toda información recogida va a ser utilizada para propósitos únicamente educativos. No se reportarán resultados individuales de los participantes en los reportes.

Su participación de esta investigación es completamente voluntaria y anónima, se puede abstener de responder a alguna pregunta en particular, así como a retirarse de la investigación en cualquier momento sin ningún tipo de penalidad. De igual forma, usted obtendrá una copia de este documento para su referencia. Si desea obtener más información acerca de este proyecto o los resultados finales del mismo se puede comunicar con Julio Martin, al teléfono (939) 579-4165 o por correo electrónico: julio.martin1@upr.edu. De igual forma se puede comunicar con la Dra. Cristina Pomales, supervisora de tesis, por medio de correo electrónico: cristina.pomales@upr.edu.

Encuesta sobre dolores musculares y seguridad ocupacional en trabajadores agrícolas en Puerto Rico

Instrucciones: A continuación, encontrará una serie de preguntas con el propósito de recopilar información demográfica, dolores musculares y sobre salud y seguridad en el ambiente de trabajo. Escoja una sola contestación por cada pregunta o escriba la contestación correspondiente a la pregunta en el blanco provisto. Para su referencia, se ha incluido una imagen del cuerpo humano en este documento.

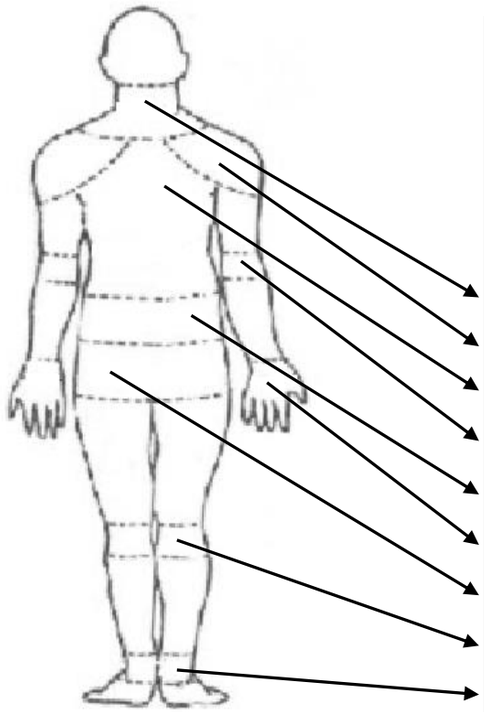
Perfil del participante

1) Edad: _____ años
2) Sexo
    a. Hombre
    b. Mujer
3) ¿Es ciudadano americano?
    a. Si
    b. No
4) Estatura: _____pies _____pulgadas
5) Peso: _____ libras
6) ¿Cuál es el grado de estudios más alto que posee?
    a. escuela elemental
    b. escuela intermedia
    c. escuela superior
    d. grado asociado
    e. bachillerato
    f. maestría
    g. doctorado
7) ¿Cuántos años lleva trabajando en agricultura? _____ años
8) Aproximadamente, ¿Cuántas horas de trabajo diarias usted le dedica a la agricultura? _____ horas diarias
9) Aproximadamente, ¿Cuántos días a la semana trabaja? _____ días a la semana
10) ¿Su mano dominante es la derecha o la izquierda?
    a. Derecha
    b. Izquierda
11) Indique el tipo de cultivos que típicamente trabaja durante el año y el periodo de tiempo (semanas o meses) que dedica a cada uno.

Cultivo	Semanas o Meses
a. _____	_____
b. _____	_____
c. _____	_____

Nivel de Dolor o Molestia en el Cuerpo

Basándose en la Escala de Dolor provista en la hoja adjunta, califique el Nivel de Dolor (0, 2, 4, 6, 8, 10) que ha sentido en las diferentes partes del cuerpo en los pasados 12 meses y en los pasados 7 días.



En los pasados **12 meses**, ¿Ha sentido algún tipo de dolor, molestia o incomodidad en alguna parte del cuerpo?	Nivel de Dolor	En los pasados **7 dias**, ¿Ha sentido algún tipo de dolor, molestia o incomodidad en alguna parte del cuerpo?	Nivel de Dolor
Cuello		Cuello	
Hombros		Hombros	
Espalda Alta		Espalda Alta	
Codos		Codos	
Espalda Baja		Espalda Baja	
Manos/Muñecas		Manos/Muñecas	
Caderas		Caderas	
Rodillas		Rodillas	
Tobillos		Tobillos	

¿Ha recibido algún tipo de atención médica por dolor, molestia o incomodidad en alguna parte del cuerpo?	Cuello	Hombros	Espalda Alta	Codos	Espalda Baja	Manos/Muñecas	Caderas	Rodillas	Tobillos
No he recibido atención médica									
Visita al médico u hospital									
He recibido tratamiento en el hogar									

¿En algún momento su jornada laboral se ha visto afectada por dolor, molestia o incomodidad en alguna parte del cuerpo?	Cuello	Hombros	Espalda Alta	Codos	Espalda Baja	Manos/Muñecas	Caderas	Rodillas	Tobillos
Si									
No									

Seguridad en el ambiente laboral

1) Indique cuál de estos equipos de protección (EPP) si alguno, usted utiliza para realizar sus tareas diarias realizando una marca de cotejo en el espacio provisto (marque todos los que apliquen).

Botas de Seguridad
Gafas de Seguridad
Guantes
Delantal
Mascarilla de Polvo
Respirador
Capacete
Orejeras
Otro:_____
No utilizo ningún EPP

2) ¿Cuántas horas pasa en el sol realizando sus tareas?
    a. Menos de 1 hora
    b. 1-2 horas
    c. 3-5 horas
    d. 6-8 horas
3) Indique tipo de protección solar que usa (marcar todas las que aplique)
    a. Loción o crema solar (*sunblock/sunscreen*)
    b. Camisa/camiseta de mangas largas
    c. Pantalones largos
    d. Gorra o sombrero de ala ancha
    e. Gafas de sol
    f. No uso ningún tipo de protección contra el sol
4) ¿Utiliza plaguicidas (productos químicos) en sus cultivos?
    a. Si. ¿Con cuánta frecuencia utiliza estos plaguicidas?
        i. Diariamente
        ii. 1-2 veces a la semana
        iii. 1-2 veces al mes
        iv. Otro: _____
    b. No
5) ¿Conoce usted los riesgos a la salud asociados a las diferentes tareas que realiza en su trabajo?
    a. Si
    b. No
    c. Conozco un poco del tema
6) Marque su respuesta en el encasillado correspondiente para cada pregunta

Preguntas:	Si	No
¿Ha recibido algún adiestramiento para llevar a cabo sus tareas sin lastimarse?		
¿Siente usted que se le da prioridad a su seguridad en el ambiente de trabajo?		
¿Ha sufrido algún accidente mientras realiza su trabajo?		
¿Utiliza maquinaria pesada en su área de trabajo?		

Hábitos o estilos de vida/condiciones de salud

1) Marque su respuesta en el encasillado correspondiente para cada pregunta

¿Realiza alguna de las siguientes actividades actualmente?	Si	No	No, lo hacía en el pasado
Fumar			
Bebidas alcohólicas			

2) ¿Realiza actividad física?
   a. Si
   b. No
   c. Muy poco
3) Indique si actualmente padece de las siguientes condiciones de salud

Condición de salud	Si	No	Comentario
Alergias			Tipo:
Asma			
Cáncer			Tipo:
Cataratas			
Depresión			
Diabetes			
Enfermedad del corazón			
Enfermedad del riñón			
Envenenamiento por plaguicidas			
Hipertensión (presión alta)			
Quemaduras piel			
Sinusitis			
Otra			Indique:

Estos rostros muestran cuánto algo puede doler. El rostro a mano izquierda no muestra ningún dolor (malestar). Los rostros muestran más y más dolor hasta el último a mano derecha que muestra que ha sentido dolor insoportable en el área.

0 - No he sentido dolor

2 – He sentido un poco de molestia en el área

4 - He sentido bastante molestia en el área

6 - He sentido dolor en el área

8 - He sentido dolor fuerte en el área

10 - He sentido dolor insoportable en el área

Estos rostros muestran cuánto algo puede doler. El rostro a mano izquierda no muestra ningún dolor (malestar). Los rostros muestran más y más dolor hasta el último a mano derecha que muestra que ha sentido dolor insoportable en el área.

0 - No he sentido dolor

2 – He sentido un poco de molestia en el área

4 - He sentido bastante molestia en el área

6 - He sentido dolor en el área

8 - He sentido dolor fuerte en el área

10 - He sentido dolor insoportable en el área

Appendix C: Total number of primary and secondary MSD conditions by type of worker

Table 50: Total number of primary and secondary MSD among agricultural worker

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	305	19.92	19.92
M54.2	122	7.97	27.89
M25.511	73	4.77	32.66
M15.0	65	4.25	36.90
M25.512	53	3.46	40.37
M62.838	52	3.40	43.76
M25.561	51	3.33	47.09
M62.830	46	3.00	50.10
M25.562	45	2.94	53.04
M25.50	33	2.16	55.19
G56.01	24	1.57	56.76
M17.12	22	1.44	58.20
M25.551	21	1.37	59.57
M51.26	19	1.24	60.81
M54.16	19	1.24	62.05
M05.79	16	1.05	63.10
M25.571	16	1.05	64.14
M17.11	15	0.98	65.12
M48.06	15	0.98	66.10
M25.531	13	0.85	66.95
M06.9	12	0.78	67.73
M19.041	12	0.78	68.52
M25.572	12	0.78	69.30
M54.6	12	0.78	70.08
G56.02	11	0.72	70.80
G56.03	11	0.72	71.52
M54.31	10	0.65	72.18
G56.00	9	0.59	72.76
M06.4	9	0.59	73.35
M25.522	9	0.59	73.94
M54.41	9	0.59	74.53
M19.011	8	0.52	75.05
M19.012	8	0.52	75.57
M19.042	8	0.52	76.09
M25.552	8	0.52	76.62
M45.9	8	0.52	77.14
M51.37	8	0.52	77.66
M54.17	8	0.52	78.18
M54.89	8	0.52	78.71
M25.532	7	0.46	79.16
M47.812	7	0.46	79.62
M51.06	7	0.46	80.08
G56.91	6	0.39	80.47
M05.9	6	0.39	80.86
M16.11	6	0.39	81.25
M25.521	6	0.39	81.65
M25.541	6	0.39	82.04
M47.16	6	0.39	82.43
M05.89	5	0.33	82.76
M13.0	5	0.33	83.08
M17.0	5	0.33	83.41
M25.542	5	0.33	83.74
M25.569	5	0.33	84.06
M47.817	5	0.33	84.39
M48.02	5	0.33	84.72
M51.27	5	0.33	85.04
M51.36	5	0.33	85.37
M54.32	5	0.33	85.70
M54.42	5	0.33	86.02
G57.92	4	0.26	86.28
M06.211	4	0.26	86.54
M06.212	4	0.26	86.81
M06.89	4	0.26	87.07
M47.26	4	0.26	87.33
M47.819	4	0.26	87.59
M48.07	4	0.26	87.85
M65.221	4	0.26	88.11
M17.4	3	0.20	88.31
M19.049	3	0.20	88.50
M19.071	3	0.20	88.70

ICD10 Code	Total number of diagnostics	%	Cumulative %
M23.611	3	0.20	88.90
M25.519	3	0.20	89.09
M47.814	3	0.20	89.29
M47.816	3	0.20	89.48
M50.33	3	0.20	89.68
M54.12	3	0.20	89.88
M54.30	3	0.20	90.07
M62.81	3	0.20	90.27
M06.00	2	0.13	90.40
M16.10	2	0.13	90.53
M17.10	2	0.13	90.66
M18.31	2	0.13	90.79
M24.532	2	0.13	90.92
M25.322	2	0.13	91.05
M25.549	2	0.13	91.18
M25.761	2	0.13	91.31
M25.774	2	0.13	91.44
M46.47	2	0.13	91.57
M47.27	2	0.13	91.70
M50.121	2	0.13	91.84
M50.32	2	0.13	91.97
M51.16	2	0.13	92.10
M51.34	2	0.13	92.23
M51.35	2	0.13	92.36
M51.46	2	0.13	92.49
M51.9	2	0.13	92.62
M54.14	2	0.13	92.75
M65.332	2	0.13	92.88
M65.339	2	0.13	93.01
M65.342	2	0.13	93.14
S32.020A	2	0.13	93.27
S52.532A	2	0.13	93.40
S53.125S	2	0.13	93.53
S92.415A	2	0.13	93.66
G56.41	1	0.07	93.73
G56.80	1	0.07	93.79
G56.93	1	0.07	93.86
G57.01	1	0.07	93.93
G57.02	1	0.07	93.99
M05.062	1	0.07	94.06
M05.10	1	0.07	94.12
M05.761	1	0.07	94.19
M06.041	1	0.07	94.25
M06.042	1	0.07	94.32
M06.09	1	0.07	94.38
M13.161	1	0.07	94.45
M13.861	1	0.07	94.51
M13.89	1	0.07	94.58
M15.8	1	0.07	94.64
M15.9	1	0.07	94.71
M16.0	1	0.07	94.77
M19.019	1	0.07	94.84
M19.039	1	0.07	94.91
M19.072	1	0.07	94.97
M19.079	1	0.07	95.04
M19.179	1	0.07	95.10
M19.90	1	0.07	95.17
M23.222	1	0.07	95.23
M24.322	1	0.07	95.30
M24.541	1	0.07	95.36
M24.575	1	0.07	95.43
M25.40	1	0.07	95.49
M25.422	1	0.07	95.56
M25.461	1	0.07	95.62
M25.462	1	0.07	95.69
M25.469	1	0.07	95.75
M25.70	1	0.07	95.82
M25.762	1	0.07	95.89
M25.775	1	0.07	95.95
M46.06	1	0.07	96.02
M46.46	1	0.07	96.08
M47.22	1	0.07	96.15
M47.894	1	0.07	96.21
M47.899	1	0.07	96.28
M50.00	1	0.07	96.34
M50.021	1	0.07	96.41
M50.023	1	0.07	96.47
M50.12	1	0.07	96.54
M50.20	1	0.07	96.60
M50.30	1	0.07	96.67
M50.83	1	0.07	96.73
M51.17	1	0.07	96.80
M51.87	1	0.07	96.86
M54.02	1	0.07	96.93
M54.06	1	0.07	97.00
M54.13	1	0.07	97.06

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.40	1	0.07	97.13
M54.9	1	0.07	97.19
M60.88	1	0.07	97.26
M60.89	1	0.07	97.32
M60.9	1	0.07	97.39
M62.121	1	0.07	97.45
M62.89	1	0.07	97.52
M65.222	1	0.07	97.58
M65.241	1	0.07	97.65
M65.271	1	0.07	97.71
M65.272	1	0.07	97.78
M65.30	1	0.07	97.84
M65.331	1	0.07	97.91
M65.341	1	0.07	97.98
M65.829	1	0.07	98.04
M65.872	1	0.07	98.11
M67.432	1	0.07	98.17
M67.441	1	0.07	98.24
S10.85XA	1	0.07	98.30
S32.028D	1	0.07	98.37
S33.6XXS	1	0.07	98.43
S42.214D	1	0.07	98.50
S43.004A	1	0.07	98.56
S46.101D	1	0.07	98.63
S52.592A	1	0.07	98.69
S53.001D	1	0.07	98.76
S53.442A	1	0.07	98.82
S62.212P	1	0.07	98.89
S68.021S	1	0.07	98.95
S69.80XA	1	0.07	99.02
S69.90XA	1	0.07	99.09
S72.141D	1	0.07	99.15
S76.312S	1	0.07	99.22
S82.002D	1	0.07	99.28
S82.392S	1	0.07	99.35
S83.200D	1	0.07	99.41
S83.211A	1	0.07	99.48
S83.242A	1	0.07	99.54
S83.252D	1	0.07	99.61
S83.412A	1	0.07	99.67
S90.852A	1	0.07	99.74
S92.001A	1	0.07	99.80
S92.405A	1	0.07	99.87
S93.412D	1	0.07	99.93
S93.492D	1	0.07	100.0

Table 51: Total number of primary and secondary MSD diagnostics among non-agricultural workers

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	235	18.40	18.40
M54.2	111	8.69	27.09
M25.562	58	4.54	31.64
M15.0	57	4.46	36.10
M25.511	57	4.46	40.56
M25.512	57	4.46	45.03
M62.830	57	4.46	49.49
M25.50	43	3.37	52.86
M25.561	43	3.37	56.23
M62.838	32	2.51	58.73
M51.26	21	1.64	60.38
M25.552	18	1.41	61.79
M06.9	16	1.25	63.04
M48.07	14	1.10	64.13
G56.02	13	1.02	65.15
M25.551	13	1.02	66.17
M25.572	12	0.94	67.11
G56.01	11	0.86	67.97
M05.79	11	0.86	68.83
M54.16	11	0.86	69.69
M17.0	10	0.78	70.48
M54.6	10	0.78	71.26
M51.37	9	0.70	71.97
M54.31	9	0.70	72.67
G56.00	8	0.63	73.30
M48.02	8	0.63	73.92
M62.81	8	0.63	74.55
M06.00	7	0.55	75.10
M15.8	7	0.55	75.65
M17.11	7	0.55	76.19
M17.12	7	0.55	76.74
M25.531	7	0.55	77.29
M25.571	7	0.55	77.84
M54.17	7	0.55	78.39
M06.211	6	0.47	78.86
M13.0	6	0.47	79.33
M50.33	6	0.47	79.80
M51.16	6	0.47	80.27
M54.41	6	0.47	80.74
M06.89	5	0.39	81.13
M19.012	5	0.39	81.52
M25.541	5	0.39	81.91
M48.06	5	0.39	82.30
M51.27	5	0.39	82.69
M54.89	5	0.39	83.09
M06.4	4	0.31	83.40
M19.011	4	0.31	83.71
M19.049	4	0.31	84.03
M25.532	4	0.31	84.34
M25.542	4	0.31	84.65
M47.22	4	0.31	84.96
M47.812	4	0.31	85.28
M47.819	4	0.31	85.59
M51.36	4	0.31	85.90
M54.9	4	0.31	86.22
M65.30	4	0.31	86.53
G56.03	3	0.23	86.77
M16.10	3	0.23	87.00
M17.10	3	0.23	87.24
M19.042	3	0.23	87.47
M19.90	3	0.23	87.71
M25.519	3	0.23	87.94
M25.521	3	0.23	88.18
M45.9	3	0.23	88.41
M47.26	3	0.23	88.65
M51.06	3	0.23	88.88
M54.12	3	0.23	89.12
M54.30	3	0.23	89.35
M65.341	3	0.23	89.58
M05.19	2	0.16	89.74
M05.369	2	0.16	89.90
M05.70	2	0.16	90.05
M06.80	2	0.16	90.21
M13.161	2	0.16	90.37
M15.9	2	0.16	90.52
M16.11	2	0.16	90.68
M19.029	2	0.16	90.84
M19.041	2	0.16	90.99
M25.522	2	0.16	91.15
M25.559	2	0.16	91.31
M25.569	2	0.16	91.46
M25.579	2	0.16	91.62

ICD10 Code	Total number of diagnostics	%	Cumulative %
M45.7	2	0.16	91.78
M47.16	2	0.16	91.93
M47.813	2	0.16	92.09
M47.817	2	0.16	92.25
M50.10	2	0.16	92.40
M50.20	2	0.16	92.56
M54.32	2	0.16	92.72
M54.42	2	0.16	92.87
M65.272	2	0.16	93.03
S63.492A	2	0.16	93.19
S93.401A	2	0.16	93.34
S93.402A	2	0.16	93.50
G57.01	1	0.08	93.58
G57.90	1	0.08	93.66
M05.169	1	0.08	93.74
M05.49	1	0.08	93.81
M05.612	1	0.08	93.89
M05.861	1	0.08	93.97
M06.09	1	0.08	94.05
M16.12	1	0.08	94.13
M17.31	1	0.08	94.21
M17.5	1	0.08	94.28
M19.171	1	0.08	94.36
M23.041	1	0.08	94.44
M24.412	1	0.08	94.52
M24.512	1	0.08	94.60
M24.641	1	0.08	94.68
M24.661	1	0.08	94.75
M25.062	1	0.08	94.83
M25.422	1	0.08	94.91
M25.529	1	0.08	94.99
M25.752	1	0.08	95.07
M25.761	1	0.08	95.14
M25.871	1	0.08	95.22
M47.15	1	0.08	95.30
M47.23	1	0.08	95.38
M47.27	1	0.08	95.46
M47.811	1	0.08	95.54
M47.814	1	0.08	95.61
M47.815	1	0.08	95.69
M47.816	1	0.08	95.77
M47.896	1	0.08	95.85
M47.9	1	0.08	95.93
M48.46XS	1	0.08	96.01
M48.56XA	1	0.08	96.08
M50.120	1	0.08	96.16
M50.13	1	0.08	96.24
M50.22	1	0.08	96.32
M50.30	1	0.08	96.40
M50.322	1	0.08	96.48
M51.24	1	0.08	96.55
M51.25	1	0.08	96.63
M51.35	1	0.08	96.71
M53.88	1	0.08	96.79
M54.05	1	0.08	96.87
M54.15	1	0.08	96.95
M60.80	1	0.08	97.02
M62.82	1	0.08	97.10
M62.831	1	0.08	97.18
M65.222	1	0.08	97.26
M65.311	1	0.08	97.34
M65.312	1	0.08	97.42
M65.321	1	0.08	97.49
M65.331	1	0.08	97.57
M65.332	1	0.08	97.65
M67.431	1	0.08	97.73
S32.050A	1	0.08	97.81
S39.022A	1	0.08	97.89
S43.015S	1	0.08	97.96
S52.002A	1	0.08	98.04
S52.124S	1	0.08	98.12
S52.135A	1	0.08	98.20
S52.302D	1	0.08	98.28
S52.501A	1	0.08	98.36
S52.501E	1	0.08	98.43
S52.571D	1	0.08	98.51
S59.902A	1	0.08	98.59
S62.306A	1	0.08	98.67
S62.645D	1	0.08	98.75
S62.655A	1	0.08	98.83
S62.663A	1	0.08	98.90
S62.663D	1	0.08	98.98
S66.301A	1	0.08	99.06
S76.211A	1	0.08	99.14
S82.221D	1	0.08	99.22
S82.221E	1	0.08	99.30

ICD10 Code	Total number of diagnostics	%	Cumulative %
S82.251B	1	0.08	99.37
S82.842D	1	0.08	99.45
S83.194S	1	0.08	99.53
S83.231A	1	0.08	99.61
S83.231S	1	0.08	99.69
S83.271A	1	0.08	99.77
S92.302P	1	0.08	99.84
S92.514A	1	0.08	99.92
S93.02XA	1	0.08	100.00

Table 52: Total number of primary and secondary MSD diagnostics among female agricultural workers

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	123	16.14	16.14
M54.2	64	8.40	24.54
M15.0	41	5.38	29.92
M25.512	34	4.46	34.38
M62.838	34	4.46	38.85
M25.511	32	4.20	43.04
M25.561	25	3.28	46.33
M62.830	22	2.89	49.21
M25.50	21	2.76	51.97
M25.562	18	2.36	54.33
G56.01	14	1.84	56.17
M17.12	13	1.71	57.87
M25.551	13	1.71	59.58
M17.11	12	1.57	61.15
M05.79	10	1.31	62.47
M25.531	8	1.05	63.52
M19.012	7	0.92	64.44
M19.041	7	0.92	65.35
M25.552	7	0.92	66.27
G56.00	6	0.79	67.06
M19.042	6	0.79	67.85
M54.16	6	0.79	68.64
M54.31	6	0.79	69.42
M54.6	6	0.79	70.21
G56.02	5	0.66	70.87
M25.522	5	0.66	71.52
M51.27	5	0.66	72.18
M54.41	5	0.66	72.83
M05.9	4	0.52	73.36
M06.211	4	0.52	73.88
M06.212	4	0.52	74.41
M06.4	4	0.52	74.93
M06.89	4	0.52	75.46
M06.9	4	0.52	75.98
M19.011	4	0.52	76.51
M25.521	4	0.52	77.03
M25.532	4	0.52	77.56
M25.571	4	0.52	78.08
M25.572	4	0.52	78.61
M48.02	4	0.52	79.13
M48.06	4	0.52	79.66
M51.26	4	0.52	80.18
M05.89	3	0.39	80.58
M17.0	3	0.39	80.97
M19.049	3	0.39	81.36
M23.611	3	0.39	81.76
M25.519	3	0.39	82.15
M25.541	3	0.39	82.55
M25.542	3	0.39	82.94
M47.16	3	0.39	83.33
M47.812	3	0.39	83.73
M48.07	3	0.39	84.12
M50.33	3	0.39	84.51
M51.06	3	0.39	84.91
M51.37	3	0.39	85.30
M54.17	3	0.39	85.70
M54.32	3	0.39	86.09
M54.42	3	0.39	86.48
M54.89	3	0.39	86.88
M62.81	3	0.39	87.27
M65.221	3	0.39	87.66
G56.03	2	0.26	87.93
M16.10	2	0.26	88.19
M17.4	2	0.26	88.45
M25.322	2	0.26	88.71
M25.549	2	0.26	88.98
M25.761	2	0.26	89.24
M45.9	2	0.26	89.50
M46.47	2	0.26	89.76
M47.26	2	0.26	90.03
M50.121	2	0.26	90.29
M51.46	2	0.26	90.55
M65.339	2	0.26	90.81
M65.342	2	0.26	91.08
S53.125S	2	0.26	91.34
G56.41	1	0.13	91.47
G57.01	1	0.13	91.60
G57.02	1	0.13	91.73
M06.00	1	0.13	91.86
M13.161	1	0.13	91.99
M13.89	1	0.13	92.13
M15.8	1	0.13	92.26

ICD10 Code	Total number of diagnostics	%	Cumulative %
M15.9	1	0.13	92.39
M16.11	1	0.13	92.52
M19.019	1	0.13	92.65
M19.039	1	0.13	92.78
M19.071	1	0.13	92.91
M19.072	1	0.13	93.04
M19.079	1	0.13	93.18
M19.179	1	0.13	93.31
M19.90	1	0.13	93.44
M23.222	1	0.13	93.57
M24.322	1	0.13	93.70
M25.40	1	0.13	93.83
M25.461	1	0.13	93.96
M25.462	1	0.13	94.09
M25.469	1	0.13	94.23
M25.569	1	0.13	94.36
M25.762	1	0.13	94.49
M46.46	1	0.13	94.62
M47.22	1	0.13	94.75
M47.27	1	0.13	94.88
M47.814	1	0.13	95.01
M47.817	1	0.13	95.14
M47.899	1	0.13	95.28
M50.021	1	0.13	95.41
M50.023	1	0.13	95.54
M50.12	1	0.13	95.67
M50.20	1	0.13	95.80
M51.16	1	0.13	95.93
M51.17	1	0.13	96.06
M51.87	1	0.13	96.19
M51.9	1	0.13	96.33
M53.3	1	0.13	96.46
M54.02	1	0.13	96.59
M54.12	1	0.13	96.72
M54.13	1	0.13	96.85
M54.30	1	0.13	96.98
M54.40	1	0.13	97.11
M54.9	1	0.13	97.24
M60.88	1	0.13	97.38
M65.271	1	0.13	97.51
M65.272	1	0.13	97.64
M65.30	1	0.13	97.77
M65.331	1	0.13	97.90
M65.332	1	0.13	98.03
M65.341	1	0.13	98.16
M65.872	1	0.13	98.29
S32.020A	1	0.13	98.43
S32.028D	1	0.13	98.56
S33.6XXS	1	0.13	98.69
S42.214D	1	0.13	98.82
S52.592A	1	0.13	98.95
S53.001D	1	0.13	99.08
S53.442A	1	0.13	99.21
S76.312S	1	0.13	99.34
S80.812A	1	0.13	99.48
S83.200D	1	0.13	99.61
S83.211A	1	0.13	99.74
S83.412A	1	0.13	99.87
S93.492D	1	0.13	100.00

Table 53: Total number of primary and secondary MSD diagnostics among male agricultural workers

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	182	23.61	23.61
M54.2	58	7.52	31.13
M25.511	41	5.32	36.45
M25.562	27	3.50	39.95
M25.561	26	3.37	43.32
M15.0	24	3.11	46.43
M62.830	24	3.11	49.55
M25.512	19	2.46	52.01
M62.838	18	2.33	54.35
M51.26	15	1.95	56.29
M54.16	13	1.69	57.98
M25.50	12	1.56	59.53
M25.571	12	1.56	61.09
M48.06	11	1.43	62.52
G56.01	10	1.30	63.81
G56.03	9	1.17	64.98
M17.12	9	1.17	66.15
M06.9	8	1.04	67.19
M25.551	8	1.04	68.22
M25.572	8	1.04	69.26
G56.02	6	0.78	70.04
G56.91	6	0.78	70.82
M05.79	6	0.78	71.60
M45.9	6	0.78	72.37
M54.6	6	0.78	73.15
M06.4	5	0.65	73.80
M13.0	5	0.65	74.45
M16.11	5	0.65	75.10
M19.041	5	0.65	75.75
M25.531	5	0.65	76.39
M51.36	5	0.65	77.04
M51.37	5	0.65	77.69
M54.17	5	0.65	78.34
M54.89	5	0.65	78.99
G57.92	4	0.52	79.51
M19.011	4	0.52	80.03
M25.522	4	0.52	80.54
M25.569	4	0.52	81.06
M47.812	4	0.52	81.58
M47.817	4	0.52	82.10
M47.819	4	0.52	82.62
M51.06	4	0.52	83.14
M54.31	4	0.52	83.66
M54.41	4	0.52	84.18
G56.00	3	0.39	84.57
M17.11	3	0.39	84.95
M25.532	3	0.39	85.34
M25.541	3	0.39	85.73
M47.16	3	0.39	86.12
M47.816	3	0.39	86.51
M05.89	2	0.26	86.77
M05.9	2	0.26	87.03
M17.0	2	0.26	87.29
M17.10	2	0.26	87.55
M18.31	2	0.26	87.81
M19.042	2	0.26	88.07
M19.071	2	0.26	88.33
M24.532	2	0.26	88.59
M25.521	2	0.26	88.85
M25.542	2	0.26	89.11
M25.774	2	0.26	89.36
M47.26	2	0.26	89.62
M47.814	2	0.26	89.88
M50.32	2	0.26	90.14
M51.34	2	0.26	90.40
M51.35	2	0.26	90.66
M54.12	2	0.26	90.92
M54.14	2	0.26	91.18
M54.30	2	0.26	91.44
M54.32	2	0.26	91.70
M54.42	2	0.26	91.96
S52.532A	2	0.26	92.22
S92.415A	2	0.26	92.48
G56.80	1	0.13	92.61
G56.93	1	0.13	92.74
M05.062	1	0.13	92.87
M05.10	1	0.13	93.00
M05.761	1	0.13	93.13
M06.00	1	0.13	93.26
M06.041	1	0.13	93.39
M06.042	1	0.13	93.51
M06.09	1	0.13	93.64

ICD10 Code	Total number of diagnostics	%	Cumulative %
M13.861	1	0.13	93.77
M16.0	1	0.13	93.90
M17.4	1	0.13	94.03
M19.012	1	0.13	94.16
M24.541	1	0.13	94.29
M24.575	1	0.13	94.42
M25.422	1	0.13	94.55
M25.552	1	0.13	94.68
M25.70	1	0.13	94.81
M25.775	1	0.13	94.94
M46.06	1	0.13	95.07
M47.27	1	0.13	95.20
M47.894	1	0.13	95.33
M48.02	1	0.13	95.46
M48.07	1	0.13	95.59
M50.00	1	0.13	95.72
M50.30	1	0.13	95.85
M50.83	1	0.13	95.98
M51.16	1	0.13	96.11
M51.9	1	0.13	96.24
M54.06	1	0.13	96.37
M60.89	1	0.13	96.50
M60.9	1	0.13	96.63
M62.121	1	0.13	96.76
M62.89	1	0.13	96.89
M65.221	1	0.13	97.02
M65.222	1	0.13	97.15
M65.241	1	0.13	97.28
M65.332	1	0.13	97.41
M65.829	1	0.13	97.54
M67.432	1	0.13	97.67
M67.441	1	0.13	97.80
S32.020A	1	0.13	97.92
S43.004A	1	0.13	98.05
S46.101D	1	0.13	98.18
S62.212P	1	0.13	98.31
S68.021S	1	0.13	98.44
S69.80XA	1	0.13	98.57
S69.90XA	1	0.13	98.70
S72.141D	1	0.13	98.83
S82.002D	1	0.13	98.96
S82.392S	1	0.13	99.09
S83.242A	1	0.13	99.22
S83.252D	1	0.13	99.35
S88.012D	1	0.13	99.48
S90.852A	1	0.13	99.61
S92.001A	1	0.13	99.74
S92.405A	1	0.13	99.87
S93.412D	1	0.13	100.0

Table 54: Total number of primary and secondary MSD diagnostics among female non-agricultural workers

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	157	16.63	16.63
M54.2	82	8.69	25.32
M15.0	54	5.72	31.04
M62.830	44	4.66	35.70
M25.512	42	4.45	40.15
M25.562	39	4.13	44.28
M25.511	38	4.03	48.31
M25.50	30	3.18	51.48
M25.561	27	2.86	54.34
M62.838	23	2.44	56.78
M06.9	15	1.59	58.37
M25.552	13	1.38	59.75
M51.26	11	1.17	60.91
G56.01	10	1.06	61.97
G56.02	10	1.06	63.03
M05.79	10	1.06	64.09
M25.551	10	1.06	65.15
M25.572	10	1.06	66.21
M17.0	9	0.95	67.16
M48.07	9	0.95	68.11
M54.31	9	0.95	69.07
M54.6	9	0.95	70.02
M62.81	8	0.85	70.87
M06.00	7	0.74	71.61
M17.12	7	0.74	72.35
G56.00	6	0.64	72.99
M06.211	6	0.64	73.62
M13.0	6	0.64	74.26
M15.8	6	0.64	74.89
M25.531	6	0.64	75.53
M50.33	6	0.64	76.17
M51.16	6	0.64	76.80
M51.37	6	0.64	77.44
M54.16	6	0.64	78.07
M17.11	5	0.53	78.60
M54.41	5	0.53	79.13
M54.89	5	0.53	79.66
M06.4	4	0.42	80.08
M19.011	4	0.42	80.51
M19.012	4	0.42	80.93
M19.049	4	0.42	81.36
M25.541	4	0.42	81.78
M25.571	4	0.42	82.20
M47.22	4	0.42	82.63
M47.819	4	0.42	83.05
M48.02	4	0.42	83.47
M54.9	4	0.42	83.90
M65.30	4	0.42	84.32
G56.03	3	0.32	84.64
M16.10	3	0.32	84.96
M17.10	3	0.32	85.28
M19.042	3	0.32	85.59
M25.519	3	0.32	85.91
M45.9	3	0.32	86.23
M47.812	3	0.32	86.55
M48.06	3	0.32	86.86
M51.06	3	0.32	87.18
M51.27	3	0.32	87.50
M54.17	3	0.32	87.82
M05.19	2	0.21	88.03
M05.369	2	0.21	88.24
M05.70	2	0.21	88.45
M06.80	2	0.21	88.67
M06.89	2	0.21	88.88
M13.161	2	0.21	89.09
M15.9	2	0.21	89.30
M16.11	2	0.21	89.51
M19.029	2	0.21	89.72
M19.041	2	0.21	89.94
M19.90	2	0.21	90.15
M25.521	2	0.21	90.36
M25.532	2	0.21	90.57
M25.559	2	0.21	90.78
M25.579	2	0.21	91.00
M45.7	2	0.21	91.21
M47.16	2	0.21	91.42
M47.26	2	0.21	91.63
M47.813	2	0.21	91.84
M47.817	2	0.21	92.06
M50.10	2	0.21	92.27
M50.20	2	0.21	92.48
M51.36	2	0.21	92.69

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.32	2	0.21	92.90
M54.42	2	0.21	93.11
M65.272	2	0.21	93.33
M65.341	2	0.21	93.54
S93.402A	2	0.21	93.75
G57.01	1	0.11	93.86
G57.90	1	0.11	93.96
M05.169	1	0.11	94.07
M05.49	1	0.11	94.17
M05.612	1	0.11	94.28
M05.861	1	0.11	94.39
M06.09	1	0.11	94.49
M16.12	1	0.11	94.60
M17.31	1	0.11	94.70
M17.5	1	0.11	94.81
M19.171	1	0.11	94.92
M23.041	1	0.11	95.02
M24.412	1	0.11	95.13
M24.512	1	0.11	95.23
M25.422	1	0.11	95.34
M25.522	1	0.11	95.44
M25.529	1	0.11	95.55
M25.542	1	0.11	95.66
M25.569	1	0.11	95.76
M25.752	1	0.11	95.87
M25.761	1	0.11	95.97
M47.15	1	0.11	96.08
M47.23	1	0.11	96.19
M47.27	1	0.11	96.29
M47.811	1	0.11	96.40
M47.815	1	0.11	96.50
M47.816	1	0.11	96.61
M47.896	1	0.11	96.72
M48.46XS	1	0.11	96.82
M48.56XA	1	0.11	96.93
M50.120	1	0.11	97.03
M50.13	1	0.11	97.14
M51.24	1	0.11	97.25
M51.25	1	0.11	97.35
M51.35	1	0.11	97.46
M54.05	1	0.11	97.56
M54.12	1	0.11	97.67
M54.15	1	0.11	97.78
M54.30	1	0.11	97.88
M62.831	1	0.11	97.99
M65.222	1	0.11	98.09
M65.311	1	0.11	98.20
M65.312	1	0.11	98.31
M65.321	1	0.11	98.41
M65.331	1	0.11	98.52
M65.332	1	0.11	98.62
M67.431	1	0.11	98.73
S32.050A	1	0.11	98.83
S39.022A	1	0.11	98.94
S43.015S	1	0.11	99.05
S52.135A	1	0.11	99.15
S62.306A	1	0.11	99.26
S76.211A	1	0.11	99.36
S82.842D	1	0.11	99.47
S83.231A	1	0.11	99.58
S83.231S	1	0.11	99.68
S83.271A	1	0.11	99.79
S92.514A	1	0.11	99.89
S93.401A	1	0.11	100.0

Table 55: Total number of primary and secondary MSD diagnostics among male non-agricultural workers

ICD10 Code	Total number of diagnostics	%	Cumulative %
M54.5	78	23.42	23.42
M54.2	29	8.71	32.13
M25.511	19	5.71	37.84
M25.562	19	5.71	43.54
M25.561	16	4.80	48.35
M25.512	15	4.50	52.85
M25.50	13	3.90	56.76
M62.830	13	3.90	60.66
M51.26	10	3.00	63.66
M62.838	9	2.70	66.37
M25.552	5	1.50	67.87
M48.07	5	1.50	69.37
M54.16	5	1.50	70.87
M48.02	4	1.20	72.07
M54.17	4	1.20	73.27
G56.02	3	0.90	74.17
M06.89	3	0.90	75.08
M15.0	3	0.90	75.98
M25.542	3	0.90	76.88
M25.551	3	0.90	77.78
M25.571	3	0.90	78.68
M51.37	3	0.90	79.58
G56.00	2	0.60	80.18
M17.11	2	0.60	80.78
M25.532	2	0.60	81.38
M25.572	2	0.60	81.98
M48.06	2	0.60	82.58
M51.27	2	0.60	83.18
M51.36	2	0.60	83.78
M54.12	2	0.60	84.38
M54.30	2	0.60	84.98
S63.492A	2	0.60	85.59
G56.01	1	0.30	85.89
M05.79	1	0.30	86.19
M06.9	1	0.30	86.49
M15.8	1	0.30	86.79
M17.0	1	0.30	87.09
M19.012	1	0.30	87.39
M19.90	1	0.30	87.69
M24.641	1	0.30	87.99
M24.661	1	0.30	88.29
M25.062	1	0.30	88.59
M25.521	1	0.30	88.89
M25.522	1	0.30	89.19
M25.531	1	0.30	89.49
M25.541	1	0.30	89.79
M25.569	1	0.30	90.09
M25.871	1	0.30	90.39
M47.26	1	0.30	90.69
M47.812	1	0.30	90.99
M47.814	1	0.30	91.29
M47.9	1	0.30	91.59
M50.22	1	0.30	91.89
M50.30	1	0.30	92.19
M50.322	1	0.30	92.49
M53.88	1	0.30	92.79
M54.41	1	0.30	93.09
M54.6	1	0.30	93.39
M60.80	1	0.30	93.69
M62.82	1	0.30	93.99
M65.341	1	0.30	94.29
S52.002A	1	0.30	94.59
S52.124S	1	0.30	94.89
S52.302D	1	0.30	95.20
S52.501A	1	0.30	95.50
S52.501E	1	0.30	95.80
S52.571D	1	0.30	96.10
S59.902A	1	0.30	96.40
S62.645D	1	0.30	96.70
S62.655A	1	0.30	97.00
S62.663A	1	0.30	97.30
S62.663D	1	0.30	97.60
S66.301A	1	0.30	97.90
S82.221D	1	0.30	98.20
S82.221E	1	0.30	98.50
S82.251B	1	0.30	98.80
S83.194S	1	0.30	99.10
S92.302P	1	0.30	99.40
S93.02XA	1	0.30	99.70
S93.401A	1	0.30	100.0

Appendix D: Classification of MSD conditions

Table 56: MSD condition classification for agricultural workers

Category	Description	Code	# of diagnostics
Pain	Low back Pain	M54.5	305
Pain	Cervicalgia	M54.2	122
Pain	Pain in the right shoulder	M25.511	73
Pain	Pain in left shoulder	M25.512	53
Pain	Pain in right knee	M25.561	51
Pain	Pain in left knee	M25.562	45
Pain	Pain in unspecified joint	M25.50	33
Pain	Pain in right hip	M25.551	21
Pain	Pain in right ankle and joints of right foot	M25.571	16
Pain	Pain in right wrist	M25.531	13
Pain	Pain in left ankle and joints of left foot	M25.572	12
Pain	Pain in thoracic spine	M54.6	12
Pain	Pain in left elbow	M25.522	9
Pain	Pain in left hip	M25.552	8
Pain	Other dorsalgia	M54.89	8
Pain	Pain in left wrist	M25.532	7
Arthritis	Primary generalized osteoarthritis	M15.0	65
Arthritis	Unilateral primary osteoarthritis of the left knee	M17.12	22
Arthritis	Rheumatoid arthritis of multiple sites	M05.79	16
Arthritis	Rheumatoid arthritis	M06.9	12
Arthritis	Primary osteoarthritis in the right hand	M19.041	12
Arthritis	Inflammatory polyarthropathy	M06.4	9
Arthritis	Primary osteoarthritis, right shoulder	M19.011	8
Arthritis	Primary osteoarthritis of the left shoulder	M19.012	8
Arthritis	Primary osteoarthritis, left hand	M19.042	8
Arthritis	Ankylosing spondilitis of unspecified sites in spine	M45.9	8
Arthritis	Unilateral primary osteoarthritis of the right knee	M17.11	15
Muscle	Muscle spasm of back	M62.830	46
Discs and nerves	Intervertebral disc displacement in the lumbar region	M51.26	19
Discs and nerves	Radiculopathy of the lumbar region	M54.16	19
Discs and nerves	Spinal stenosis in the lumbar region	M48.06	15
Discs and nerves	Sciatica, right side	M54.31	10
Discs and nerves	Lumbago with sciatica in the right side	M54.41	9
Discs and nerves	Other intervertebral disc degeneration, lumbosacral region	M51.37	8
Discs and nerves	Radiculopathy of lumbosacral region	M54.17	8

Category	Description	Code	# of diagnostics
Discs and nerves	Spondylosis without myelopathy or radiculopathy, cervical region	M47.812	7
Discs and nerves	Invertebral disc disorders with myelopathy, lumbar region	M51.06	7
Discs and nerves	Carpal tunnel syndrome in right upper limb	G56.01	24
Discs and nerves	Carpal tunnel syndrome in the left upper limb	G56.02	11
Discs and nerves	Carpal tunnel syndrome in bilateral upper limbs	G56.03	11
Discs and nerves	Carpal tunnel syndrome in unspecified upper limb	G56.00	9

Table 57: MSD condition classification for non-agricultural workers

Category	Description	ICD-10 Code	# of diagnostics
Pain	Low back pain	M54.5	235
Pain	Cervicalgia	M54.2	111
Pain	Pain in left knee	M25.562	58
Pain	Pain in right shoulder	M25.511	57
Pain	Pain in left shoulder	M25.512	57
Pain	Pain in unspecified joint	M25.50	43
Pain	Pain in right knee	M25.561	43
Pain	Pain in left hip	M25.552	18
Pain	Pain in right hip	M25.551	13
Pain	Pain in left ankle and joints of left foot	M25.572	12
Pain	Pain in thoracic spine	M54.6	10
Pain	Pain in right wrist	M25.531	7
Pain	Pain in right ankle and joints of right foot	M25.571	7
Arthritis	Primary generalized osteoarthritis	M15.0	57
Arthritis	Rheumatoid arthritis, unspecified	M06.9	16
Arthritis	Rheumatoid arthritis of multiple sites	M05.79	11
Arthritis	Bilateral primary osteoarthritis of knee	M17.0	10
Arthritis	Rheumatoid arthritis without rheumatoid factor, unspecified site	M06.00	7
Arthritis	Other polyosteoarthritis	M15.8	7
Arthritis	Unilateral primary osteoarthritis of right knee	M17.11	7

Category	Description	ICD-10 Code	# of diagnostics
Arthritis	Unilateral primary osteoarthritis, left knee	M17.12	7
Arthritis	Rheumatoid bursitis, right shoulder	M06.211	6
Arthritis	Polyarthritis, unspecified	M13.0	6
Muscle	Muscle spasm of back	M62.830	57
Muscle	Other muscle spasm	M62.838	32
Muscle	Muscle weakness (generalized)	M62.81	8
Discs and nerves	Other intervertebral disc displacement in the lumbar region	M51.26	21
Discs and nerves	Spinal stenosis in the lumbosacral region	M48.07	14
Discs and nerves	Radiculopathy, lumbar region	M54.16	11
Discs and nerves	Other intervertebral disc degeneration, lumbosacral region	M51.37	9
Discs and nerves	Sciatica, right side	M54.31	9
Discs and nerves	Spinal stenosis, cervical region	M48.02	8
Discs and nerves	Radiculopathy of the lumbosacral region	M54.17	7
Discs and nerves	Other cervical disc degeneration, cervicothoracic region	M50.33	6
Discs and nerves	Invertebral disc disorders with radiculopathy, lumbar region	M51.16	6
Discs and nerves	Lumbago with sciatica in the right side	M54.41	6
Discs and nerves	Carpal tunnel syndrome in left upper limb	G56.02	13
Discs and nerves	Carpal tunnel syndrome in right upper limb	G56.01	11
Discs and nerves	Carpal tunnel syndrome in unspecified upper limb	G56.00	8

Appendix E: Percent of missing data per variable

Variables	% of missing data
Age	2.56%
Sex	0%
Years.Experience	0%
Weight.Status	1.71%
Days.Week	0%
Academic.Degree	0%
Hours.Day	0%
Training.received	0%
Period.pain	0%
Body.Area	0%