Quantifying the Work Demands of Municipal Waste Workers to determine Physical Workload and Perception.

By

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THESIS

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ABSTRACT

Objective: This study aimed to quantify physical and perceptual workloads through the nature of the work demands of municipal waste workers. Waste workers investigated were waste collectors, street sweepers [or public cleansers], drivers and mechanics.

Methods: 154 City of Tshwane municipal waste workers volunteered to participate in the study. Observation-based tools were used to measure physical workload namely, the RAMP 1 and 2, REBA and RULA, and the hand-held dynamometer was used for pushing and pulling tasks. Subjective perceptual questionnaires were used to measure Perceptual load namely the NASA TLX and the QWIQ.

Results: Differences in physical workload were evident between the occupation groups. Round bin collection was the waste collection type pertaining to the highest work-related risk of musculoskeletal development. Public cleansers and flatbed truck collectors' results displayed lower task-related risks associated in relation to the other occupations. Significant differences were found between the groups, particularly between waste collectors and drivers [had high workload outputs] in relation to public cleansers [low workload] for both perceptual workload tools. A significant difference was found in the mental and physical demands, as well as the organisational constraints and quantitative workloads. Mechanics showed no significant differences between groups but had high levels of frustration.

Conclusion: A relationship between physical and perceived workload intensity is evident. Development of musculoskeletal diseases and injury shall incur if measures are not reinstated.

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CHAPTER I: INTRODUCTION

1.1. BACKGROUND

Municipal manual solid waste work is comprised of diverse occupations that assist in the functioning of our societal structures (Abou-Elwafa et al., 2012). These occupations include waste collectors; street sweepers and pickers; recyclers; drivers and vehicle mechanics. These occupations require a high physical output compatibility in order for them to complete their relative tasks. The nature of the work demands involved in municipal waste work has been shown to elicit high risk in the development of musculoskeletal disorders and, work-related accidents in many countries (Kuijer & Frings-Dresen, 2004; Lucia et al., 1997). These work-related disorders and accidents are a result of long term exposure to physically taxing environments (Lund, Iversen, & Poulsen, 2001). In addition, research has shown an association between physical work and cognitive appraisal, and as a result the 'weighting' of work upon the worker (Marras & Hancock, 2014). The implication being that although the nature of the work completed may be physically taxing, the task-related and external work factors also influence a worker's perception towards their work. Worker perception can impact performance either by creating an effect on workers, or by exasperating the occurrence of injuries and accidents (Li, Yu, Gao, Maikala, & Tsai, 2009; Marras, 2012). In order to understand this, one must first establish the meaning of work demands.

'Work demands' refers to the tasks, activities and handling of materials that is entailed within the job itself (Ford & Jin, 2015; Sluiter, Frings-dresen, Meij-, & Heisterkamp, 2019). Within any job or task activity there are requisites and objectives that need to be met; measuring work demand activities includes quantifying the work-related demands of the processes used to achieve a specific and measurable goal, using a prescribed method (Teh, Jamson, Carsten, & Jamson, 2014). Workload is the amount of physical exposure and information resources used within a time period or task completion period, to meet the level of performance required (Macdonald, 2003). Workload serves as an indication of the effect the work demand has on the worker as well as the worker's state of mind, or perceived interaction with their work (Teh et al., 2014). There are many ways to measure physiological and biomechanical responses that can indicate either an increase or decrease in workload. These measures include: ergonomic risk assessments, range of motion, acceleration, heart rate, energy

expenditure, and electroencephalography activity. Perception is a state of awareness of your environment including its attributes and dynamics; this occurs through visual, auditory and bodily stimuli (Smith, 2005) Perceptual measures include interviews, subjective self-reports or established questionnaires which quantify the job demands, as well as the environmental, organisational and other external demands and how they influence the worker's view of their work (Lin, Efranto, & Santoso, 2021). Questionnaires such as the NASA-Task Load Index and the Pittsburgh sleep questionnaire can help address perceptual responses. There are also objective cognitive measures that identify mental activity, the increase in wave frequency and intensity in the brain is often a suggestive indicator of situational mental strain, the tool that measures this the electroencephalogram (Boksem, Meijman, & Lorist, 2005).

This study sought to carry this investigation through quantitative workload measures, primarily within the physical workload and perceptions. The workload measures also involve measuring the mechanics of movement in relation to work and its influence on performance (Aritan, 2015). A combination of the physical and perceptual workloads assists in identifying and determining possible injury risks prone to occur if certain movements are actioned (Aritan, 2015). Ford & Jin (2015) state that one's perception towards their workload may contribute to the prediction of strain beyond the workload levels alone.

1.2. STATEMENT OF PROBLEM

The research evidence related to task demands and physical workload characteristics which South African waste workers are subject to is not only limited but also understudied when compared to other countries (Inyang, 2007; Kawakami & Kogi, 2005; P. Kuijer, Frings-dresen, Looze, Visser, & Beek, 2000; Li et al., 2009; Yang, Chang, Chuang, & Tsai, 2001). Using manufacturing and construction occupations as an exemplary basepoint, waste workers have similar work characteristics to these occupations in terms of the manual loading and physical energy required to do their job (Li et al., 2009). However with waste workers, particularly waste collectors and street sweepers, material weight and handling variability amongst the objects handled and the bins lifted, pushed and/ or pulled increases the risk of muscle discomfort and strain (Dempsey & Brien, 2011; Smith & Jiang, 1984). Contrarily within manufacturing processes, the load carried is often consistent and thus becomes easier to monitor and

quantify. Another task demand factor that influences perception and physical workloads is the work completion being determined by homes or streets allocated for the day (Ewis, Mohamed, Hifnawy, & Arafa, 2013; Yang et al., 2001). Office and manufacturing plants often work within the allocated work hours, whereas waste workers must complete the work within their designated areas for the day.

Lastly, although biomechanical movements and physiological outputs are directly related to work/task requirements; the environmental conditions and organisational resources have a dominant impact on municipal waste performance efficiency. This is an important aspect as it feeds greatly into the workers' ability to work and thus their perceptions of work. Thus, through a workload analysis of waste workers, this thesis breaks down work demands and workload characteristics associated. In this, a foundation can be set in addressing the work-related challenges faced by waste workers and contributing methods to improve the work conditions of workers.

1.3. BRIEF OVERVIEW

There has been much literature written on the musculoskeletal and health-related risks in relation to waste collecting in several countries; but there has been no study done within the South African context. Therefore, the aim of this study is to use different methods to quantify the different aspects of workload in the various waste work occupations. From the workload, an understanding of the stressing mechanisms that may result in musculoskeletal strain are investigated and a physical and perceptual level. A few of studies have quantified the task, environmental and social factors within the waste/refuse division that can cause physical strain, if not exasperate, injuries and illnesses that occur. This study seeks to find the movements and individual tasks that impact the worker on a physical and perceptual level. These methods include physical workload assessment tools that can identify and monitor physiological stress as well as biomechanical movement. These methods will also include perceptual workload tools that can assess worker perceptions towards their job as well as other external factors such as environment and organisational influences. The second aim is to compare the data collected between groups to gage the differences in work demands and work perceptions.

Through a work task analysis, utilising ergonomic methods and tools, the identification of 'high risk' movements can be found, and utilised to know which tasks need the most attention if change were to be implemented. The information collected can be observed in relation to age of retirement, job-related injuries and illnesses, employee morale etc. The Tshwane Municipality Waste Sector based in Pretoria, Gauteng, South Africa, was where the research study was administered. The testing and observation took place in 2020 during Covid -19 regulations, therefore it was limited to non-contact assessments , particularly the physical and perceived job demands assessments.

CHAPTER II: REVIEW OF LITERATURE

Waste workers are required to do extensive hours of gross movement work within volatile weather conditions. The nature of the work combined with psychosocial influences, such as civilian interference or outrage as well as organisational, and interpersonal stressors, impact on how the worker does the work and perceives the work. The following section will delve into the nature of the work within the waste sector and the relevant occupations contributing to the waste management system.

2.1. WASTE WORK

Solid waste, also known as “refuse”, “garbage” or “trash”, in this context, is categorised as discarded goods varying in materials from metals, clothing, plastic, glass and food (Bleck & Wettberg, 2012). Waste Generation and disposal is usually classified under one of the following 3 categories: Municipal, Industrial, and Hazardous waste. Municipal waste constitutes of solid waste generated from households as well as small organisations, institutions and businesses. Hazardous waste is liquid or solid refuse that is harmful either chemically, with toxicity, flammability or corrosiveness usually found in heavy metals (Jerie, 2016). Industrial waste is waste resulting from a mass production or attaining of goods. Some examples include waste generated from factories, retail manufacturers, mining and agriculture. This study investigated the municipal waste management category.

Municipal solid waste (MSW) work particularly waste collection is the process civilians are exposed to the most. Municipal waste work in this context refers to the occupations associated in the gathering, collecting and disposing of waste, particularly on the ground level (Figure 1). Waste collectors, street sweepers and drivers, are the most dominantly researched occupation groups whereby their work in relation to occupational health and ergonomic risks has been researched over the years (Çakit, 2015; Ewis, Mohamed, Hifnawy, & Arafa, 2013; Girish, Khanzode, Iqbal, & De, 2015; P. Kuijer, Frings-Dresen, Looze, Visser, & Beek, 2000; P. P. F. Kuijer & Frings-Dresen, 2004; Lund, Iversen, & Poulsen, 2001).

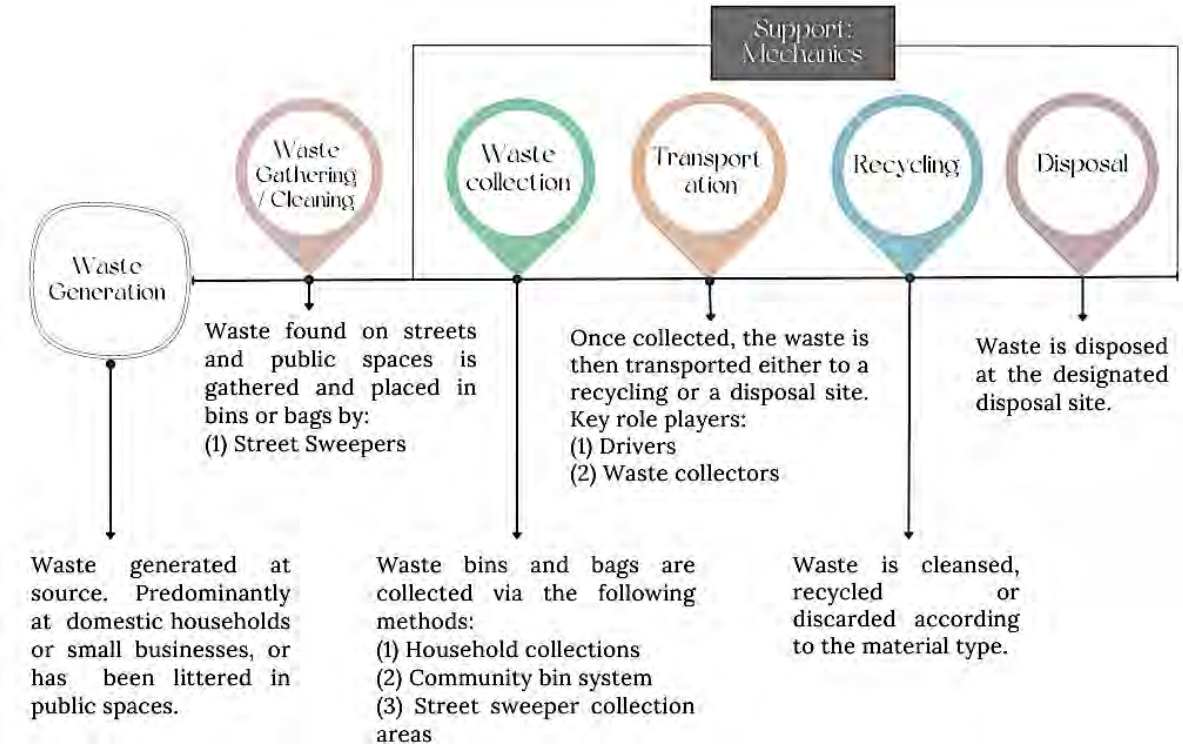

Figure 1: A hierarchical municipal waste management process adapted from several journals (Hilburn, 2019; Abedin & Jahiruddin, 2015. and Inyang, 2007)

Figure 1 displays a conventional waste collection cycle from waste generation to disposal if not recycling. The collection cycle is based off a multitude of literature, the process can vary depending on the situational contexts of different towns, cities and countries (Gazette, 2009; Hilburn, 2019; Inyang, 2007). For this study, the occupation groups mentioned within each phase of the cycle were primary sources of investigation. The only group that was not assessed was the recycling group. Below, a breakdown of the occupation groups is given with regards to their work demands in line with Figure 1, parts of their work description illustrated in literature, as well as the musculoskeletal/ work-related risks associated with these occupations.

2.2. OCCUPATIONAL GROUPS

When it comes to waste work, waste collection is the most cited area of research. However, there are various other occupational functions that assist the functioning of waste management processes. Some of these occupational functions include street sweepers, drivers, mechanics and recyclers. These occupation groups (with the exemption of drivers) all demand gross manual materials handling (MMH) movements. One of the definitions of MMH movements is “any activity requiring the use of force

exerted by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain a person, animal or thing" (cited in Straker, 1999). The task demands involved are physically demanding, exerting frequent energy in bouts, which if unregulated can result in biomechanical and physiological strain (Dempsey, 2010). Each occupation's function enables the health and safety of civilians, helps decrease chemical emissions, and upholds cleanliness within towns and cities. Municipal Solid waste management is governed differently in various countries, states, provinces, cities and towns (DEA, 2019; Gazette, 2009; Sluiter et al., 2019). The occupations identified that shall be discussed below are waste collectors, street sweepers, drivers and mechanics. From epidemiological studies, the nature of the occupations and their working factors from different researchers is compared below.

2.4.1. Waste collectors

Waste collecting requires the worker to retrieve garbage from a household or a commercial region. Their job requires them to pick up the garbage by the given means of the municipality or company. Waste is packaged and disposed of in various ways prior to collection. The methods in which household waste is disposed of is through plastics or paper bags, drums, two- and four-wheeled containers, baskets, pushcarts dustbins or if no disposal site is in reach it would be discarded on the ground (Bleck & Wettberg, 2012; Jayakrishnan, Jeeja, & Bhaskar, 2013; Kuijer & Frings-Dresen, 2004).

Municipal waste collecting is characterised by a series of tasks and the execution differs based on the economic development of the country, as well the technological advancement relative to regions within countries (Bleck & Wettberg, 2012; Çakit, 2015; Jayakrishnan et al., 2013). In most developing countries, waste is collected manually within residential areas (as well as public areas). The manual tasks involve repetitive carrying, lifting, overhead lifting, pushing, and pulling of light to heavy instruments. Heavy or repetitive external physical stressors (the object being utilised) whilst performing a task (pushing or pulling etc.) can cause strain on the musculoskeletal and cardiovascular system (Dempsey, 2010). The prolonged strain on the body can exceed the body's capability to manage, which in minor cases leads to discomfort, fatigue or injury and in major cases, disability, impairment and fatalities.

Mechanised automation in developed countries has assisted in easing the physical stress waste collectors have to undergo. In the US and the Netherlands, the waste management systems use collection trucks with automated lifting devices to empty the bins into the trucks within residential regions (Çakit, 2015; Kuijer & Frings-Dresen, 2004). Whereas in developing countries, a study done in nucleated settlements in Addis Abba, Ethiopia, it became apparent that the lack of automation required more manual labour (Bleck & Wettberg, 2012). Unlike in other studies they had identified collection groups documented as the pre-collectors and collectors. The pre-collectors collect the waste from each home, transferring them on pushcarts, manually lifting the garbage overhead and stacking them into the municipal containers. Thereafter the collectors would physically load onto trucks to be sent to the disposal point (Bleck & Wettberg, 2012).

Unlike the other occupations, waste collection requires exertive lifting, pushing and pulling of waste varying in weight, handling and size. The National Institute of Occupational Health and Safety (NIOSH) (Waters et al. 1993), suggested that under ideal conditions, in an 8-hour work shift, a worker should be lifting a maximal acceptable ‘constant load’ of 23kg. The International Standards Organisation (2007a and 2007b) state that the total load lifted, carried, pushed and pulled should not exceed 10 000kgs per 8-hour shift. Pushing and pulling place stress on the muscles and anatomical structures, particularly around the shoulder and lower back regions (Dempsey & Brien, 2011).

Organisational operations and task completion methods vary from country to country. The worker group of waste collectors are all tasked with different operations. In Taiwan, per compactor vehicle, 3-4 people were allocated. Having to manually load and empty the waste loads to and from the trucks (Yang et al., 2001). In the Netherlands, one driver and two collectors are allocated per truck with hydraulic lifts, where the collector is to push or pull the bin/s correctly between the load-bearing points (Kuijer & Frings-Dresen, 2004).

In the Ethiopian case, subtasks were needed for the [pre]collectors depending on whether the task was done individually or in a group. One to three individuals to (1) push the pushcart to the container, (2) two to climb in and empty the bags and 1 to lift

(Bleck & Wettberg, 2012). As observed, not all waste collection methods are the same, the physical workload of the job places a high risk of developing work-related musculoskeletal disorders or injuries. However, the tasks being done in combination with the environmental elements of the job increase the hazardousness of the occupation.

2.4.2. Street sweepers

Street sweepers are required to remove rubbish from the ground and any other surrounding areas (i.e. trees, beneath bushes and cars) and transfer them to bags or buckets. Sweepers continue this process of collecting litter until their required bags or buckets have been filled. The studies identified when investigating street sweepers do not focus on describing the tools and equipment used by street sweepers, nor the work criteria (i.e. hours spent, quantity of work done). These studies have heavily investigated the bioaerosol exposition of chemicals and fumes to which street sweepers are exposed to daily (Ewis et al., 2013; Jayakrishnan et al., 2013). Although this is very important, the current study focuses on quantifying the external load in relation to the body, in contrast to investigating the effects of the external environment on the physiological respiratory system.

Few studies have assessed the risk of MSD development among street sweepers (Salve & Chokhandre, 2016). Studies conducted among street sweepers have predominantly focused on their exposure hazardous environments resulting in eye, skin and respiratory morbidities. Street sweepers spend extensive hours walking and standing. Leg and lower back discomfort and pain has been associated with prolonged hours of standing and walking (Garcia, Wall, Steinhilber, Läubli, & Martin, 2016). Physiologically, prolonged standing activates the erector spinae muscles to maintain an upright posture. Biomechanical movements of street sweepers involve bending, static posturing, walking and repetitive upper arm lifts and wrist deviations (Adebesin & Adedeji, 2020; Ewis et al., 2013). Upper body weight compressing on the L3/L4 and L5/S1 vertebrae, accompanied by carrying of loads in the hands distal from the body, places more pressure on the lower back area (Fulton, 2013).

2.4.3. Drivers

Waste collection drivers sustain many hours seated within a vehicle (truck, car, open-body flatbed trucks) daily. Their main function is to transport the waste collected within a demarcated area from point A to point B. As cars are becoming more technical with technological advancements, the human resource requirements become more apparent in driving situations (da Silva, 2014). Driving exposes the worker to a broad spectrum of information, both in and outside the car. The driver perceives and interprets the information and constructs a mental presentation of the ongoing situation presented before them (Spielholz et al., 2008 and Endsley, 2020). From this mental presentation, the driver selects which information is relevant and uses that to justify or perform any actions or decisions (Endsley, 2020).

The results of truck drivers in association with road accidents only made up 2% of the referred hospital patients in the waste sector compared to other injuries and accidents. However, the study also mentioned that in the event that an accident occurs, these accidents are near-fatal (Jerie, 2016). A study conducted in Australia investigated drivers' risks and the drivers' perception to their health and safety. The results showed that 51% of drivers suffered from some form of illness if not a chronic illness, with 31% having submitted complaints of habitual back pain (Mayhew and Quinlan, 2000).

2.4.4. Mechanics

There was little to no evidence found pertaining to mechanics in the waste sector. Thus, an investigation into mechanical occupations that are similar to that of the waste sector was completed. The occupation groups found were automotive vehicle repair mechanics and welders. Welders repair and assemble metal components through heat and moulding (Törner, et al., 1991).

Two studies found that musculoskeletal strain in the shoulder and neck are common symptoms in welders (Törner, et al., 1991 and Weyh et al., 2020), with few complaints pertaining to the lower back, and ankle region. The more recent study conducted a 24-week strength and endurance training program and had chosen the trapezius muscle in particular for welders based on previous research having found that peak stress for welders is during overhead repairs, putting pressure on the trapezius. Through the intervention training intervention positive results were found through direct methods

(EMG) and each participant's perception of the strain improvement (using the visual analogue scale (VAS) max and rate of perceived exertion (RPE) max). Their findings deduced that with increased workload strengthening was associated with an increase in muscle capacity, reducing musculoskeletal risk (Weyh et al., 2020).

Vehicle mechanical work requires work both physically and mentally. Prabaswari & Utomo, (2020) state that it is an occupation that requires precision and temporal consistency. Prabaswari & Utomo's (2020) study showed that although the tasks involved in mechanics in indeed physically taxing, the reported results showed that it requires the cognitive requirement exceeds the physical. The reason for a high metal load was due to the problem-solving elements of the job and having to continuously acclimate decisions based on the various models and assembly. The workers in this study also placed time pressure above physical demand, based on voluminous vehicles needing attendance for the day.

2.3. CONTEXTUALISING WASTE WORK

2.3.1. Waste generation and management in South Africa

It is a part of the local government mandate to provide household and commercial waste collection and disposal services (Department of Environmental Affairs, 2019). The regional municipality oversees operating and executing such services. Some municipalities outsource vehicles to compensate for the lack of resources and large collection demands. In metropolitan areas, companies (mostly private) attain subcontracts from the municipalities to assist with waste management performance (Department of environmental affairs, 2019).

According to the Bizcommunity news forum, the South African waste management industry is "constantly developing" and suggest it could be regarded as " as one that is most efficient within the African continent" (Stubbs, 2020). Yet in retrospect, South Africans generates 42 million tonnes of waste per annum according to the 2017 Statistics (Kohler et al., 2018); with 90% disposed to landfill sites, amounting to approximately R25.5 billion worth of waste (Stubbs, 2020). The SA legislation and waste management policy are notably one of the best, yet the Department of Environmental Affairs report stated that the country does not have the human capital

nor the adequate technical capability to support the waste management division (DEA, 2015). The 2019 revised government gazette highlighted that their goal for the country is to establish and promote “waste awareness and a culture of compliance resulting to end pollution, litter and illegal dumping”. The gazette also details a retrospective view of the municipality’s shortcomings in their management and service to the community which they recognize has incentivized individuals to litter (DEA, 2019). Kohler et al., (2018) in their South African waste report, state that littering is an area of concern as it has become a norm for South African citizens.

In 2016, the Department of Environmental affairs conducted a survey finding that 59% of households had their waste collected by either the local authority, service provider or a community member, while 2% of households had their waste collected from a communal container or central collection point (DEA, 2015 and Kohler et al., 2018). Approximately 34% of households disposed of their waste at a communal dump or their own dump, and the remaining 5% of waste was dealt with it through other means (DEA, 2015).

2.3.2. Socioeconomic status of waste workers

Studies have shown differences in socioeconomic factors in waste worker pay, benefits and employment. In July 2019, Pretoria, ZA, the contracted waste collectors protested against the exploited labour brokering (i.e. outsourcing casual labour) for contracted workers; having requested of government to provide equal housing and medical benefits for temporary workers as they do for permanent workers (Rekord Newspaper, 2019). Not all countries permanently employ waste working staff, for instance in Egypt, 55%, of the study’s participants in the waste division, were contracted employees (Ewis et al., 2013). However, since this was a voluntary study, this may not be a true reflection of the distribution of permanent-contracted workers. This was mostly due to the salary payment plan they had described, that was provided either daily or monthly with no organisational health insurance cover; [sometimes] protective equipment; as well as the contract ruling occasionally margining worker constitutional rights through and workers having no salary for missing days. A study in Nigeria found that a few permanent staff received adequate clothing, and the temporary staff received no protective equipment (Inyang, 2007). In Ethiopia, workers were required to buy their own protective gear and were allowed free screenings, but further examinations came

out of their earnings. They were also not paid a salary: an officer would count the sacks collected and one is paid by the volume (Bleck & Wettberg, 2012).

South African waste collectors have one of the lowest earning state occupations at R72000 per annum minimum (R6000/month; approx.. R37.5/hour) (Businesstech, 2016). The minimum wage for a waste collector in the UK is 15000 Euros (R292 009) per annum (i.e.R24 334/month; R101,39/hr) (UK Crown, 2021). The salary received monthly affects one's socioeconomic status and day-to-day affordability. Ewis et al. (2013) found that most of the municipal street sweepers in Beni-Suef, Egypt, acquired an additional job on top of street sweeping to increase their earnings.

2.3.3. Climate and working under unpredictable working conditions

The environment plays a fundamental role in the way waste is collected. Multiple variables from people to settlement design, animals and weather all contribute to the complexities of waste collection. Occupational health related morbidities are the dormant triggers that affect waste collectors. The environment can affect a worker through two pathways: exposure and physical contact pathways. Exposure pathways: smoke and dust emitted from bags or in the air cause eye injuries (Jerie, 2016). There is moderate evidence supporting that adverse health problems like respiratory and gastrointestinal infections have been associated with collectors (Ewis et al., 2013; Inyang, 2007; Ncube, Ncube, Esper, & Voyi, 2017). This can be caused by sudden inhalation of fumes from waste toxins and chemicals (especially when heated upon in the summer); or prolonged exposure to contaminated air propagates respiratory difficulties like chronic bronchitis and asthma (Jerie, 2016). Physical contact pathways: residue off bags can result in direct contact with harmful liquids which cause skin irritations if not infections if placed on open wounds. Transmission of chronic human diseases such as the hepatitis B virus (HBV), human immunodeficiency virus (HIV), fungi, parasites and tetanus has been found in some cases, caused from lacerations, punctures from broken glasses, metal edges and needles (Jayakrishnan et al., 2013; Jerie, 2016).

2.4. ERGONOMICS IN WASTE WORK: WORK DEMANDS, WORKLOADS AND PERCEPTION

Ergonomics is the study of the human at work. The waste sector is known for its labour-intensive job setting. Prolonged collecting, lifting, picking, driving, manoeuvring and managing refuse can be strenuous and exhaustive on the body. Extremes of the job requirements and workload characteristics of the occupation groups in the waste sector can lead to the development of muscle strains and aches, if not errors which could lead to injuries and fatalities. Ergonomics seeks to balance the job requirements with an employee's characteristics and compatibility. Quantifying the job demands thus plays an important role in identifying what strength requirements and job-related strain risks are probable with continuity. Once these are identified, implementations and alternative procedures are introduced to mitigate muscle strain and injury. For this section quantifying work demands can be explained through the stress-strain theory. Environmental conditions, organisational structure, MSDs and their development as well as other hazardous effectors that contribute to the exasperation of the work demands shall be discussed.

2.4.1. Work demands

Work and/or job demands are the effortful factors that contribute, influence and form the composition of the job (Bos, Kuijer, & Frings-Dresen, 2002; Bos et al., 2007; Macdonald, 2003). These factors include the physical, cognitive, social, environmental and organisational facets that create the job. Depending on the job, psychological stress, muscle strain and injury have been identified in highly demanding jobs (Macdonald, 2003). Sometimes the job itself can be demanding, but if the person is also not suitable for that job, it places them at a higher risk of stress or strain. However, employees can be strengthened to allow them to develop the skills and capabilities to deal with work stressors.

For any job, objectives and descriptions are allocated and need to be fulfilled. Physically strenuous jobs can be taxing and can create a misfit between the worker's capabilities and the task requirements (Marras & Hancock, 2014). This misfit if not accounted for, can lead to serious injuries, the development of musculoskeletal diseases (MSDs), and if not cautious could result in fatalities (Lucia et al., 1997). The work demands refer to the tasks, activities and handling of materials that is entailed

within the job itself. In order to quantify workloads, the procedures and tasks involved will highlight where the areas of concern are in relation to the worker and the work. work demand can be defined as the ‘demands of the process of achieving a specific and measurable goal using a prescribed method’ (Teh et al., 2014).

2.4.2. Physical Workloads

Workload depending on the field and its use, has various definitions. (Macdonald, 2003) explaining workload from a human factors psychology perspective states that workload is a “construct emerged from extensive, task-specific research on the capacities and limitations of the human information processing system; it reflects the perceived margin between task demands and an individual’s motivated coping capacity”.

Physical workload can be determined through various methods. Bagherifard et al. (2022) used direct physiological response measures to assess physical workload. Energy expenditure, rate of perceived exertion (RPE) and heart rate were their primary methods of measure. These three have been used in many studies amongst other physiological measures [e.g. hormone concentration, minute ventilation, breathing frequency]. Mean Heart rate was 96.13 ± 18.09, and mean RPE scoring was 16.60 ± 1.94 in their study. Bagherifard et al. (2022) also found that the mean VO2max results for street sweepers was 2.60±0.66 $l.min^{-1}$. The mean physical work capacity (maximum energy consumed within the 8hr work shift) was 4.30 ± 1.09$kcal.min^{-1}$.

A comparative study on waste collectors assessed physical workload and defined it as the percentage of VO2 max [i.e. energy expenditure] during lifting or pushing/pulling (loading) and the average during the course of the day (P. Kuijer et al., 2000). They also compared trunk, arm and knee degrees of movement. The study compared 3 different reports based in the Netherlands, particularly observing the physiological and biomechanical differences between plastic bag and 2-wheeled bin collectors. Percent VO2max for the loading and working day conditions didn’t differ much between the plastic bags (±48% and ±52%) and the two-wheeled bins (±40% and ±45%). However, there was a significant difference found with the rate of perceived exertion in both plastic and two-wheeled bin collectors despite the VO2max being similar. The RPE ratings in the other regions were significantly higher than those in the city of Haarlem;

for both plastics bag and 2-wheeled bin collectors. The authors suggested that this difference was due to contemporary workers having more awareness of occupational risks than those who participated in the earlier study. In addition to this justification, the workers in the other regions spent a significantly greater amount of time working in awkward, strenuous postures, particularly at the level of the trunk and arm. This applied to both plastic bag and wheeled bin collectors (P. Kuijer et al., 2000).

For drivers, in particular, Hoedemaeker (2002, cited in (da Silva, 2014), suggests 3 investigative frameworks to categorise workload. These workload categories are (1) visual workload (e.g., how many types of elements and stimuli the driver has to be visually cognizant of); (2) motor workload (e.g., what are the operating stimuli and processes the driver needs to be physically engaged with?) and (3) mental workload (e.g., the information that needs to be perceived and cognitively processed, and the quantity of the load processing stimuli) (da Silva, 2014).

Workload is the amount of physical exposure and information resources used within a time period or task completion period, to meet the level of performance required. Workload gives an indication of the effect the work demand has on the worker as well as the worker's state of mind or perceived interaction with their work (Teh et al., 2014). This serves purpose to the rising matter of perceptions. A worker's perception of the task gives reason to their ensuing actions and decision. Due to the resultant and close relationship between workload and perception, it is important to factor in perception when measuring and quantifying workload.

2.4.3. Perception

Perception has been investigated vastly, and has a wide array of definitions depending on the field of research and the study objectives when researching perception. (Kirakowski, 2002) discusses evidence suggesting that subjective perception can be characterised "our thoughts and feelings [that] are only triggered by external circumstances". Hancock & Diaz (2002) discuss the integration of other research disciplines to better understand ergonomics and human complexities. In doing this they present perception from the viewpoint of ecological psychology (coined by J.J. Gibbson) which stated that perception is a visual stimulation, the appearance of objects is interpreted directly as meaningful entities. Theories prior to ecological psychology

believed that perceived objects were faulty patterns, which the brain tried to cognitively process and interpret before giving them meaning at face value (Hancock & Diaz, 2002).

The world of work in various workspaces eliciting different work demands also suggests that the perceptual outlook and affecters will differ. The factors affecting perception are not just environmental but are also influenced by the individual's history, context and view of life. In the context of railway operating companies, (Wilson, 2014) found that the company would measure its performance and progress through (1) the feedback on how the civilians perceived their train journey and (2) how the railway company perceived their effectiveness in transport safety. An indicator of their rails perceived to be good, is their rails being able to safely transport goods and people e.g. health care, fresh goods, civilians, fragile goods etc. The civilian feedback is the external input of perception that heavily influences customer retention, whilst the internal inputs of how the company feels they are running can influence change management or continuous sustainment of the current operations. Only one study was found which had investigated perception from an external input with regards to waste collection.

Task demands and the physical aspects of work influence the human on a physiological bodily level, although important, ergonomics theories have gravitated to imploring the social and emotional aspects of the human at work. Using pieces of the contributions to understanding perception, Marras and Hancock (2014) propose perception as a state of awareness of one's environment including its attributes and dynamics; this occurs through visual, auditory and bodily stimuli. Thus, when assessing workloads and effectors onsetting the development of injuries and occurrence of accidents to only be projected towards the work activities at a musculoskeletal or physiological level. Rather to merge the interactive relationship between the individual's perceived cognitive appraisal of the work and environment and the body's response to work stressors placed upon it.

Perception for this study is analysed closer to the definition given by Marras and Hancock (2014). In order to quantify the work demands placed on workers, although objective measures are good, contextualizing the work from the perspective of the

human at work is just as important. In the MSDs section below, examples and explanations are given to how there are multiple internal and external factors that can affect perception and physical strain. The problem is trying to navigate the fine line between individual factors from work-related factors. This take on perception with regards to waste workers is different from previous physical workload studies. Most studies investigated perception in relation to the worker's psychophysical state, through factors such as fatigue and pain. However in quantifying perception in relation to work demands, this study is assessing perception as the deemed workload stressors identified by the workers themselves and their personal evaluation of their task output in relation to the nature of the work.

2.5. MSDS, INJURIES AND OCCUPATIONAL ACCIDENTS

Musculoskeletal diseases (MSDs) are injuries that occur either over time or at an instant, such as carpal tunnel (overtime) or an ankle sprain whilst on duty (instant). These injuries can be strained tendons, sprained ligaments, nerve impingements spinal disc slips, but also lacerations and closed wounds (Alsheikhly and Alsheikhly, 2018; CDC 2020). MSDs affect productivity and have become complicated burdens within organisations, for example, lower back injuries have been identified as one of the most expensive compensation injuries (Çakit, 2015).

Robazzi et al. 1995 (cited in Lucia et al., 1997), completed an investigation on occupational accidents in the waste sector. Their results found that 75% of waste collectors were dismissed due to injuries whilst operating the vehicles, dust exposure, fires, animal bites as well as abrasions and lacerations. The strenuous physical work required of waste workers as well as the repetitive tasks associated, increase the likelihood of employees developing overuse injuries. A study done in Zimbabwe found that 40% of waste collectors suffered lacerations and punctures. Driver-related occupational accidents and injuries have involved the lack or loss of attention which are often a result of mental overload or underload, compounded with factors such as fatigue, stress and impulsive risk-taking driving decisions (da Silva, 2014).

Lower back disorders (LBDs) are common musculoskeletal diseases amongst waste workers. The cause of work-related LBDs is believed to be triggered by a complex multifactorial interaction of physical/biomechanical work demands, psychosocial stress and organisational factors complimented with individual characteristics (Davis, Marras, Heaney, Waters, & Gupta, 2002). Studies have shown that physical/biomechanical work-related influences are the cause of between 11% and 80% of reported low back injuries (Marras, 2012). In addition, environmental, psychosocial and organisational factors attributed to approximately between 14% and 63% of LBDs (Marras, 2012).

An injury occurs when the stress placed on the body surpssed the internal muscle tissue tolerance which causes mechanical strain, resulting in signs and symptoms such as tissue damage, pain, impairment or injury (Davis et al., 2002; Fulton, 2013; Marras, 2000). The “tissue-load tolerance” model has been an influential model in

understanding stress loading, and is still being used contemptuously (Mcgill, 2010). This model explains the law of musculoskeletal injury from a biomechanical perspective (Figure 3).

In the case of the appearance of LBDs, pinpointing the source of injury becomes a challenge due to the multifactorial context of LBD development (Mcgill, 2010). Figure 2 displays the load-tolerance relationship which projects a threshold which muscle tissues are able to be sustained if kept beneath this threshold. During a MMH task operation, an object or task naturally bears a load on the spinal tissues, however if that load exceeds the threshold/tolerance level, injury in the form of tissue damage and structural displacement can occur. Spinal loading is acceptable if it occurs within the safety margin, or tissue load tolerance level, activities bearing loads exceeding this safety margin increases the immanency level of injury. Thus the model assists in illustrating the equilibrium of risk by displaying the relationship between work-related imposed loading in relation to the structural threshold of the spine (Marras 2000).

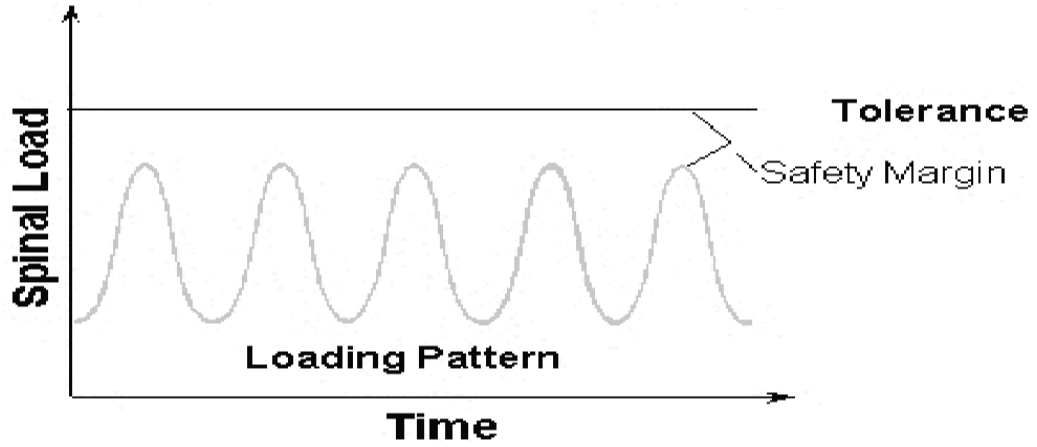

Figure 2: Biomechanical model for injury displaying the load-tolerance relationship for the back (Marras, 2000)

This relationship is however more complex than depicted in Figure 2. In a workday, the load-tolerance relationship can be affected by variables other than direct loading. The most common factors observed and measured are associated with tasks involving task repetition, worker technique, duration and intensity (Bos et al., 2002; Marras & Hancock, 2014). Figure 3 gives a more realistic relationship exchange of the load tolerance. The work environment of waste workers is unpredictable thus the relationship in Figure 2 considers elements of tissue wear and tear. This diagram demonstrates how when a higher load than usual is placed on the muscle tissues, the

contingency of an accident injury increases. In addition to this, instances of spinal overload, although may not cause tissue damage imminently, over time a substantially lower load placed can cause in an injury due to the decline in tissue tolerance (Marras, 2000). This model accounts for frequency and durations and instances of immense tissue loading that was near to causing an instant injury or MSD occurrence. The model identifying the decrease in muscle capacity gives an outline that forecasts the reasoning for injuries that occur even when the load one may have carried or picked up wasn't of tremendous weight. Today a waste worker might pick up a 40kg bag of refuse, but unlike in production where the lifting weight is often set/known prior, the next time a weight like this is picked up for a waste worker could be in the next 20 seconds, hour, next day, and if the individual is not prepared in handling that weight [muscle strengthening], the worker may incur tissue damage from their lack of training or wear and tear of the muscle.

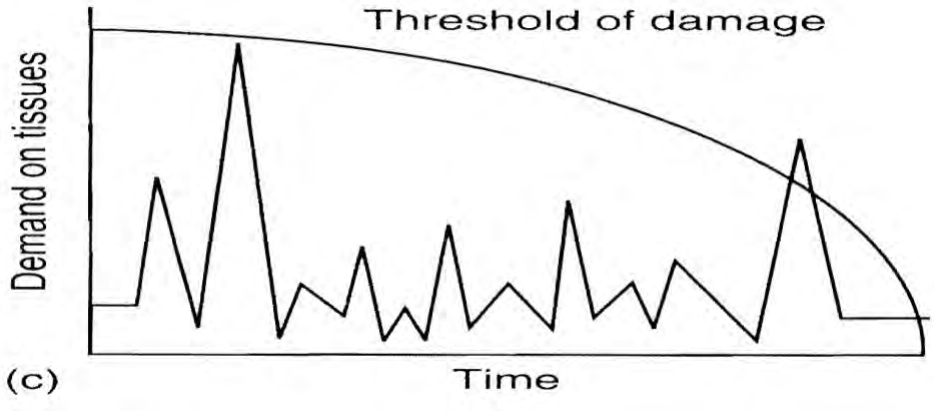

Figure 3: Variable nature of load-tolerance relationship over time (Marras, 2000)

Over the years, studies have shown the strong correlations between perceptual, psychosocial and organisational factors in relation to musculoskeletal disorders. Organisational and psychosocial factors have been shown to influence musculoskeletal pain development, particularly of the lower back such as: perceived effort, job satisfaction, senior management support, safe and comfortable environments, work-related stress, and task monotony (Hart & Staveland, 1988; Marras & Hancock, 2014; Spector & Jex, 1998). Such factors have been shown to contribute to injury causation through the increased internal stress in combination with the imposed load placed on the muscles (Marras, 2012; Marras & Hancock, 2014).

Increased psychosocial stress and perception of effort have shown evidence of decreasing tissue tolerance to loading as well as increasing pain experience. This has also shown to increase recruitment of unfavourable muscle groups, compensating the movement pattern(s) during the performance which can lead to supplementary force being exerted on the musculoskeletal structures causing further tissue damage on surrounding areas (Marras, 2005).

From the theories above and research, there has been a substantial amount of evidence that shows a relationship between MSDs and physical load and perception. Disorders of the back often include tasks such as heavy lifting, twisting, load moment, repetitive hyperflexion when bending, and vibration forces (National Academies of Sciences, Engineering, and Medicine, 2001). National Academies of Sciences, Engineering, and Medicine (2001) has reported that upper extremities disorders are caused by force, repetition, and vibration imposed work-related tasks. Work-related psychosocial factors recognised by the panel to be associated with low back disorders included low decision latitude, low vertical migration, job-related stress factors, high temporal work pace, monotonous work and low job satisfaction. A relative increase in job demands and high job stress have been identified the primary work-related psychosocial factors associated with the occurrence of upper extremity disorders (National Academies of Sciences, Engineering, and Medicine, 2001).

Waste management for workers managing and dealing with the waste itself is predominantly physical. As a result, most of the literature focuses on the physical hazards and health-related risks in relation to physical waste management work. When discussing quantifying waste management workload. Research has focused on the physical workload; however, it has neglected the contribution to the individual's interpretation of that workload which in itself is a very material factor in the quantification of the workload for waste management. This is where the perceptual facet steps in. Engaging in the physical and perceptual load gives greater insight into the world of work of waste workers in the Tshwane Municipal District of South Africa.

2.6. ERGONOMIC METHODS OF WORK ASSESSMENTS

2.6.1. Work familiarisation

The accurate measurement of a worker's exposure to work-related tasks, activities and factors that influence the development of musculoskeletal diseases requires a relative understanding of the work environment, the tasks and the surrounding elements impacting the labouring worker (David, 2005). Work familiarisation is open-ended process that learns about and evaluates the worker within the workplace in order to identify areas that pose risk or injury, generating research interests based on the observation of human performance. Participatory ergonomics describes work familiarisation in the context of the researcher as the process of learning at the technical level of the subject matter (Kuorinka, 1997). Work familiarisation is a contextual paradigm used to better understand the system the worker is operating in. Depending on the investigation, researchers may further categorise the levels of the job through a task analysis. This ergonomic method breaks down the tasks in the job into components, and produces a hierarchical breakdown of the important tools, task lists, and job performance expectations (Annett & Stanton, 2000). Direct and indirect methods and tools are applied after the familiarisistation stage. Methods of collecting, classifying and interpreting analysing physiological, biomechanical and cognitive data based on human performance are selected and applied once the work familiarisation is complete. There are multiple tools available that assess cognitive, physical and biomechanical workload, in their vastness, tools and methods are selected based on their ability to determine the magnitude of influence of the present symptoms; the output of verifying the risks imposed by the work demands, and its ability to yield the prospects of the research aim(s).

2.6.2. Physical and Perceptual workload tools

Many methods can be used to gather both subjective and objective information. There are a variety of ergonomic risk factors that contribute to injuries in the waste management process (Abedin & Jahiruddin, 2015; Bos et al., 2002; P. Kuijer et al., 2000). Understanding the basis of physical and perceptual ergonomics is important to know what tools to use and understanding what area the researcher wants to investigate. Physical ergonomics assesses and characterises the human anatomic, anthropometric, physiological, and biomechanical features of the body in relation to

workplaces, environments and the internal and external factors influencing the system in which the human performs (Mehta, Texas, Station, & Parasuraman, 2013). Cognitive ergonomics investigates the mental processes, such as perception, motor response, memory and reasoning and how these affect the worker during physically or mentally taxing tasks (Mehta, 2016). Over the years, various methods and tools have been developed to assess physical workload stress and exposure.

Perception tools differ depending on the investigation. Most prior waste collector investigations and physical workload studies had investigated worker task perception in relation to the to their psychophysical state (Li et al., 2009; Mackinnon, 2010). Often perception categorised from the feelings of the worker have been under the categories of fatigue, pain or shortness of breath; whilst doing a aerobically demanding task (Thurstone, 2010). The most commonly used tool to assess perception under this state has been the rate of perceived exertion (RPE) scale (Borg & Borg, 2019). Although important, the fatigue attributes are not the sole perceptual attributes sought for this study. In quantifying the perceived workload, tools assisting in identifying what the workload stressor have been selected. Spector & Jex (1998) identified Quantitative workload has been as an important factor in understanding worker strain from their perspective, it also identifies tasks that are deemed challenging and sometimes unpleasant to accomplish. For this reason, the NASA Task Load Index developed by Hart & Staveland (1988), and the Quantitative workload inventory questionnaires developed by Spector & Jex (1998) were selected.

Physiological tools have been used in ergonomics to understand the body's reaction to stress factors, and how to alleviate stress so much so that it doesn't cause burnout, fatigue and work-related injuries (David, 2005). On a physiological level, bodily response indicators have been used to assist in the measurement of physiological load (Dempsey, 2010; Jaiswal, 2018; Wong, Chung, Chan, Wong, & Yi, 2014). Factors that can influence load such as stress, alertness, fatigue are measured by witnessing the increase or decrease in organ or cell functioning i.e. heart rate, blood pressure, skin and core temperature, EEG and EMG (Dempsey, 2010).

Biomechanical exposure tools have been developed in order to identify hazards leading to musculoskeletal disorders, to monitor the effects of ergonomic changes and

what tasks and activities place a person at risk of developing an MSD (David, 2005). Biomechanics based tools assess the movement patterns, observing movement compensations seeking movements that will increase performance and decrease any movements that may illicit strain and injuries (Aritan, 2015). Observed movements include movements posture lifting, repetitive lifting, , overexertion, pulling and pushing, and frequent heavy lifting. Biomechanical measurements include observation-based checklists and risk assessments were made of manual handling tasks, force requirements using a dynamometer, task repetition and duration, and work equipment characteristics and more (David, 2005). More advanced technologies have been able to measure the change in joint angles positions, speed and distance movements in real-time. These technologies include motion capture software, force measurements and biomechanical modelling (Aritan, 2015).

Risk assessment tools are observation-based instruments developed to measure workplace or work-related risks that are assessed and examined by an external observer who records the information on readily formatted sheets (David, 2005). Assessments vary for the different tools, assessing predominately physical workload exposure factors. The advantage of risk assessments is their user-friendly data recording as well as their practicality in various workspaces both in the field, laboratory and office spaces. The aim of the tool is to prescribe within which limits a task is orientated within (i.e. high risk vs low of MSD development). The disadvantage of these tools is that their end result is weighted, thus the interaction between these weighted values is not quantified, or rather can only be quantified through a more direct measure. Multiple assessments may need to be used depending how dynamic the movements within the occupation and the risk assessment itself (David, 2005). Practicality in observing field-based physically taxing, fast-paced environments like the waste collection sector, the robust tools that were utilised identified were , (1) Risk management tool for manual handling proactively (RAMP 1 and 2) the Screening Assessments, the (2) Rapid upper limb assessment (RULA) employee Sheet, the (3) Rapid entire body assessment (REBA) employee sheet.

Work Rose and Lind (2017, cited in Lind et al., 2019) created the RAMP screening tool sto determine -related musculoskeletal risk. The tool evaluates posture, frequency and recovery; lifting loads, repetitive movements, handling as well as pushing and pulling.

The assessment tool also includes a subjective measure which is based on the employees' perceived workload and discomfort (Lind et al., 2019). RAMP 1 is a checklist that assesses and identifies occupational movements that have potential to cause musculoskeletal injuries and accidents. This is a pen and paper tool, having 7 sections looking at different manual materials handling movements. Section (1) focuses on posture, (2) on work movements and repetition, (3) lifting handling, (4) pushing and pulling, (5) influencing physical and psychosocial factors, (6) organisational reports on work accidents and strain, and (7) task-specific perceived discomfort. RAMP 1's tool utilisation requirements include the assessor having base knowledge of physical ergonomics, and the assessor familiarising themselves with the work observed before conducting assessment (Rose and Lind, 2017). An assessor can use this tool on site during an observation or can record video footage of the work done and assess the task during the tape review. The tool requires for the assessor to tick the 'normal' work routine of the task carried out, and document extreme cases of work movements that may occur rarely or frequently warranting a need for assessment. Ramp 2 is a direct observation- based assessment tool which guides and outputs a more intensive investigation of the risk areas identified in RAMP 1 (Nord, Barman, Lind, & Rose, 2020). RAMP 2's inter-rater reliability was statistically displayed as a percent of proportional agreement (p0) and Light's linearly weighted kappa. The p0 value must be >80%, 73% of the RAMP 2 questions received an acceptable reliability. 6 out of 7 sections when averaged proved to be statistically reliable, section (2) work movements and repetition did not meet the requirements (p0 <80%) (Nord et al., 2020).

The RAMP 1 and 2 tool are recently developed tools with information, thus the validated, commonly used reliable tools REBA and RULA have been included for research reliability assurance. The RAMP 2 has user-friendly inclusions for researchers with basic ergonomics knowledge, featured in one instead of utilising several tools: (1) It considers organisational and psychosocial factors, (2) the RAMP tool also factors in time in relation to task/movement execution which can be the difference between acute, immediate or overuse strain, (3) it includes a simple screening method of quantifying lifting and pushing/pulling tasks.

The RULA method has been developed by Dr. Lynn McAtamney and Professor E. Nigel Corlett. The RULA is a risk screening tool, which evaluates musculoskeletal risk

factors and centres its investigation on upper body movements (i.e. upper arms, lower arms, wrist, neck, trunk). Rapid Upper Limb Assessment (RULA). Rapid Upper Limb Assessment is a survey method developed for use in ergonomic investigations of workplaces where work-related upper limb disorders are reported (McAtamney, 1993). Since the RULA method needs no specialised tools, it is not only restrained to experts and professionals, minimal training is required to use this tool, but an understanding of ergonomic safety postures is important. The RULA tool used to measure and verify upper body posture risks imposed by the job on the worker. Diagram illustrations of body postures and scoring tables are used to evaluate risk exposure factors. Completing a RULA on a job task prior to making changes will give you a risk factor for comparison. Once changes to the job task have been implemented a post-RULA should be performed to determine if the changes made have lowered the risk factor. Risk factors addressed in the form are: force, abduction and adduction, pronation and supination, flexion and extension, static and repetitive work. RULA, although accommodating the legs, does not capsulise effects on the legs sufficiently, focusing is on the upper body (David, 2005). RULA is a reliable tool commonly used by engineering and ergonomics professionals.

The REBA was developed by Dr. Sue Hignett and Dr. Lynn McAtamney, to associate the risk of musculoskeletal injury with the recorded postures. Rapid Entire Body Assessment was specifically designed to be sensitive to unpredictable working postures found in health care and other service industries (Hignett & McAtamney, 2000). The development of REBA was aimed to quantify whole body exposure. It determines whether the task done could lead to any injuries that can occur overtime (overuse injuries) or instant injuries that could lead to disabilities or rise in disorders (Hignett & McAtamney, 2004). Unlike RULA, the tool intensively looks at the external load places on the trunk neck and legs, as well as the load coupling at arms level (Motamedzade, Ashuri, Golmohammadi, & Mahjub, 2011).

CHAPTER III: METHODOLOGY

This study measured the physical and organisational stressors and strain placed on waste workers based on their work demands. The workers' perception of work was also measured using quantitative tools. Observation-based and direct tools were used to measure the work demands on a physical level. Questionnaires and interviews were used to assess the organisational demands and the perception of work from the workers' perspective.

Specifically, the study examined the nature of work for each occupation group investigated, quantified the level of musculoskeletal risk or injury associated with the work, and compared the occupation groups highlighting the workload differences between groups from a perceptual and physical perspective using appropriate measures. This chapter describes the methodological investigations, the selection of research design, recruitment of participants, ethics, the phases by which this study was executed, and lastly the analysis of data.

3.1 RESEARCH OBJECTIVE AND DESIGN

3.1.1 Research Aim

Municipal waste workers worldwide accumulate occupational-related musculoskeletal damage and/ or injury (P. Kuijer et al., 2000). This study's aim was to quantify the work demands faced by municipal waste workers through their physical workloads and perception. To reach this objective, different methods were selected to assist in quantifying the physical and perceptual workload through the work demands and external influences amongst various waste work occupations. Municipal waste workers worldwide accumulate occupational-related musculoskeletal damage and/ or injury (P. Kuijer et al., 2000). This study's aim was to quantify the work demands faced by municipal waste workers through their physical workloads and perception. To reach this objective different methods were selected to assist in quantifying the physical and perceptual workload through the work demands and external influences amongst various waste work occupations.

3.1.2 Research Design

The study took the form of a field-based study in Gauteng using quantitative measures to describe the prevalence of workload among municipal waste workers. To measure this the physical and perceptual workload, observational, direct and subjective methods were utilised. The research design applied was a cross-sectional descriptive design. A cross-sectional design seeks to provide information and characteristics of a particular group being the workers in their various occupations in the waste sector (Mann, 2003). A descriptive design approach described the characteristics of the group; which included the age, weight and height, years of experience and other demographic information (Muijs, 2010). The research study required an 'identification/work familiarisation' element to gain an understanding of the different jobs involved within the waste cleaning; collection and disposal processes before data could be collected. Thus, a study concept was developed to split the field investigation into two phases. The concept phases are elaborated below and the instruments within each are detailed further down.

3.1.3 Research Questions and Hypothesis

The following hypotheses were generated for the study.

3.1.3.1 Physical Workload Hypotheses

This hypothesis investigated whether job demands on a physical level would result in an effect between the occupation groups. The null hypothesis stated the various occupation groups would elicit no difference in the mean physical workload quantification. The alternative hypothesis stated there is a difference in mean physical workload between the different occupations.

Research hypothesis 1 : Physical workload between all the occupations

Null hypothesis: H_0: $\mu_{PC} = \mu_{WC} = \mu_{Drivers} = \mu_{Mechanics}$

Alternative Hypothesis: H_A: $\mu_{PC} \neq \mu_{WC} \neq \mu_{Drivers} \neq \mu_{Mechanics}$

3.1.3.2 Perceptual workload Hypothesis

This hypothesis investigated whether perceptual workload would result in an effect between the occupation groups. The null hypothesis stated the various occupation groups would elicit no difference in the mean perceptual responses when quantifying the workers' view of their work. The alternative hypothesis stated there is a difference in the mean perceived workload between the different occupations.

Research hypothesis 2: Perceptual workload between all occupations

Null Hypothesis: H_0: $\mu_{PC} = \mu_{WC} = \mu_{Drivers} = \mu_{Mechanics}$

Alternative Hypothesis H_A: $\mu_{PC} \neq \mu_{WC} \neq \mu_{Drivers} \neq \mu_{Mechanics}$

3.1.4 Research Concept

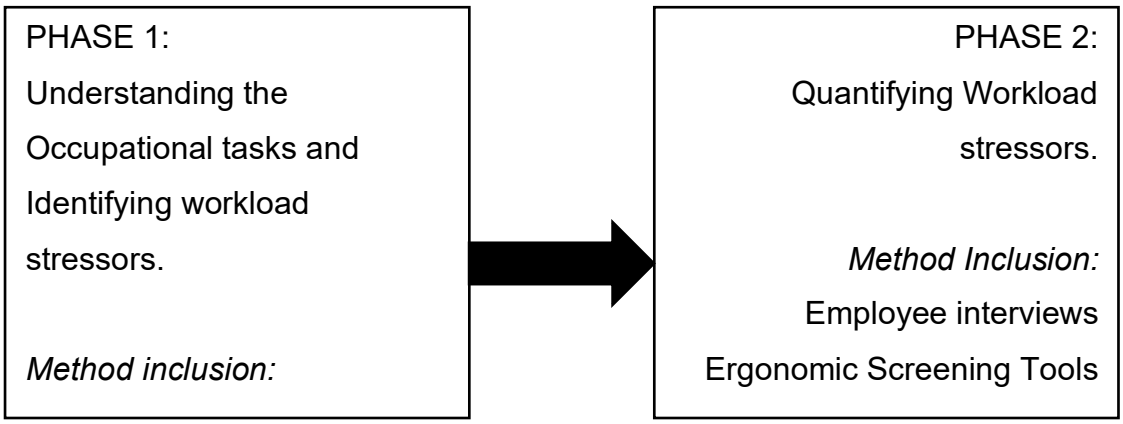

Figure 4: A schematic diagram of the phases of the methodology execution and instrumentation types utilised within each phase.

Phase 1 entailed identifying interactions associated with each occupation. Part of this phase included observing the interactions between the workers, the tasks, the environment and the organisation. Phase 1 observed the physical taxation of each occupation, before any physiological or biomechanical direct measures such as heart rate and energy expenditure. A checklist was used to categorise the movements, repetitions, and general activities done completed by workers within each occupation. This phase used 2 checklists to identify the level of musculoskeletal risk placed on the employees due to their work demands. This assist in determining the stress-strain factors that play a function in the manifestation of musculoskeletal injuries and work

perceptions. This phase only highlighted the areas that could pose risk to the worker. Phase 1 investigated the physical risks coupled with all occupations i.e., public cleansers, waste collectors, mechanics and drivers.

Inverse to Phase 1, Phase 2 did not only highlight areas of risk but categorises the work done within each occupation group; and uses validated instruments to assess which positions and bodily segments were at risk of injury and or strain. Phase 2 involved a more detailed observation and assessment of each occupation, comprehending and investigating the systemic influences associated job demands. Phase 2 with regards to the physical workload evaluation, entailed the inclusion of four objective tools that measured the postural, biomechanical, manual materials handling loads placed on the worker. This phase also included tools that evaluated the cognitive aspect of workload from the perspective of the worker.

Two subjective quantitative tools were used to highlight what workers perceived their areas of taxation were, be it physical, mental or temporal. The tools also identified and could quantify the perceived sentiment of workers in relation to each other, and their superiors. The tools also assist in quantifying the organisation's support with regard to resources, and work autonomy and gives light to ailments and injuries associated with the work. There were restrictions by which the researcher was allowed to assess the work of the various occupation groups. Thus, it is important to note that for the quantification of physical workload only public cleansers [street sweepers] and waste collectors were fully assessed. For the perceptual workload analysis, all occupations were assessed.

Utilising tools that can objectively assess the workloads in conjunction with workers' cognitive view towards their work, is ergonomically essential for captivating the workload factors placed upon waste workers. Wilson (2014), states that ergonomic findings and research are insufficient if only rationed factions of ergonomics are considered i.e. physical, cognitive or organisational. Working is not just a physical accomplishment. There are emotional, cognitive and social interactions established whilst working. The inclusion of subjective questionnaires is to gain a better understanding of workload quantity on the human being.

3.2 PARTICIPANTS

3.2.1 Participant Characteristics

Participants were recruited from the Tshwane Municipal district from different areas such as Basden, Kruger, Atteridgeville and Laudium and the Pretoria West depot site. The sample consisted of both male and female participants. All participants were either employed as permanent or contracted staff members under the Tshwane Municipality. The sample group criteria was: all employees doing physical and manual materials handling work in the waste sector being the 2-wheeled bin waste collectors, round bin collectors, bag collectors on the trucks and flatbeds; public cleaners (street sweepers); vehicle mechanics and drivers. Excluded participants were those in managerial positions and those who did not fit within the above-mentioned occupational categories.

3.2.2 Recruitment

The study used a convenient sampling strategy. Participants were recruited with the aid of the Director of Waste Services and the team at the Tshwane Municipality, Pretoria. Information was spread through word of mouth by the Director, the supervisors and the researcher. Participants were informed that participation is voluntary and that they may decide to withdraw from the study at any time.

3.3 ETHICAL CONSIDERATIONS

3.3.1 Ethical Clearance:

The study received ethical approval from the Rhodes University Human Kinetics Ethics Committee under the reference number 2020-1603-4682 (see Appendix A). Gatekeeper permission was granted by the City of Tshwane Waste sector Director and provided by the City of Tshwane Strategy and Organisational performance Unit (*Appendix B*). Approval from both institutions was consented to prior to participant recruitment and data collection.

3.3.2 Informed Consent:

Prior to participation, the understanding of consent and information about the study was provided verbally and written (*Appendix C*)

3.3.3 Participation and Anonymity

Participation was voluntary, and participants were reassured that they could withdraw from the study at any time and the study will in no way affect their employment status. Data was collected on pen-and-paper, all information collected during this study period was strictly confidential. Individual identification remained anonymous, to ensure anonymity, participant data was coded. All information was stored indefinitely for use in future publications, in conferences and seminars but remained coded as well to guarantee anonymity. Research findings were shared with the Municipality as well.

3.4 PHASE 1

3.4.1 Aim

The aim of this phase was to observe and identify key components of the work environment and work tasks accomplished; this is done through work familiarisation. Recognising the potential workload stressors associated with each occupation was the crux of this phase. In accomplishing this, observations and checklists were utilised.

3.4.2 Instrumentation:

Two screen checklists were used for this phase of data collection: the OHSA ergonomics assessment checklist and the RAMP 1 screening assessment tool.

3.4.2.1 Occupational Safety and Health Act (OSHA) Ergonomic Risk Assessment

The OSHA assessment tool is a ‘yes/no’ checklist, that analyse human-task movement interactions. The tool focuses on tool handling, lifting, vibration & impact tools, workstation height and isolated limb specific task-human impact (OSAH, 2021). The limb areas targeted are the back, wrist, elbow and neck. The tool also allows for any already present organisational musculoskeletal reports or concerns to be included. The OSHA tool is a direct observation, pen -and paper instrument. It is for onsite use and assists with getting a better understanding of the task. The results of the tool give a risk prevalence rating between Low, Medium and High risk, depending on the number of ‘yes’s accounted post observation. An activity is classified as ‘High Risk’, if the researcher answered ‘yes’ to selective questions and/or 6 or more questions.(OSAH, 2021). In application, this tool assisted in identifying the stressors

of the task (i.e. public cleansing, waste collecting, mechanics or driving) on the worker (*Appendix D*).

3.4.2.2 Risk Management Tool for Manual Handling Proactively 1 (Ramp 1) Screening Assessment

The RAMP 1 screening assessment tool focusses on positions, movements and repetitions used in manual materials handling tasks (Rose and Lind, 2017). RAMP 1 checklist is a pre-check answering sheet to identify areas that are applicable to the work task observed, the assessor is to only tick 'yes' or 'no' if the presence of the work task exists. The results of this analysis display the presence of any potential risk. Part 2 (RAMP 2), then measures the degree of that potential risk (Appendix E). For this study, RAMP 1 tool could only be applied for tasks with manual material handling tasks, thus was only applied for the public cleansers, waste collectors. This tool was not suitable in application to the work accomplished by the mechanics. The tool requires a certain level task or routine consistency. The mechanics however, only worked when needed or if a mechanical problem appeared on site (Appendix E)

Table 1: The Occupation groups assessed and not assessed with the Tools utilised in Phase 1

		Occupations						
		Waste Collectors				Public Cleansers	Mechanics	Drivers
		2- Wheeled bins	Round Bins	Truck Bags	Flatbed bags			
Instruments	OHSA	✓	✓	✓	✓	✓	✓	✓
	RAMP 1	✓	✓	✓	✓	✓	✗	✗

3.4.3 Procedure:

Upon entering each depot site, permission from the Depot supervisor was required to enter the premises. Depending on the weather, and conditions of trucks, a group of workers were assigned by the supervisor for observation. 3 to 7 days were spent undergoing **work familiarisation.**

Public cleansers: observation started from 7:30am. The cleansers would be dropped off at within their allocated district, walking behind them the researcher would observe

the work done and identify components of the environment. On day 4, following 2 workers, the OHSA and RAMP checklists would be utilised to take note of the workload risks in relation to their line of work.

Waste collectors: collectors observation started from 6:30am. The trucks would drive to their allocated districts, driving behind them, the researcher observed the work done until their work-day was complete. On day 4-7, the checklists were completed having followed and observed the different tasks with the different waste collecting types (i.e. 2 wheeled bin collectors, bag and round bin collectors)

Drivers: drivers where observed during testing whilst the researcher was on the truck with the workers and, *mechanics* were observed on days the researcher was permitted and when work was apparent due to the work of mechanics being dependent on truck performance functionality. However, the observation analysis for the drivers and mechanics stopped at Phase 1, due to permission restrictions and the constrained work times. Participants from these groups nevertheless found time before work to partake in the interview procedures [being the perceptual workload assessments] within Phase 2.

3.5 PHASE 2

3.5.1 Aim and Instrumentation:

To determine workload stressors strain experienced by waste workers through the use of objective ergonomics instruments and validated subjective questionnaires. The usage of both objective and subjective instruments will corroborate the level of workload exposure. Where some tools defined the physical risks and stressors pertaining to the job, others aided in giving the subjective viewpoint of those workload constraints and broadened the scope not only having focused on the task but the biopsychosocial factors which impacted the worker as well. This section describes the tools used to quantify physical and perceptual workload, and also includes a brief on the tools that were ideal to be used but couldn't, largely due to the COVID-19 pandemic.

In order to execute phase two of the study, the following instruments were used (1) A Dynamometer, (2) Luggage Scale, (3) Risk Management Tool for Manual Handling

Proactively 2, (4) The Rapid Upper Limb Assessment and (5) The Rapid Entire Body Assessment.

3.5.2 Physical Workload Instruments

3.5.2.1. Body Mass Index (BMI)

A digital weight scale was used to measure the mass of participants. A tape measure was used to measure the demographic stature of the participants. A stadiometer would have been a more accurate tool, but due to the unlevelled surfaces and lack of portability; a tape measure was the best tool for the field study (Poskin, 2018). The weight (kg) and stature (cm) were recorded on the demographic information sheet (Appendix A), BMI was then calculated and rounded off to the nearest 0.1. For standing stature, participants stood with their feet shoulder-width apart, shoulders relaxed, with their head in Frankfort plane. Their measurements were taken post exhale for the most accurate anthropometric results. Participants measurements were taken with their boots and PPE clothing on. Head gear, hats, phones, and any additional items were taken off before measurements. The BMI was calculated by dividing mass by stature squared (kg/m^2).

3.5.2.2. Hand-held portable Dynamometer

A dynamometer is a device used to measures biomechanical force, power and/or speed (Cerbai & Placci, 2019). The Meiden hand-held, portable dynamometer utilised for this study was used in conjunction with the RAMP 2 tool. With the tool, the force output required to push and pull two-wheeled bins was measured.

3.5.2.3. Portable Analog Luggage Scale.

The luggage scale measures the weight of the load beneath in kilograms (kgs) and/or pounds (lbs) depending on the scale (Wallace-Abbott, 2019). This device is often used on luggage loads at the airport, but the portable device is primarily for home-use. The specific scale used covered a max weight capacity of 50kg. The hook at the bottom latches onto the handle or the place of grip coupling, as the device is vertically pulled, against gravity, the analog hand will motion towards the weight classification (Wallace-Abbott, 2019). This device was used to measure the end weight of the waste collected

by public cleansers, as well as the weight of the bags at the placed outside homes before being obtained by waste collectors.

3.5.2.4. The Rapid Upper Limb Assessment (RULA) Employee Sheet

The RULA is a risk screening tool, which evaluates the risk factors like posture, force exertion, repetition, and work duration of several body parts, which includes upper arms, lower arms, wrist, neck, trunk, and legs (Kong, Lee, Lee, & Kim, 2018). It identifies the muscular effort, which is associated with the above risk factors, which may consequently contribute to muscle fatigue. The results of RULA displays a 4-level risk scoring between 1 and 7+; 1 being 'acceptable posture' and 7 being of high risk, task execution change is needed, or new implementation strategies are needed before physical musculoskeletal disorders or harm occurs (David, 2005). The functioning tasks accomplished by workers in the waste sector primarily utilise the upper part of the body. Throwing, picking wielding of objects require a tool that can gage postural exertion which is why RULA is a perfect tool for this observation (Appendix F). OWSA is another working posture tool that effectively calculate working posture, and the percentage of time spent in those working postures, however OWSA requires well captured video footage for the software to capture the details of the work done (Kong et al., 2018). Due to the different residential environments, it wasn't always safe to tread with the workers on foot to capture videos, most of them were taken in the car or done very discretely. Even though it would have been effective in certain residential areas, it would have minimised the gathered data altogether. Thus, RULA proved to be the more data enhancing and safer tool than OWSA (Appendix F).

3.5.2.5. The Rapid Entire Body Assessment (REBA) Employee Sheet

This tool (similar to RULA) assesses the working postures and the risk of any work-related musculoskeletal disorders (WMSDs) of the workers, this tool measures the movement of the entire body. Once the analysis is completed REBA, provides five level scoring, ranking the risk of the task between 1 and 11+ (1 corresponding to low, 11+ being congruous with harmfully high risk respectively (*Appendix G*). For public cleansing and waste collecting, standing, walking and bending are very prominent movements in both occupations. The inclusion of REBA was thus also important in order to identify workload. REBA's inclusion of upper and lower body make the most

effective whole body postural and exertion workload measure. RULA gives more detail on the upper body workload which is why both tools were used. The disadvantage is that it also does not factor in time or length of breaks, which is where RAMP 2 aids in determining workload quantity (*Appendix G*).

3.5.2.6. Risk Management Tool for Manual Handling Proactively 2 (Ramp 2) Screening Assessment

Part 2 (Ramp 2) uses the information in RAMP 1, doing a secondary, more intensive investigation on the risk areas (Nord et al., 2020). RAMP 2 is a direct observation-based tool. For each occupation, RAMP 2 will classify the not just the categories but the specific movements within those categories that are currently producing the highest and lowest work strain on the worker which may lead to the development of a musculoskeletal disease, an injury or a possible fatality for waste workers (Nord et al., 2020). The numerical value displayed within the results program, displays a numerical value for overall risk as well as each question's risk grading/level. This will give a good comparison between occupations to not only display workload but also an indication of the degree of strain (Nord et al., 2020). (Appendix H).

Table 2: The occupation groups assessed and not assessed using the Physical Workload tools in phase 2

		Occupations						
		Waste Collectors				Public Cleansers	Drivers	Mechanics
		2- Wheeled bins	Round Bins	Truck Bags	Flatbed bags			
Instruments	Dynamometer	✓	✗	✗	✗	✗	✗	✗
	RAMP 1	✓	✓	✓	✓	✓	✗	✗
	RULA	✓	✓	✓	✓	✓	✗	✗
	REBA	✓	✓	✓	✓	✓	✗	✗

3.5.3 Perceptual Workload

The interview questionnaire sheet was split into 3 parts: Demographic information, NASA TLX questionnaire and QWIQ.

3.5.3.1. Demographic Information

Individual interviews were conducted with the participants in order to fill in the questionnaire requirements. Each participant filled in a form detailing their name, age, race, occupation, years of experience, sex, employment position (contracted vs permanent), education and anthropometry (stature and height). The details of the procedures are listed beneath the perceptual workload tool instrumentation. The Demographic information questionnaire is attached in the appendices: Appendix I.

3.5.3.2. NASA Task Load Index (TLX)

The NASA Task Load Index developed by Hart & Staveland (1988), this tool is a health and well-being questionnaire that focuses on the effects of work on the individual. It is a multi-dimensional rating scale designed to assess the subjective experience of workload. The tool categorises this under 6 different weights: (1) mental demand, (2) physical demand, (3) temporal demand, (4) effort, (5) performance and (6) frustration (Hart & Staveland, 1988). The tool has been validated and is reliable. The observation-based tools above can only inform us of the functional and structural strain experienced by the worker, they cannot determine the perceptual and cognitive workload. Conversely the NASA-TLX categorises the different types of workload demands: from the worker's cognitive taxation, time pressure, exertional effort etc. then quantifies that on a catalogue, making it the best tool to understand workloads from the perspective of the worker. This tool doesn't just identify the demand stressors but is able to value that stressor in relation to others (*Appendix J*).

3.5.3.3. Quantitative Workload Inventory Questionnaire (QWIQ)

The QWIQ questionnaire, created by Spector & Jex (1998) is used to assess the quantity of work effort required of an occupation. It measures 4 job stressor-strain related areas: The 4 stressor scales includes the Interpersonal Conflict At Work Scale (ICAWS), Organizational Constraints Scale (OCS) Quantitative Workloads Inventory (QWI); and the 1 strain scale measure is the Physical Symptoms Inventory (PSI) (Spector & Jex, 1998). The QWIQ questionnaire was the most suitable questionnaire due to the following: (1) due to simpler language translation adaptation; (2) applying the question to the workers tasks was straightforward, whereas the NASA TLX required numerical ratings of one's perception which wasn't always easy to explain nor

grasp; (3) the simple text Likert scale made it less complicated when responding i.e. yes, no, never, always, sometimes, once per month, several times a day – these are all dependent on the questions. For a lower income group, where the many individuals could not complete their secondary education, this was a suitable facile tool for this study. Altogether the tool considers interpersonal interactions, task constraints, work input intensity and physical health problems (*Appendix K*).

Table 3: The Occupation groups assessed and not assessed using the Perceptual Workload tools in phase 2

Tools	Occupation/Task Groupings						
	Waste Collectors				**Public Cleansers**	**Drivers**	**Mechanics**
	2-Wheeled Bins	**Round Bins**	**Truck bags**	**Flatbed Bags**			
QWIQ	✓				✓	✓	✓
NASA-TLX	✓				✓	✓	✓

3.6 DATA COLLECTION PROCEDURE:

The observation and testing illustration was approved by Rhodes University and the City of Tshwane Municipality, on Waste Sector employees, with intensive attentiveness towards public cleansers and Waste Collectors. Phase 2, included the use of questionnaire sheets, observation tools and demographic information questions.

Table 4: Details of the Waste collection occupations and areas used for this study with details of the workday cycle, worker distribution per occupation, worker-task elements and the days permitted for this investigation to take place.

	Public Cleansers	**2-Wheeled Bins**	**Flatbed**	**Truck**	**Round Bins**
Depot	Basden, Kruger, Laudium	Atteridgeville, Pretoria West.	Atteridgeville	Atteridgeville	Atteridgeville
Tools And Collection Form	Bags and thongs/pickers	240 litre black, green or grey 2-wheeled bins. All	Black Plastic Bags.	Black plastic Bags	50-120 litre household dustbins.

		general waste			
Group Number (*Per Truck, incl. driver)	1	4 - 7 *	4*	4 -7*	4 or 7*
Work Schedule Start Time	08:00	07:00	07:00	07:00	07:00
Collection Duration	3 - 5 hours	6 - 9 hours	45 mins - 1:30 hour (x2)	7 - 9 hours	7-9 hours
Travel Time to Dumpsite (One-Way)	0	1.5 - 2 hours	2 hours	2.5 hours	2 hours
Working Days	Mon - Saturday	Mon - Saturday	Mon - Saturday	Mon - Saturday	Mon - Saturday
Observation Time Period	09 Sept- 30 October	02 Nov - 23 Nov; 23 Nov - 10 Dec	02 Nov - 23 Nov	02 Nov - 23 Nov	02 Nov - 23 Nov

3.6.1 Interviews: Demographic Info and Perceptual Workload tools administration

Between 7:00 - 8:00 am onwards, workers of all occupations had to do their delegated work tasks, thus a short time period between 20mins - 1hr before work commenced was the time availed to conduct interviews. A team of 3-4 translators was assembled to assist with translating the questionnaires effectively as well as collecting an equitable number of participants within the daily short time periods given. Prior to the interview proceedings, a two-hour information and practice interviewing session was completed to give the translators knowledge of what is being sought through these questionnaires and how to apply them in the context of the organisation. On the days of data collection, the team would arrive 1 hr before the working group set in motion, depending on the area and the workers, between 3 and 20 participants were interviewed in a day. Interview time would take between 5 and 25 minutes to complete depending on the worker's literacy and ability to understand the question. Interviews were predominantly done early morning and occasionally in the afternoon for workers that had more time availed later in the day.

Interviews were conducted in Sepedi, Setswana, Sesotho, IsiZulu, Venda and English depending on the participant. Translators were fluent in 3 or more of the above languages. Respondents were only those working within the City of Tshwane Waste Sector. The demographic information composed the first portion of the questionnaire, part of this section required the anthropometric measurements of the individual.

All weight measurements were taken with shoes on, thus adding an additional 0.5-2kgs depending on the type of industrial or non-industrial shoe, this factor remained consistent for all workers. All excess equipment and items were kindly asked to be removed. With the tape measure, stature was measured as anthropometrically correct as possible which included these postural features: Back straightened, knees straightened, pelvis in neutral and chin parallel to the ground. The weight and height of the participant were measured respectively. All respondents thereafter commenced in answering the Likert scale questions based on the QWIQ and NASA TLX questionnaires.

3.6.2 Work Familiarisation and Physical Workload tools administration and execution

After the early morning interviewing period, work familiarisation observations continued during the day. Translators took part in this process to better understand the working environment and in turn assisted the interview processes, germanely relating the questionnaires to the worker occupation. In Phase 2 during the work familiarisation, the REBA, RULA and RAMP tools were utilised. Video recordings were also taken whilst these instruments were used to assess. The video recordings were analysed in relation to what was documented on the tool to ensure all movements were considered and analysed correctly. Video recordings were also used for time and motion analysis specifically for waste workers due to their diverse movements, unlike the public cleansers.

For measuring force exertion of the push and pull tasks, 2 waste collectors volunteered to perform the analysis. Testing was done outside the residential homes of 2 different income areas. The preparation took approximately 30 minutes and had to be ready in time for the volunteer collection workers. The assessor demonstrated how to utilize the tool before commencing data collection. 3 trial runs were undertaken in order for the

participants to familiarise themselves with the gripping and execution. After the trials, for standardizing the participants performed the task 3 times, 3 data sets were captured including initial and continuous force. This was done over 4 days, timing and preparing the force tool prior to the participant's arrival.

After several weeks of observations, the team (translators and the researcher) undertook 4 days of embedding, (2 days with public cleansers; 4 days with waste collectors and drivers). As part of this process, the researcher not only observed the tasks but also performed them to gain a better understanding of the task themselves. Embedding with the public cleansers was done at Pretoria West, and waste collection occurred at Atteridgeville and Pretoria West. PPE gear was bought prior to the task activity, this included boots, gloves and blue overalls. The research team worked with the public cleansers bag collectors, round collectors and 2-wheeled bin collectors.

One of the translators who had a Code 10 license had the opportunity to undergo the experience of waste collection from the driver's perspective. Executing this task disclosed how much habituation and task experience is needed in order to operate as a waste Truck driver. Task execution was done by one of the translators, during his execution, the researcher would ask him differences felt from driving a normal car, if not a differing truck, in comparison the driven compactor truck and operations. Questions were posed regarding discomfort areas from the top of the head to the back and asked about the operations. The same was asked of the actual drivers of the trucks when heading on the collection process.

3.7 DATA PROCESSING

3.7.1. Data capturing and cleaning

The OHSA results were calculated manually and captured on an Excel spreadsheet. RAMP having its own developed results output program, the observation markers were inserted as instructed. The outputs of the areas of risk on both checklists attributed to the appropriate selection of tools within Phase 2. The occupations permitted for this phase were both manual materials handling dominant occupations, thus physical ergonomics assessment tools were chosen.

The pen-and-paper data sheets were collected at the end of each morning interview session. The data was captured on an Excel spreadsheet at the end of each week. The data reduction included removing interviewed participants of seniority (e.g., supervisors and managers) as well as those who had incomplete questionnaires specifically applying to the QWIQ and NASA TLX due to each question being pertinent in calculating each category's and the overall workload score as prescribed by the creators of the tool.

The RAMP, RULA and REBA, excel basic statistics comparisons were made. The dynamometer data was captured on Excel, the average, minimum and maximum values were calculated the tabulated.

3.7.2. Data Analysis and statistical procedures

3.7.2.1. Descriptive Stats:

The demographic information was sectioned and tabulated on Excel. Mean and standard deviation, median and interquartile range, frequency distributions were outputted from the data in the form of bar graphs, pie-charts and tables.

3.7.2.2. Inferential Stats:

Questionnaires that only had incomplete/missed demographic data were still included. Statistical analysis was conducted using TIBCO Statistica™10.0 statistics software. Non-parametric Anova, Kruskal Wallis test and Median test were calculated to compare the occupations for the perceptual workload questionnaires: the QWIQ questionnaire and the NASA TLX. P values <0.05 were considered statistically significant. Non-parametric independent variables analysis was completed for the QWIQ and NASA-TLX tools. Where a significant difference of <0.05 was identified, further non-parametric and other statistical tests were administered. Occupation groups and particular variables within the tools would be analysed; significant differences were documented in the results, and non-significant analyses were placed in the appendices.

CHAPTER IV: RESULTS

In this chapter, the findings have been separated into 3 sections: the Demographic information section includes sex, education, work experience for all occupations investigated. The second section, Phase 1 displays the results found post administering the screening assessments. The last section, Phase 2, details the outcomes shown of the physical and perceptual workload assessments. This includes details of within-occupation duties, workday schedules, job-specific and external loads. It also illustrates and compares the between-group responses found within this study.

Before delving further into this section, Please note that information beneath the blue headers are part of the Phase 1 category, headers in blue are under Phase 2.

Table 5 and Table 6 have been created as a guide to assist in giving direction to the results displayed. Chapter 3 had categorised which occupations were observed with the various tools under Phase 1 and 2. As a continuum, Please note that information beneath the blue headers are part of the Phase 1 category, headers in blue are under Phase 2.

Table 5 and Table 6, below, breakdown the groups observed with the assessment tools for the results to come. The tables can be used as reference when reviewing and comparing the results. Please note that information beneath the blue headers are part of the Phase 1 category, headers in blue are under Phase 2.

Table 5 illustrates the Physical workload tools and Table 6, the perceptual tool and occupations. From the guide below, you will witness that Mechanics had very little physical date in gathering, As indicated in chapter 3, data collection in detail for their physical work demand information was not possible, but they were able to spare time

for an interview, and thus only the perceptual workload was detailed. The investigation of the remaining occupations has been detailed in this subsequent chapter. Table 6 displays that waste collectors as a whole and not in their subgroups; this is a product of the interview process having been initiated prior to the detailed physical workload investigation. Thus, the only subgroups identified under waste collectors was either 'waste collectors' or 'flatbed collectors'. For clarity, all collectors were mutually referred to as waste collectors unless stipulated otherwise. Please note that information beneath the blue headers are part of the Phase 1 category, headers in blue are under Phase 2.

Table 5: Breakdown of Groups analysed utilising the Physical Workload assessments tools under Phase 1 and 2.

Tools	Occupation/Task Groupings						
	Waste Collectors				**Public Cleansers**	**Drivers**	**Mechanics**
	2-Wheeled Bins	**Round Bins**	**Truck bags**	**Flatbed Bags**			
PHASE 1							
OHSA	✓	✓	✓	✓	✓	✓	✓
RAMP 1	✓	✓	✓	✓	✓	✗	✗
PHASE 2							
Observation description	✓	✓	✓	✓	✓	✓	✗
Time and Motion	✓	✓	✓	✓	✗	✗	✗
Dynamometer	✓	✗	✗	✗	✗	✗	✗
REBA	✓	✓	✓	✓	✓	✗	✗
RULA	✓	✓	✓	✓	✓	✗	✗
RAMP 2	✓	✓	✓	✓	✓	✗	✗

Key:

Table 6: Groups analysed utilising the Perceptual Workload assessments tools under Phase 2.

Tools	Occupation Groups			
	Waste Collectors	**Public Cleansers**	**Drivers**	**Mechanics**
QWIQ	✓	✓	✓	✓
NASA TLX	✓	✓	✓	✓

4.1. DEMOGRAPHIC INFORMATION

4.1.1 Demographic Information by Occupation

Table 7: Descriptive demographics of Municipal Participants

		Participant Groups						
		ALL	**PC**	**WC**	**WC - Runner**	**WC- Flatbed Loader**	**Mechanic**	**Driver**
Occupation (n)		154	34	87	6	12	4	11
Age (years)	***Min***	21	21	28	29	27	31	27
	Max	69.0	69.0	60	55	63	48	62
	Mean	41	42.0	40.6	42.1	42.23	39.8	41.9
	±SD	9.4	10.5	7	8.6	9.8	8.5	13
Stature (cm)	***Min***	158	158	170.4	166.1	160	168	160.1
	Max	190.1	186.9	190.1	180.4	190	177.8	185
	Mean	172.4	171.1	171.4	167.3	170.0	167.0	169.9
	±SD	7.2	8.9	13.6	7.5	12.4	6.4	4.4
Mass (kg)	***Min***	36.5	57.4	36.5	59.8	49.5	57.3	54.2
	Max	135	135	116.6	104.8	92	119.1	91.6
	Mean	73.5	77.5	72.7	68.0	67.3	67.9	68.2
	SD	16.1	17.8	10.3	14.2	15.2	16.3	17.7
BMI	***Mean***	23.8	26.7	24.4	23.2	22.6	23.1	22.9
	±SD	5.8	7.0	5.5	5.1	4.7	5.3	4.9
Work Experience (years)	***Min***	0.1	0.1	1	4	1	0.5	2
	max	35	35	19	12	11	6	18
	Mean	6.7	7.9	9.9	8	5.7	3.1	5.8
	±SD	4.5	8.7	4.2	3	3.4	2.8	4.7

Public cleansers recorded having the highest mean BMI (26.5) and Flatbed Loaders had the lowest mean (23.3). The occupation having the highest municipal work experience was waste-collecting with an average of 10 years, whilst mechanics had the lowest average work experience (3 years). The average age amongst workers was 41 years, the youngest individual being 21, and the oldest being 69 years old (Table 7).

4.1.2 Level of education of waste workers

Table 8: Distribution of educational levels for the different participant groups

	Participant Groups			
	PC	**Waste collector**	**Mechanics**	**Driver**
No schooling completed	2	2	0	0
Nursery school to Primary School	0	5	0	0
High school but did not finish	16	62	2	5
Finished High school, diploma or similar education (for example: GED)	14	33	2	6
Diploma or University Degree accomplished	2	3	0	0

Majority of workers attended high school (n=85) however many were not able to complete their high school education. This is with the exception of drivers where the majority of drivers finished their secondary education or took courses of similar qualification (n=6).

4.1.3 Sex and Employment status

Table 9: Sex and Employment status

		Participant Groups						
		ALL	**PC**	**WC**	**WC - Runner**	**WC-FBL**	**Mechanic**	**Driver**
Sex	***Male***	142 (92%)	22 (14%)	87 (56%)	6 (7%)	12 (8%)	4 (3%)	**11 (7%)**
	Female	12 (8%)	12 (8%)	0	0	0	0	0
Employment	***Permanent***	99 (64%)	23 (15%)	67 (44%)	1 (1%)	4 (3%)	1 (1%)	3 (2%)
	Contracted	49 (32%)	5 (3%)	20 (13%)	5 (3%)	8 (5%)	3 (2%)	8 5%)
	No Response	6 (4%)						

For this study, public cleansers were the only occupation group with recorded female participants (n=12). Waste collectors (WC) had the highest number of male participants (n=87), with Mechanics having the lowest, only male recruitment (n=4). The majority of workers were permanent staff (64%). Waste collectors had the highest percentage of permanent staff, compared to drivers and flatbed waste collectors that had more contracted workers than permanent workers (Table 9).

4.1.4 Age and Work Experience

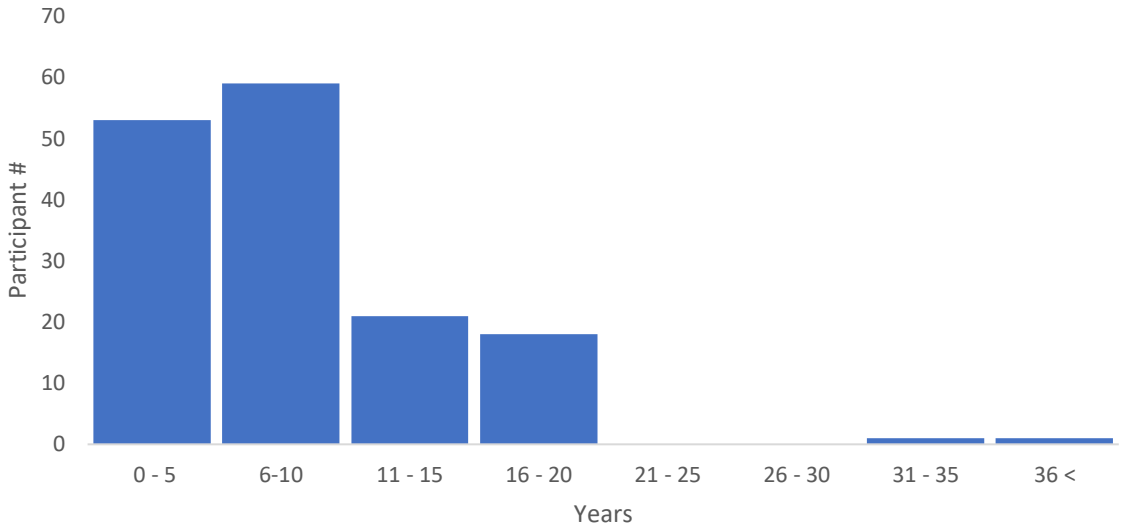

Figure 5: Years Employed within the Waste Sector for all employees (n=154)

Individuals working on the waste sector have displayed a lengthy job retention, the majority having worked within between 6 - 10 years (38%) (Figure 5). 2% of the workers have reported having sustained 31 < years of employment.

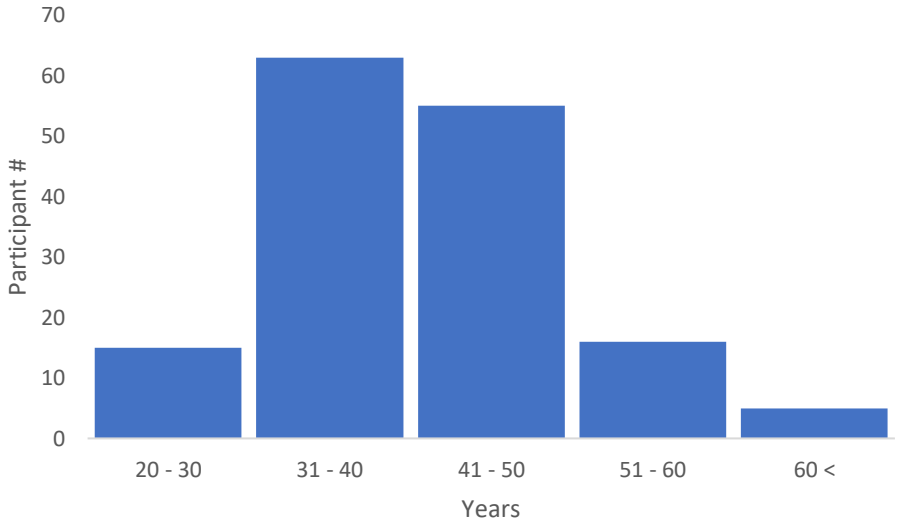

Figure 6: Age distribution of Municipal Waste participants (n=154)

Figure 6 displays that the majority of individuals working in the waste sector are between the ages of 30 and 40 years (41%), only 10% is composed of the youth (20-30 years old) and very few seniors that were older than 60 years (3%).

4.1.3 Waste Sector Occupation distribution and Occupation-Methods breakdown

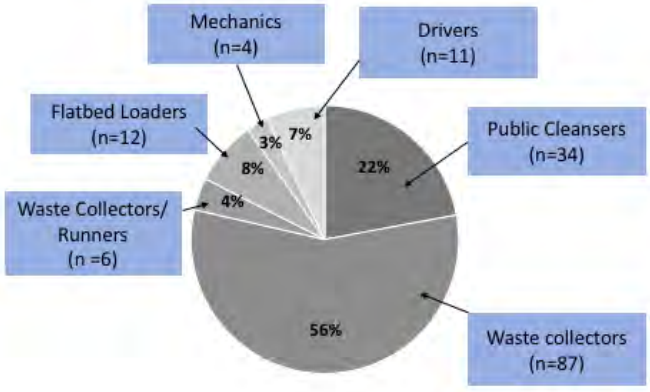

Figure 7: Percentage of Waste Occupations within this study (n=154)

Waste collectors made the largest contribution to the study, composing 56% of the participants (n=87), followed by public cleansers with 22% (n=34). The lowest numbers were the mechanics 3% (n=4) and drivers and waste collection runners (n=6). Flatbed loaders (8%) and Drivers (7%) were very close in number of participants that had participated respectively (n= 12 and 11).

4.2 PHASE 1:

4.2.1 RAMP 1 Results

Table 10: RAMP 1 Risk Category Output Analysis per Occupation

	2-Wheeled Bins	Round Bins	Truck Bags	Flat Bed Bags	Public Cleansers
1. Postures	4	8	7	7	4
2. Work movements and repetitive work	1	1		1	1
3. Lifting		10	9		5
4. Pushing and pulling	3				
5. Influencing factors	6	6	1	5	5
6. Reports on physically strenuous work					
7. Perceived physical discomfort	1	1		1	1
Results Summary					
Number of red assessments - High risk/action level	**1**	**0**	**1**	**0**	**0**
Number of yellow assessments - Risk/action level	**14**	**26**	**18**	**22**	**16**
Number of green assessments - Low risk/action level	**25**	**13**	**20**	**17**	**24**

The RAMP 1 analysis output program has categorised the areas of risk, the numbers indicating the number of items per category having the probability of high (red),

moderate (orange), low (green) or inconclusive risk that needed further investigation (Table 10). The analysis shows that 2-wheeled bin waste collectors displayed having the most frequent low risk tasks occurring (25) followed by Public cleansers (24) and Flatbed workers (20). The analysis showed high risk for 2 occupations in different task categories. 2-wheeled bin workers showed a high risk in work movements and repetitive work, as well as pushing and pulling, and Flatbed workers displayed major risk in the area of influencing factors. Each occupation showed overall, a deeper analysis needed to pin point areas contribution to physiological and biomechanical risk (Table 10).

4.2.2 OHSA Results:

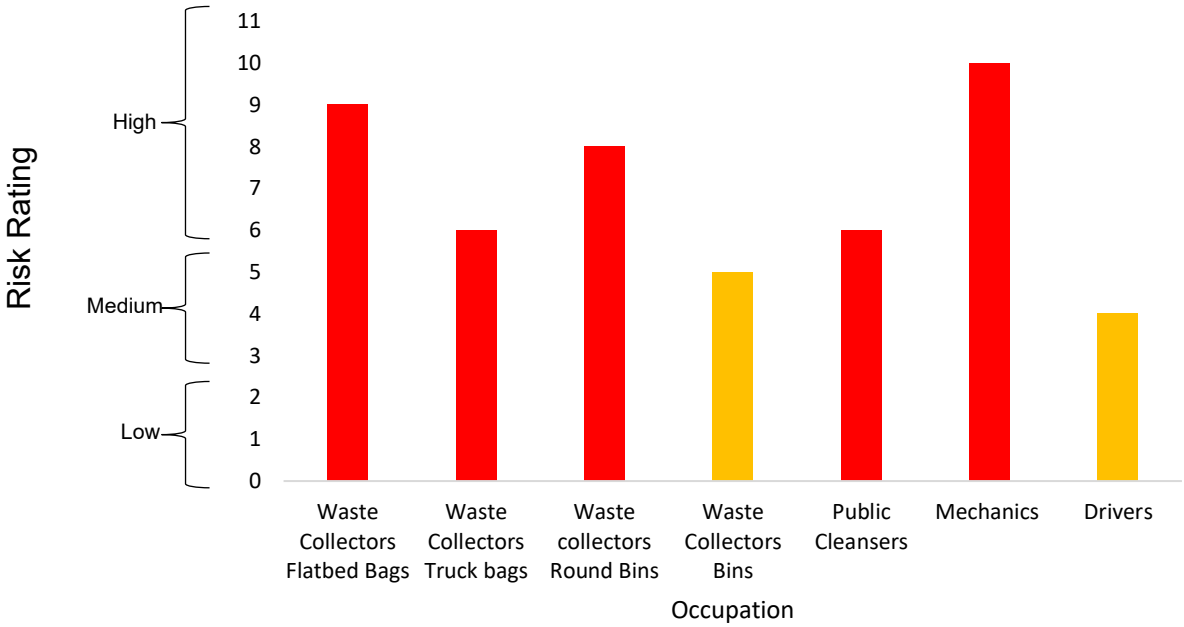

Figure 8: OHSA Ergonomic Risk Rating per Occupation

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Figure 8 (above) shows the results from a single observation of each task. Green indicates low risk of musculoskeletal development, orange indicates medium risk and red is high risk occupation. The calculated risk rating of 5 occupations showed high risk exposure quantification having a rating greater than 6. These occupations were Flatbed bag, Truck bags, Round Bins, Public Cleansers and Mechanics. 2-wheeled bin collectors and Drivers were estimated to be at a medium risk exposure (5 and 4). No occupations were of low risk.

4.3 PHASE 2

4.3.1 Physical Workload

4.3.1.1 Work Schedule per Occupational group

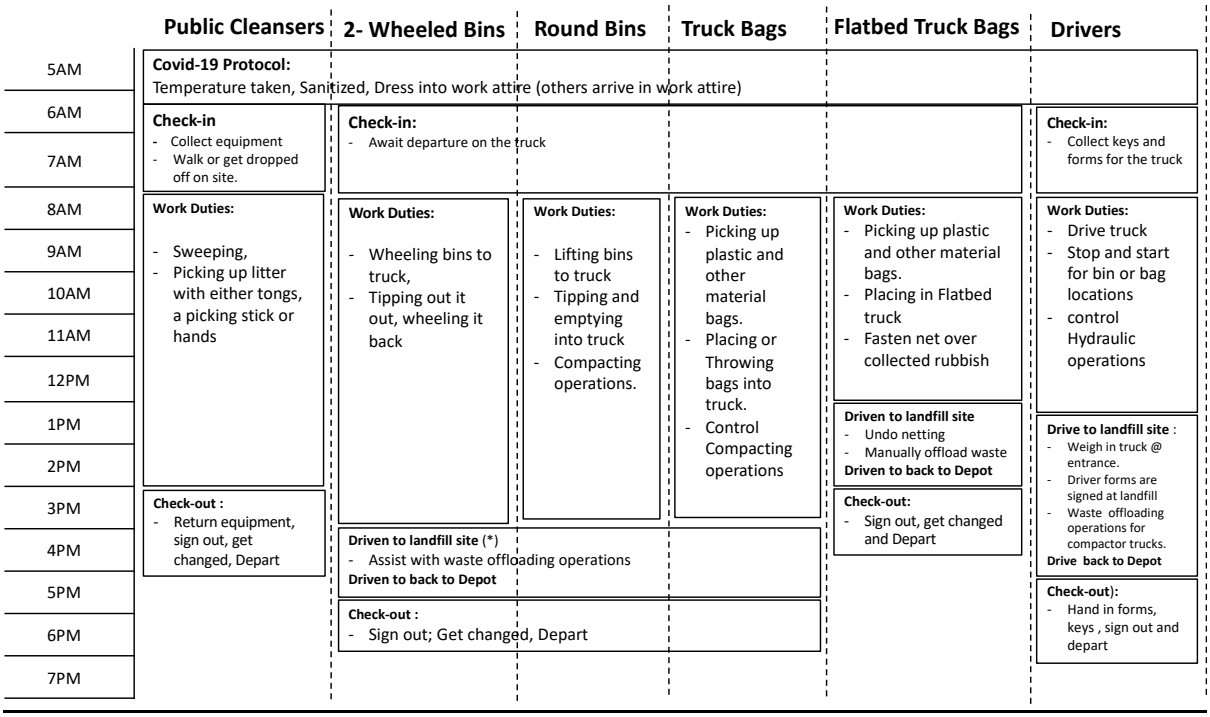

Figure 9: Exemplary description of the average day of public cleansers, waste collector divisions (2-wheeled bin, round bin, truck bag & flatbed bag collectors) and drivers.

Table 11: Workload characteristics and Body postures

Public Cleansers	2- Wheeled Bins	Round Bins	Truck Bags	Flatbed Truck Bags	Drivers
- Bending - Carrying - Repetitive movements	- Pushing - Pulling - Lifting (sometimes) - Running - Compactor truck operations	- Bending - Carrying - Lifting - Compactor truck operations	- Bending - Carrying - Lifting - throwing - Compactor truck operations	- Bending - Carrying - Overhead lifting - Throwing	- Hydraulics Operations - Leg contraction - foot dorsiflexion - Whole body vibration

Figure 9 shows the daily work schedule spent by workers within their occupational field. Public cleansers and flatbed truck collectors had the promptest check-out time between 2 and 4 pm. Waste workers and driver check-out time varied in depending on

the timeliness of collection for their delegated areas, earliest was 4:30pm, and latest was 7pm. Due to the Covid-19 pandemic, a Covid protocol check is completed before workers can check in and change. The work duties illustrate the actual tasks being handled per occupation (
Figure 9). Table 11 is a breakdown of the workload characteristics, defined by their movement mechanics and occupational functions/tasks.

4.3.1.2 Observation-based Work Description

Photographic and schematic evidence of Task operations during observation.

a) Public Cleansers

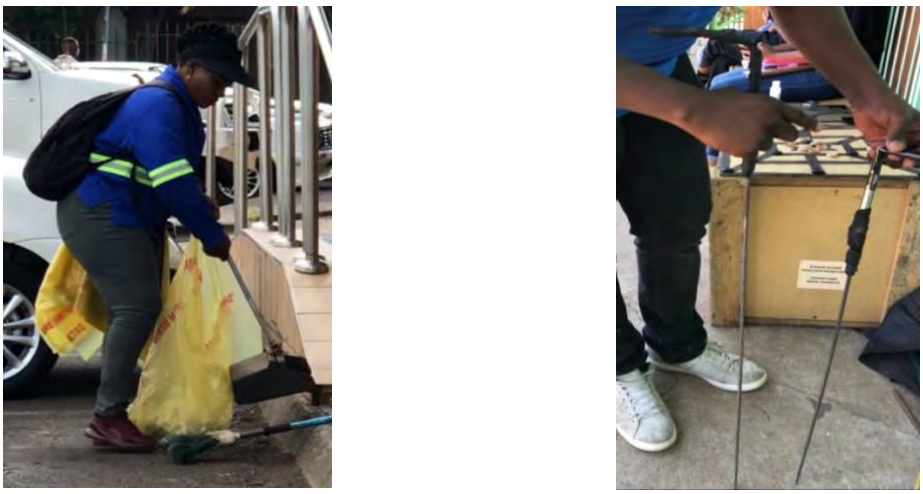

Figure 10: A woman sweeping litter in the town centre (left) and images of the ‘picking sticks’ crafted to complete the picking of litter (right)

Public Cleansers used the following instruments (other than their PPE) to help facilitate their work: ‘sticks’, tongs, dustpans and brooms. All workers are given between 5 and 7 garbage bags to fill for the day. The bags weighed between 1.5 and 7kgs, this weight was highly dependent on the type of waste collected. The instruments used were chosen based on the terrain the individual was allocated to, however, employees do have the autonomy to choose which they prefer. Some depot sites had a limited supply of equipment, equipment distribution was on a ’first come first serve’ bases. In Figure 10, the woman in the town centre carried a broom, dustpan and tongs. This choice is suggested to be due to the concrete surface and the pervasiveness of broken and smaller litter that has to be picked up. This smaller litter comes in the form of broken

glass, sweet wrappers and cigarette buds etc. The tongs would be used for bigger objects, such as bottles, cans and boxes. The 'picking sticks' are ideal for collecting rubbish in soil-bedded areas such as plastics, papers, polystyrene packaging and cans (Figure 11). It was observed a few workers consume food and beverages and once finished, they would dispose of their litter back on the ground or into the bushes. After witnessing this, I enquiring their decision leading to their action, and they stated 'I am going to pick it up again tomorrow anyway'.

Figure 11: Public cleanser picking, placing and closing the plastic

In addition to the observation, the researcher had the opportunity to perform the task. The researcher experienced their back, legs, and calves becoming more uncomfortable as the day went by. This impact was caused primarily by walking and bending. Whilst carrying the bag, they experienced repetitive arm flexion and abduction. the material type picked mattered due to the load it would bear on the arm. Many workers were found having left glass bottles for last, if not reluctant to pick them up at all. They reported that the reason was due to the glass bottles impacting the loaded carrying weight of the bags compared to the lightness of tins, paper and other littered object materials. The tongs created discomfort in the wrist area due to the extended time my wrist was spent flexed, this discomfort was one of the reasons sticks were preferred over tongs.

b) Waste Collectors

Unlike the public cleansers and the other occupation groups, the observation-based investigation found that waste collectors had many different forms of task execution;

thus for the description of the waste collectors, the occupation had been separated into 5 divisions. To assess and quantify the job demands of the waste collectors, the collectors were identified by their primary material handling usage. The recognised and categorised handling materials were 2-wheeled bins, round bins and bags. Bags were further categorised in association with the vehicle in use, as this fundamentally changed the postural and biomechanical movements done by the worker. Having this been said, the bag operations were divided into Truck bag and Flatbed bag loader task operations. Another additional group was identified within the collection operation, being the ‘runners’. the function of this waste collection group is detailed below under subsection D. As mentioned previously only a few of the divisions had been assessed in accordance with their collection division titles when tool applications commenced in Phase 2. The below descriptions explicitly define the specifics of the task engagements associated with the waste collection divisions.

Truck Bag Waste Collectors

The posture when collecting the bags for the garbage trucks was different from those collecting for the flatbeds. The measured bags weighed between 1.8 and 9kgs. Unlike the Flatbed workers, arm elevation rarely exceeded above shoulder height when lifting (Figure 12). The frequency of bags lifted was dependent on the area servicing type (residents placing their bags in demarcated clusters vs home-by-home collection). The collection of bags in clusters was observed primarily in small towns and townships. Figure 13 shows that the conventional black bag was not the only rubbish bag type used. The bag type varied from maize bags, plastic grocery bags etc. which makes the coupling and handling of bags for workers different every time. The weight variation and colleague interference also affect the rate of lift and throw combination per minute.

Figure 12: Bag collection with trucks

Figure 13: clustered bag collection

Round Bin Waste Collectors

A two-wheeled bin was attached to the back of the truck, this assisted in the bin positioning height when rubbish was being disposed. Instead of workers lifting the bins above their heads, arm elevation and height was within the range of the upper extremities. Bins would weigh between 4 - 23kgs. On rainy days (such as in Figure 14, right image), the water would collect in the bins, making the bins a lot heavier. In this observation we found the workers helping each other more frequently with 2-3 man lifts. Most employees not have rain-protective clothing, and some lacked PPE attire such as gloves, masks and reflective clothing.

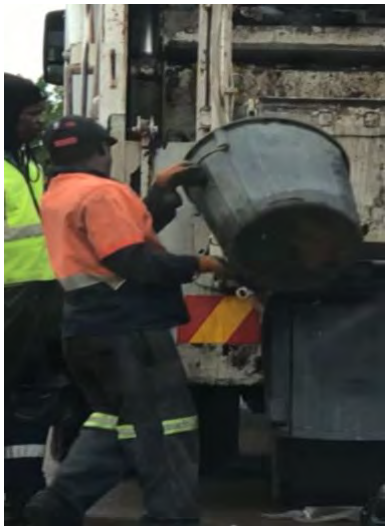

Figure 14: Round bin lifting (left) and a two-person lift (right)

Flatbed Bag Waste collectors

The Flatbed Truck workers were outsourced by the contracted Depot. The Flatbeds were contracted to collect waste specifically within the informal settlements and squatter camps. The flatbed was advantageous over compactor trucks in the squatter camps due to the rocky terrain and the narrow roads. Residents utilised both black plastic bags and smaller plastic retail store bags as their waste disposal material. The black plastic bags weighed between 3 and 10 kgs, the store bags weighed between 1 and 5 kgs. Collection was primarily from homes but included the refuse produced by smaller stores, also known as ‘spaza shops’. There would be a greater frequency of lifting and throwing outside the spazas, compared to those dispersed along the road due to the collective refuse gathered by stores (Figure 16). 6 bag lifts/minute was accomplished. This was the only observation seen of a female collector within the waste collection sector (Figure 15).

Figure 15: (Left) Overhead lift of black plastic bag and a position in preparation to lift and throw the bag into the flatbed truck (right).

Figure 16: Torso twist when throwing the black plastic bag from the ground, a few meters in distance away from the truck.

2-Wheeled Bins Waste collectors

Runners

The function of runners applied mostly in residential suburbs where houses were further apart. The runners would walk/run ahead of the truck, collect bins and place them in groups between 4 and 8 to ease the work of the collectors and driver as they approach the bins. When going to a new location, they assist with the final operations of the collecting process. All workers then climb on the truck and head to the next location.

Bin Collectors

Figure 17: two-handed 2-wheeled bin pushing (left) and one-handed 2-wheeled bin pushing (right)

The 2-wheeled bins measured weighed between 9-31 kgs, throughout the day, a worker would push between 15 and 32 bins per hour. Most workers would execute the double one-handed bin push or pull (Figure 17 – right image), this decreased their travel frequency between the bins and the truck. During the pushing and pulling task execution, when pushing muscle activation was felt most in the shoulders and upper arm regions. The initial force used to pull/push and yank the bin to propel movement was the main reason for extensive upper arm discomfort sensation. The torso would flex forwards to assist the push/pull depending on the bin weight. When pulling, grabbing and jerking backwards was less effortful. The additional aid of one foot pushing against the bin to support the bin in falling backwards was energetically helpful.

Whilst in transit, employees could either choose stand, hang on the sides of the truck; or to stand or sit in the truck hallway. For short distances, hanging on the sides or walking beside the truck was preferred. Hanging on the sides often resulted in one locking their legs, when hitting speedhumps, uneven ground or potholes this became dangerous. I often found myself hyperextending my knees, compacting that position when we re-leveled, causing a pain by the knee joint. Slipping was also experienced. I found that the workers [who hung on the sides if the truck] were often very observant of the road ahead, bending their knees when there were speed humps and manoeuvring their bodies neared trees, signs and other roadside objects. Whilst

holding/hanging onto the bar, the whole body is being supported by the arm segment holding onto the bar. Pressure was placed on the upper and lower arm, this pressure is placed before task engagement, which made the pushing and pulling more tiresome (Figure 19). Even though hanging is not safe, I found it to be less tiring on-route. Standing or sitting indoors, requires the individual to lift their whole body up and down a staircase. It required more energy physiologically and effort mentally to maintain the frequency of jumping up and down, than it did to hang with one arm and leg on the side of a truck, in addition to having a shorter jump height to get up and down.

In townships, there were bins were found without wheels which resulted in workers carrying the bin or dragging it as is. Workers said the wheels were used particularly by children for recreational and playful purposes. Whilst on doing the execution and from the observations, workers had been subjected to in slander and acts of hostility. People had thrown stones and rocks at the trucks. When truck are parked in narrow roads, community members became frustrated, most, expressed their dissatisfaction through words of slander and hate speech. Whilst others, although only having witnessed this once, had projected physical aggression towards the workers. When asking the workers about rate or recurrence of such events and their feelings, they replied in saying ‘we go through this often, it is a part of the job’.

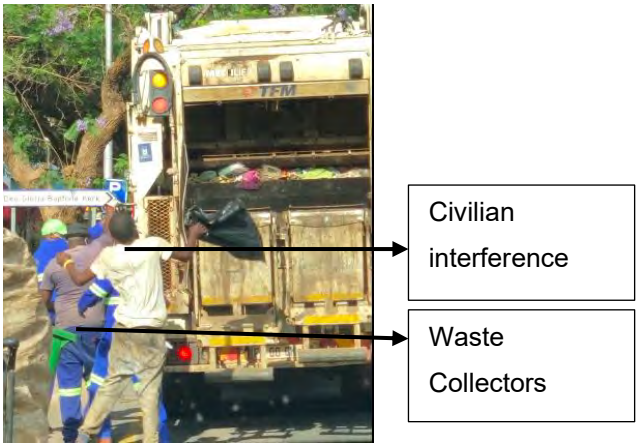

Figure 18: Civilian Interreference whilst Collecting

Figure 19: In transit waste collector standing posture.

Collector Operations Task Analysis

Depending on the truck and its crew, once the truck had yielded, 1 of the 3 collectors (excluding runners), operates the truck's lifting and lowering of the 2-wheeled bins and assists in placing the bin on and taking it off the truck per rotation. On other trucks, the individual closest to the operations unit at the time was in charge of ensuring bins are loaded and disposed. Depending on the truck the operations unit functioning was different. Most of the trucks have the operation unit on the left side some, however, have operations units on either side, thus the timing and controlling of bin placement and lifting can occur simultaneously or separately. Operations 1 (Figure 20) is an illustration of one of the trucks with the automated loading system. The newer trucks have this feature but the older trucks use a manual loading system presented in Operations 2 (Figure 21). Operations 2 requires the user to jolt the lever forwards or backwards, whereas operations 1 is button operated.

Operations 1:

Figure 20: Schematic and Photograph of the Collector operations at the rear of the truck (#1)

When bins are placed at the rear of the truck, the worker presses and holds (3) to mechanically clamp and lift the bin from the ground over and into the truck. Once the bin is emptied, the worker then holds (4) which lowers the bins down to ground level and unclamps. This process is repeated until all the surrounding bins are emptied. Once emptied, the workers that ride on the truck hop on, only when having ensured that all the workers are on is the contact button(6) pressed. The contact button signals to the driver his onus to change from the hydraulics system back to diesel. The driver and the workers then drive to the next set of bins.

Once the back of the truck gets quite full (usually after 6-8 full 240l wheeled bins), a worker presses (2) once, and the truck begins to compact the load, bringing it to the front of the truck.

Operations 2:

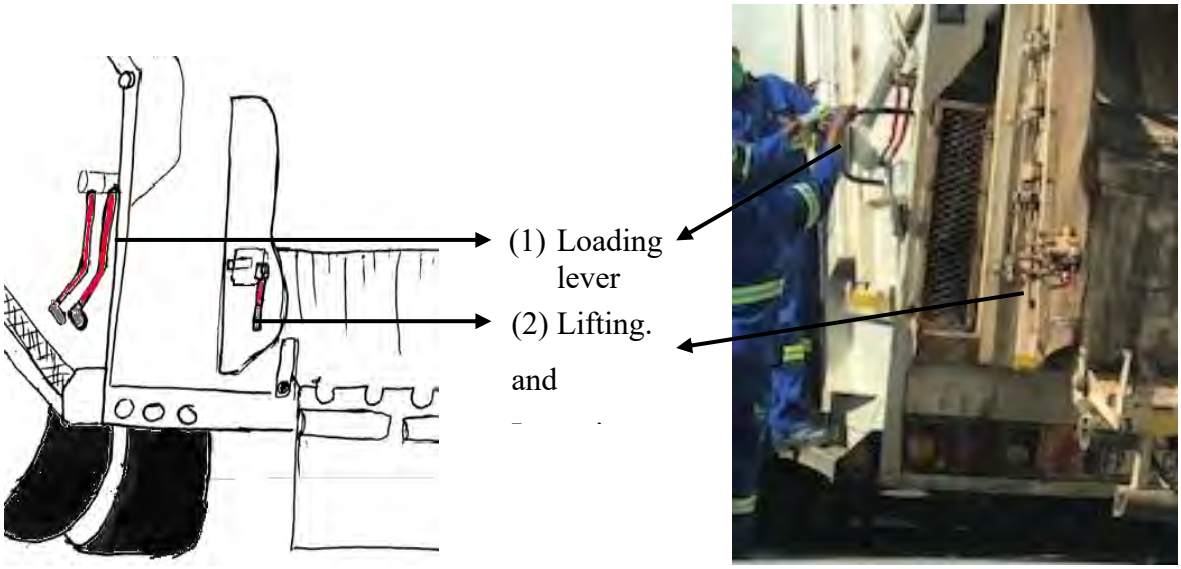

Figure 21: Schematic and Photograph of the Operations of the rear of the truck (#2)

Similar to operation 1, once the bin is placed at the rear of the truck, the worker pushes (2) forwards and holds (away from the truck) to have the bins lifted into the truck. Once emptied, the worker pushes lever (2) back and holds it to lower the bin once more. Once the back of the truck is full, the loading lever to the left is pushed back once to compact the existing waste in the truck. Unlike operations 1, there is no contact button

to signal the driver when the workers are done at the back instead, they have to shout audibly enough for the driver to know that they're ready. Once the back of the compactor is full, lever (1) is pulled back towards the user and the truck begins to compact the garbage. This operation was only seen on the trucks that could yield 2 bins at a time. Some had the operation on either side, so 2 people could operate at the same time, whilst others only had it on one side, meaning the 2 bins would lift at the same time.

Drivers

Figure 22: Drivers seating station overview

The seating conditions for some trucks were better than others. During the 2 day driving observation, the truck I was in did not have a backrest, the seat adjustability function would only allow for certain functions, and there was no extra shock absorption padding to alleviate the full body vibration experienced whilst driving (Figure 22). However, some trucks that did cover a few if not all of these factors. Drivers were held responsible for the rate of collection efficiency and timeliness, they were also liable for accidents that occur to the waste collectors and the updates on the truck's conditions. When performing the waste collection, the driver had to be conscious of the worker's positioning [whether they were hanging on the sides or in the truck] to ensure whilst driving the workers aren't hurt by environmental surroundings (trees, branches and signs). When stopping and whilst driving, drivers had to be cautious of civilians, animals and overtaking cars.

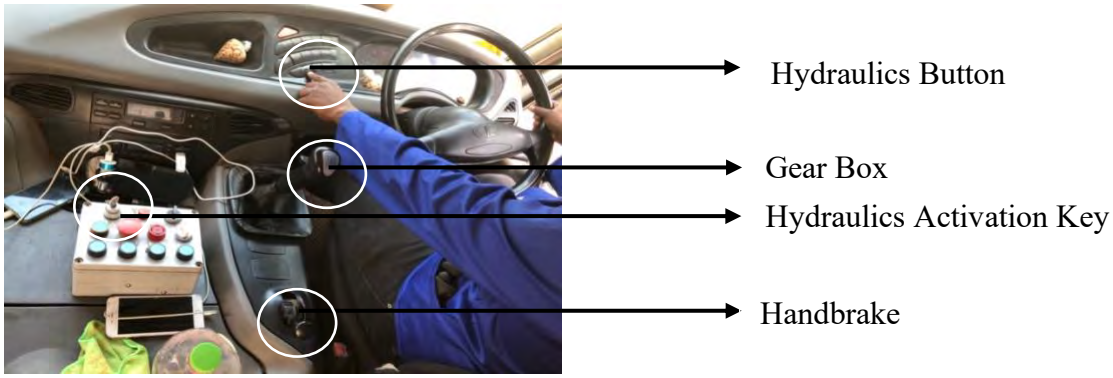

Figure 23: Driver Operations within the Compactor Truck

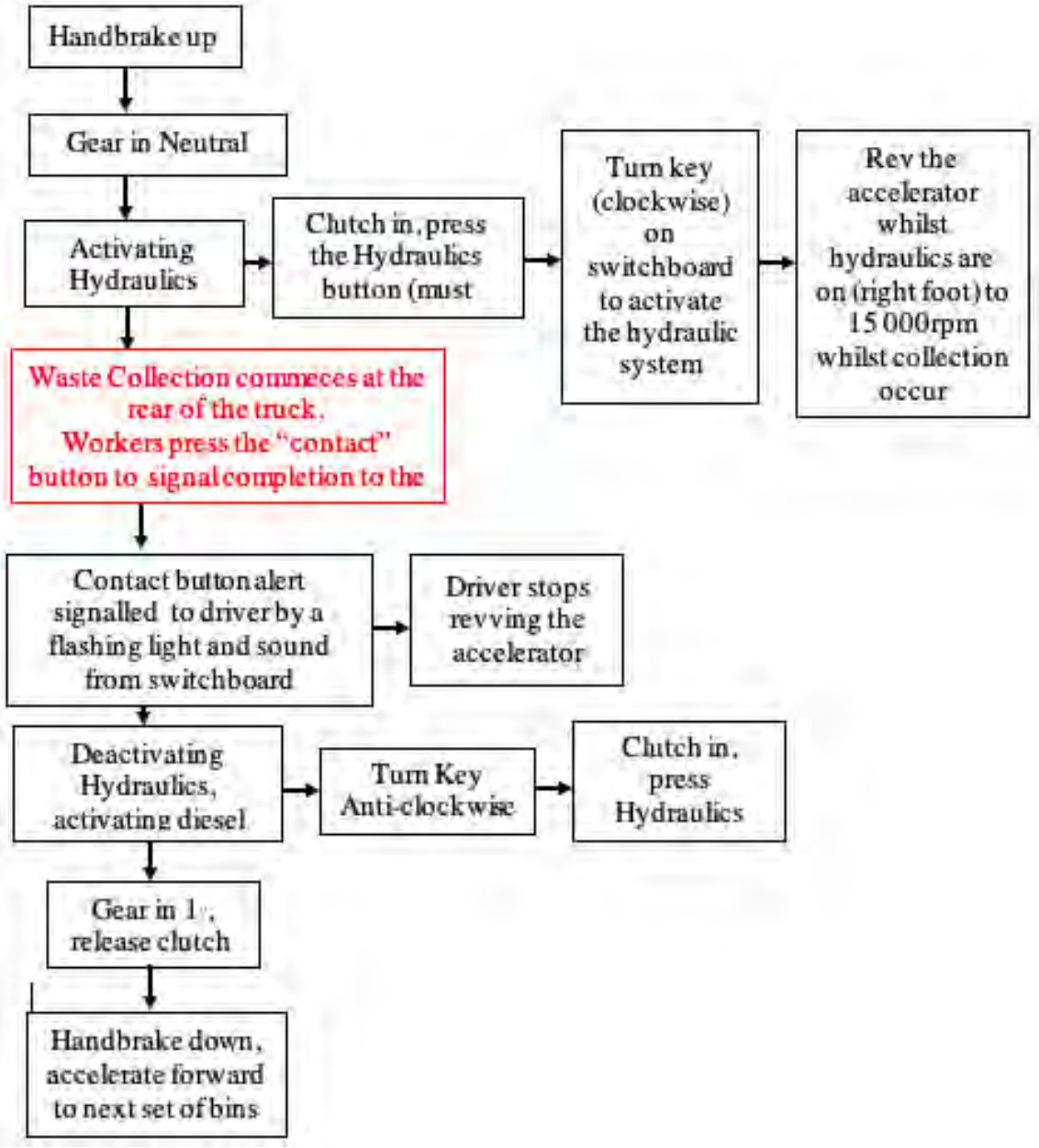

Figure 24: Driver Operations Task Analysis

The operating functions of the driver varied when driving compared to when stopping to allow the collectors to load the bins. Figure 23 displays the step- by step -process drivers perform when loading the bins. Part of this process requires the driver swap from the diesel operations (which is for the driving) to the hydraulics operations (lifting and lowering of the bins), these two cannot operate at the same time. Communication between waste collectors and the driver is important for efficient task accomplishment.

A non-experienced driver who was a part of the translation team performed this task for an understanding of how much habituation and task exposure are needed to complete this task. The individual experienced left leg was uncomfortable due to the stiffness of the clutch, there was also pain in their right ankle caused by their foot's extensive dorsiflexed position when revving/powering the hydraulics for collectors to load the bins. The driver could only continue to release their foot and move to the next set of bins when the collection operations are complete. The individual also experienced neck and lower back discomfort. Lastly, the handbrake's position was said to be very far back, they had to adjust their upper body to manoeuvre it (Figure 24).

4.3.1.3 Time and Motion Analysis

a) Average time spent Analysis

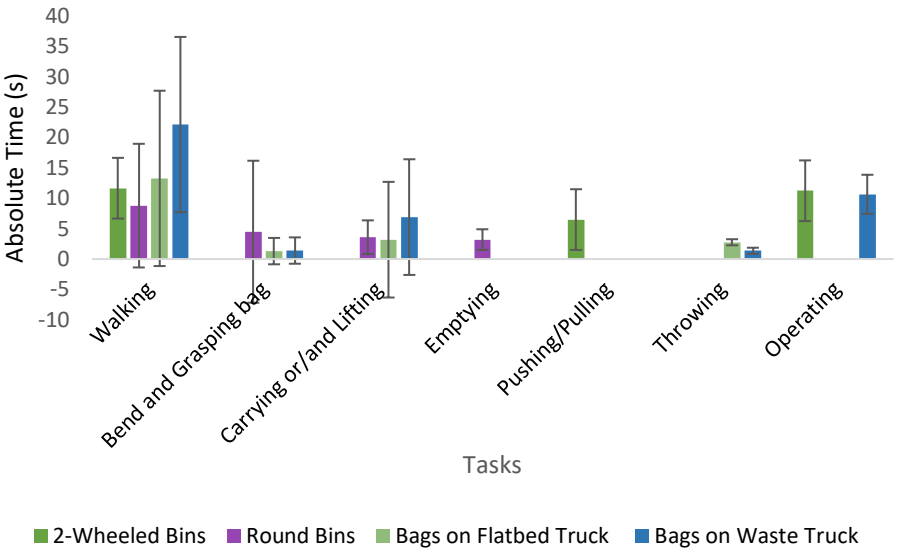

Figure 25: Average Time spent per task per Waste Collection Divisions

b) Percent time spent Analysis

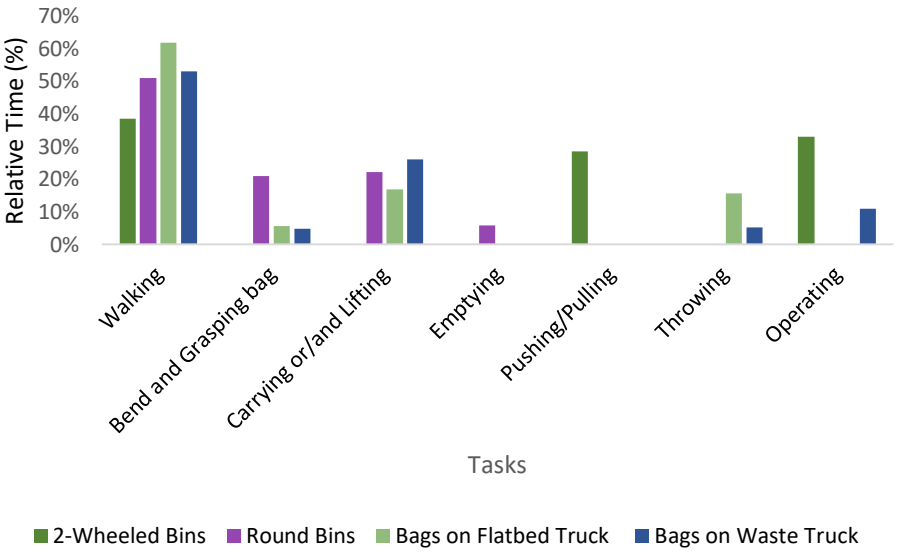

Figure 26: Percentage of the total work time spent per task per Waste collection Division

In a full workday, waste workers in all divisions spent the majority of their time walking (Figure 25). Flatbed loaders spent the greatest amount of time walking (62%), whilst

executing the process of collection took 38% of their time. Truck bag and 2-wheeled bin collectors spent approximately the same averaged time in the operations phase (10 -12s) (Figure 25), however in relation to the work cycle time, 2-wheeled bin collectors spent 33% of their cycle time doing operations whereas Truck bag collectors spent 11% (Figure 26). Round bins, Flatbed loaders and truck bag collectors, after walking spent most of their time carrying and lifting the rubbish bags (Figure 26).

4.3.1.4 Force Measurements

Table 12: Force Measurements for 2-wheeled bins within suburbs.

		Suburb 1 (large homes, further apart)	**Suburb 2 (smaller homes, closer together)**
Weight (Kgs)	***Mean***	25	15
	±SD	6.8	4.1
Initial Force (Nm)	***Mean***	164.4	89.9
	±SD	9.2	6.8
	Max	212.2	115.8
	Min	112.8	70.6
Mean Continuous Force (Nm)	***Mean***	57	43.7
	±SD	7.7	5.4
	Max	85.8	89.2
	Min	26.8	23.4

The average weight of bins within Suburb 1 was heavier than those in Suburb 2 (25 and 15kgs). Households in Suburb 1 did separate their recycling from non-recycling, the weight measurements taken for these bins were of the non-recycling/general waste bins. The initial force to pull the bins was higher for the heavier bins (mean = 164.4N±.9.2) The mean continuous force was still greater for heavier bins, however the difference in mean force was not as great for the different bin weights in both suburbs (difference in means = 13.3Nm) in comparison to the difference in initial force of bin pulls between the suburbs (74.5N) (Table 12).

4.3.1.5 Risk Assessment Results

The risk assessment results have been colour coded to classify risk levels. The colours identified below is classified based on their score or calculated output for each risk assessment tool. Green is for low risk of musculoskeletal development,

orange is for moderate risk and red is for high risk. The colour codes have been classified accordingly in

Table *13* below:

Table 13: Observation-based Instruments Risk Scoring

	Risk Level		
Risk Assessment	*Low*	*Moderate*	*High*
REBA	0	2 - 7	8 - 15
RULA	1 - 2	3 - 6	7+
RAMP	0	1 - 4.9	5+

a) REBA Results

Table 14: REBA Risk Score between Occupations

	Occupations									
	2-wheeled bins		**Round Bins**		**Bags Truck**		**Bags Flatbed**		**Public Cleansers**	
REBA Categories	starting	ending	starting	ending	starting	ending	starting	ending	starting	ending
Table A										
Neck	1	1	3	3	3	1	3	3	2	2
Trunk	2	2	5	5	5	2	5	5	3	3
Legs	1	1	1	1	2	2	2	2	2	2
Table A Score	2	2	7	7	8	3	8	8	7	7
Force/load	2	2	2	2	1	1	1	1	0	0
A. Neck, Trunk and Legs	4	4	9	9	9	4	9	9	7	7
Table B										
Upper Arm	2	2	2	5	2	5	2	5	3	3
Lower Arm	1	1	2	2	2	2	2	2	2	2
Wrist	2	2	3	3	2	3	3	3	2	2
Table B Score	2	2	4	8	4	8	4	8	5	5
Coupling	0	0	1	2	2	2	2	2	2	2
B. Arm and Wrist	2	2	6	9	6	10	6	10	7	7
Final REBA SCORE	**5**	**5**	**11**	**12**	**11**	**10**	**10**	**11**	**10**	**10**

The REBA Score (Table 14) table displays the final score and the scoring of the specific postures. Per Occupation, the starting position and the ending positions were analysed. The *starting position* was the initial contact posture assumed when the bin/bag/rubbish

item was collected. *Ending position* was final posture assumed on release of the item collected. For 2-wheeled Bins, as well as public cleansers, the starting position and ending position were had the same values throughout showing that there was not much difference in the upper and lower body postural bearings within a work cycle, however this doesn't assume that the working postures do not hold any risk. Round bin ending position had the highest final score (12), the Wrist and Arm movement attributed was the main attributer to this. The occupation with the lowest final risk score were 2-wheeled bin collectors (5). According to the REBA score ranking, all occupations except 2-wheeled bins, are of high risk.

b) RULA Results

Table 15: RULA Risk Scoring between Occupations

RULA categories	Occupations									
	2-wheeled bins		Round Bins		Bags Truck		Bags Flatbed		Public Cleansers	
	starting	*ending*	*starting*	*ending*	*starting*	*ending*	*starting*	*ending*	*starting*	*ending*
Table A										
Upper Arm	3	3	2	5	2	5	2	5	3	3
Lower Arm	1	1	3	3	3	3	3	3	3	3
Wrist	4	4	4	4	4	4	4	4	4	4
Wrist twist	1	1	1	1	1	1	1	1	2	2
Table A Score	5	5	5	7	5	7	5	7	5	5
Static/repetitive muscle use	0	0	0	0	0	0	0	0	1	1
Force/load	1	1	3	3	1	1	1	1	1	1
A. Arm and Wrist	6	6	8	10	6	8	6	8	7	7
Table B										
Neck	1	1	4	4	4	1	3	5	3	3
Trunk	3	3	5	5	5	5	6	6	3	3
Legs	2	2	2	2	2	2	2	2	2	2
Table B score	4	4	7	7	6	7	7	8	5	5
Static/repetitive muscle use	0	0	0	0	0	0	0	0	1	1
Force/load	1	1	1	1	1	1	1	1	0	0
B. Neck, Trunk and Legs	5	5	8	8	7	8	8	9	6	6
Final RULA SCORE	6	6	7	7	7	7	7	7	7	7

According to the RULA score ranking, all occupations except 2-wheeled bins, are of high risk. Round Bin collectors had the highest Arm and Wrist score both for starting and ending positions (8 and 10). Public cleansing was the only occupation with a high repetition upper arm muscle use. Flatbed workers had the highest neck, trunk and legs score (9) for their ending overhead lift position. Round bin collectors endured a greater load for their upper arms than the other occupations (3) (Table 15).

c) RAMP Results

Table 16: RAMP 2 Risk scoring between occupations

RAMP Categories	2-Wheeled Bins	Round Bins	Truck Bags	Flat Bed Bags	Public Cleansers
1. Postures					
1.1 Posture of the head - forwards and to the side	2	5	5	1	5
1.2 Posture of the head - backwards	0	3	3	3	0
1.3 Back posture - moderate bending	7	7	1	1	3
1.4 Back posture - considerable bending and twisting	3	5	5	2	2
1.5 Upper arm posture - hand in/above shoulder height*	2	10	10	2	0
1.6 Upper arm posture - hand in/outside outer work area*	0	10	7	2	7
1.7 Wrist posture*	3	7	7	2	2
1.8 Leg and foot space and surface	1	1.5	3	1	0.5
2. Work movements and repetitive work					
2.1 Movements of the arm*	0	2	2	2	2
2.2 Movements of the wrist*	0	0	0	0	3
2.3 Type of grip*	0	1	4	0	2
2.4 Shorter recovery/variation	0	0	0	0	0
2.5 Longer recovery/variation	0	0	0	0	0
3. Lifting					
3.1 Lifting (average case)	0.00	30.49	4.86	3.72	1.22
3.1 Lifting (worst case)	0.00	54.11	28.45	28.45	3.61
4. Pushing and pulling					
4.1 Pushing and pulling (average case)	4.86	0.00	0.00	0.00	0.00
4.2 Pushing and pulling (worst case)	28.48	0.00	0.00	0.00	0.00
5. Influencing factors					
5.1 Influencing physical factors hand/arm					
a+b. Hand-arm vibrations	0	0	0	0	0
c. Manually handling of warm or cold object	0	0	0	0	0
d. Hand used as impact tool	0	0	0	0	0
e. Holding hand-tools weighing > 2.3 kg, > 30 min.	0	0	0	0	0
f. Holding precision tools weighing > 0.4 kg > 30 min.	0	0	0	0	2
5.2 Other physical factors					
a+b. Whole body vibrations	2	2	2	4	0
c. Insufficient visual conditions	2	2	0	0	0
d. Hot, cold or draughty environment	2	2	2	0	2
e. Prolonged standing or walking on hard surfaces	2	2	0	0	2
f. Prolonged sitting	0	0	0	0	0
g. Prolonged standing	0	0	0	0	0
h. Kneeling/squatting	0	0	0	0	0

5.3 Work organizational and psychosocial factors					
a. No possibility to influence the work pace	**0**	**0**	**0**	**0**	**0**
b. No possibility to influence the work setting	**0**	**0**	**0**	**0**	**0**
c. Difficulties in keep up with the work tasks	**0**	**0**	**0**	**0**	**0**
d. Employees work rapidly in order to take longer breaks	**0**	**2**	**2**	**2**	**2**
6. Reports on physically strenuous work					
6.1 Documented reporting on physically strenuous work	**0**	**0**	**0**	**0**	**0**
6.2 Type of work that has led to reporting:					
7. Perceived physical discomfort					
7.1 Perceived physical discomfort	2	2	2	2	2
7.2 The worst task:					
Summary of the assessment					
Total score	**58**	**148.1**	**88.31**	**56.17**	**41.33**
Number of red assessments - High risk/action level	**4**	**9**	**9**	**3**	**3**
Number of yellow assessments - Risk/action level	**9**	**8**	**6**	**9**	**11**
Number of green assessments - Low risk/action level	**22**	**18**	**20**	**23**	**21**

The Round Bin and Truck Bag collection process had the most high risk actions and exposures (9). Both of these collection processes were found to have high risk postures. Round bins had the highest total risk scoring, the biggest contributor to this was the lifting technique and frequency. 2-wheeled bin collection was the 3rd highest risk bearer with the pushing and pulling worst case scenario having the highest scoring (28.48). Only three of the 8 posture factors were of high risk, everything else was of medium to low risk. Flatbed collectors had only 3 areas that could result in musculoskeletal injury or strain, being: posterior head tilt (3), whole body vibrations (4) and the worst case scenario for a lifting task. Public cleansers had the lowest overall scoring, posture and movements of the risk being main physical safety threat (Table 16).

4.3.2 Perceived Workload

In this section, workload was measured and identified from the subjective view of the workers themselves. The aim of this section was to use the Quantitative Workload Inventory Questionnaire and the NASA – Task Load Index to illustrate the difference in the responses between occupations under various workload categories and stressors. A Kruskal-Wallis test was used to further find if there was significance between groups under certain categories. All analyses that had no significance were attached in the appendix.

4.3.2.1 Quantitative Workload Inventory Questionnaire (QWIQ)

a) QWIQ per category sum scores between occupations.

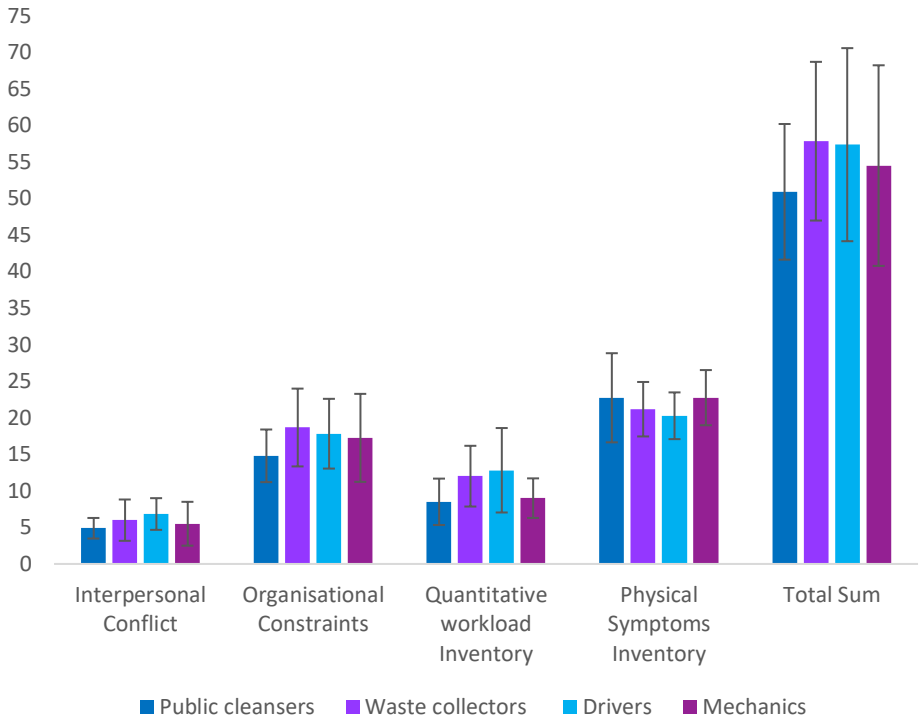

Figure 27: QWIQ average sum scores per category between occupations

Conflict between colleagues and work members (interpersonal conflict) was highest for drivers (6.83± 2.17). Waste collectors found their work more difficult to accomplish due to constraints met at an organisational level in comparison to the other occupations (18.67±5.32). Drivers responded to the quantity of work demanded for the job as quite high (12.82± 5.78) in comparison to Mechanics and Public cleansers, who perceived their daily workload as low (9.00±2.71 and 8.50± 3.17). When it came down to the physical symptoms experienced due to work conditions, public cleansers had the highest scoring. Lastly, Figure 27, shows that when all the scores are tallied, waste collectors scored the highest on the quantitative workload inventory questionnaire (57.84±10.86).

b) QWIQ – Physical symptoms Inventory per question responses

Public Cleansers

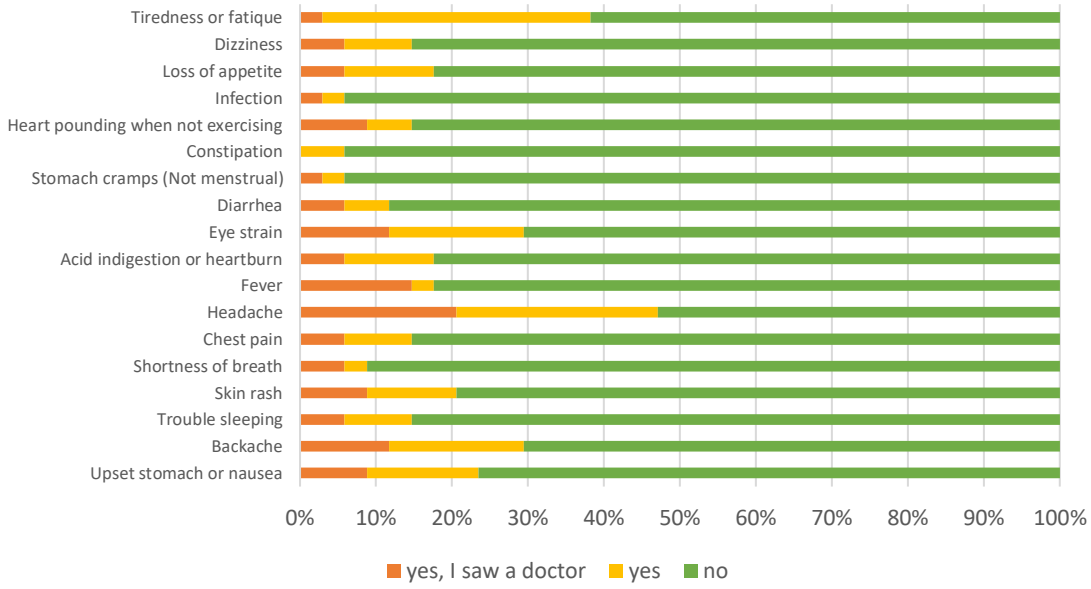

Figure 28: Public cleansers PSI response

Public cleansers 26% of public cleansers had experiences headaches within the 30-day period from which the research was conducted; 21% of these employees had received secondary help from a medical practitioner. Altogether 47% of public cleansers experienced headaches. Fatigue was another dominant symptom experienced by workers (38%) and 3% sought out a doctor for this symptom (Figure 28). Factors posed on workers that exasperate the occurrence of these symptoms is the heat and prolonged time spent walking and standing.

Waste Collectors

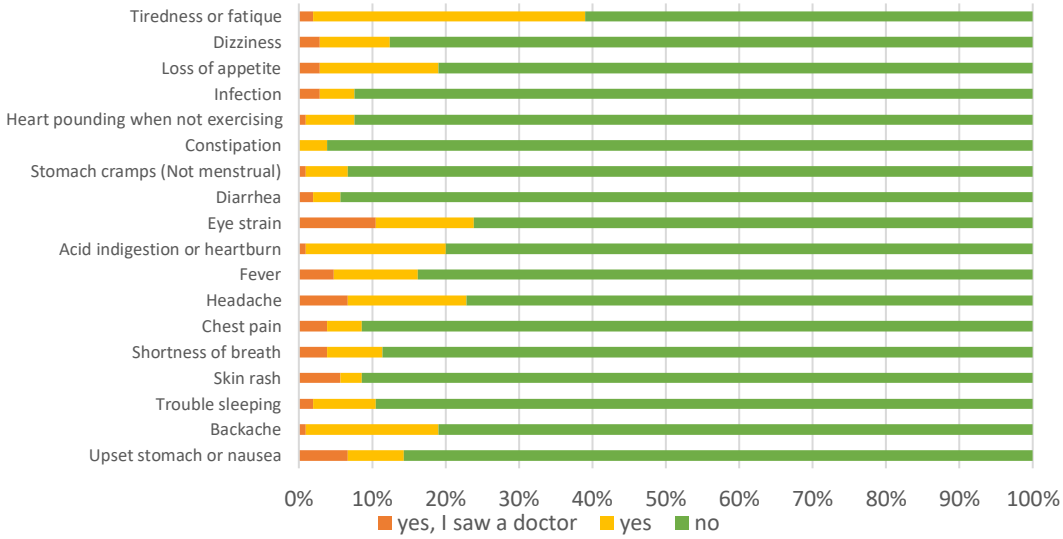

Figure 29: Waste collectors PSI response

The symptom with the most positive responses was fatigue (37%), followed by eyestrain (23%), which was the symptom that most workers went to seek medical (10%). The 3rd highest symptom was headaches (23%). 19% of waste collectors experienced backaches (Figure 29).

Drivers

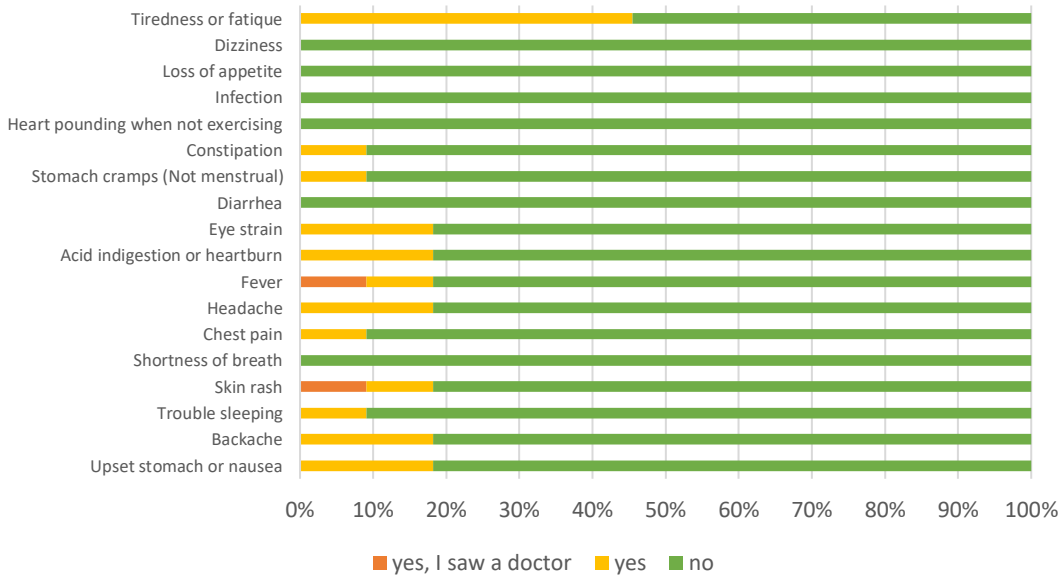

Figure 30: Drivers PSI response

The contraction of fever and appearance of skin rashes were the only symptoms experienced within the 30-day period where by medical attention was sought (5% and 6%) for drivers (

Figure 30). Tiredness had the highest positive response (45%). Followed by Eye strain, heartburn, headaches, backaches and nausea (all had an 18% positive response) (Figure 30).

Mechanics

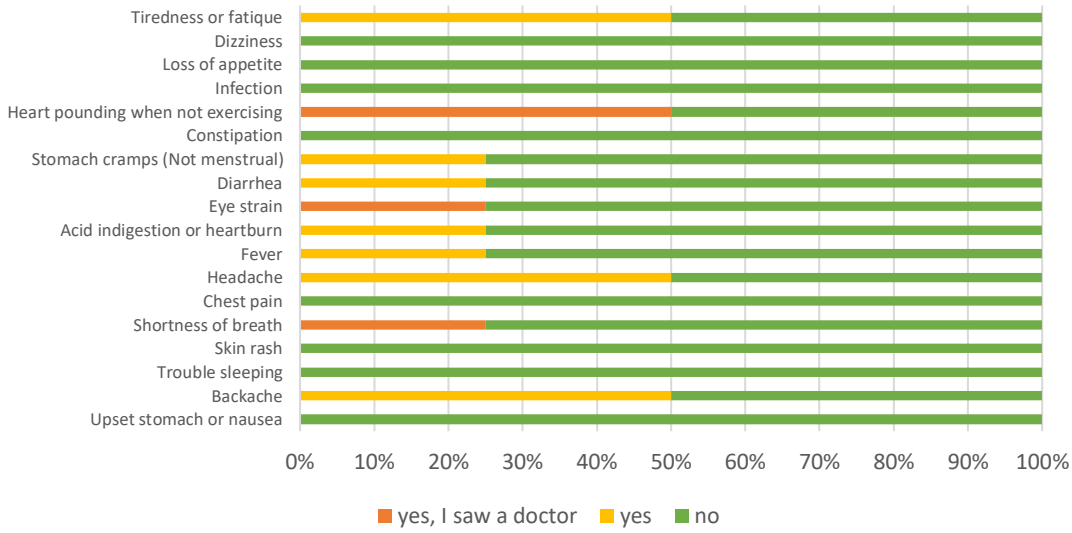

Figure 31: Mechanics PSI response

50% of mechanics had been subjected to a sudden of their heart pounding when they were not physically active, and had gone to a doctor for it. The next equally high positive responses were to the prevalence of fatigue, headaches and backaches amongst Drivers (Figure 31).

c) QWIQ scores between Occupations

Table 17: Comparison of Occupational scores for the QWIQ, Kruskal-Wallis ANOVA

*results of posthoc test differences can be seen Appendix M

Categories	Occupation	n	Mean of Rank	H	df	p	Difference*
Overall Sum Score	Public Cleansers (1)	34	56.62	7.14	3	0.01	1-2
	Waste collectors (2)	105	84.30				
	Drivers (3)	11	82.86				
	Mechanics (4)	4	61.75				
Interpersonal Conflict	Public Cleansers (1)	34	63.94	16.43	3	0.06	
	Waste collectors (2)	105	80.19				
	Drivers (3)	11	98.18				
	Mechanics (4)	4	65.38				
Organisational Constraints	Public Cleansers (1)	34	50.54	21.20	3	<0.01	1-2
	Waste collectors (2)	105	85.99				
	Drivers (3)	11	81.09				
	Mechanics (4)	4	73.88				
Quantitative Workload	Public Cleansers (1)	34	48.22	2.23	3	<0.01	1-2 1-3
	Waste collectors (2)	105	86.81				
	Drivers (3)	11	87.91				
	Mechanics (4)	4	53.25				
Physical Symptoms Inventory	Public Cleansers (1)	34	84.03	10.57	3	0.53	
	Waste collectors (2)	105	75.72				
	Drivers (3)	11	67.55				
	Mechanics (4)	4	96.00				

The Kruskal-Wallis H test showed that there was a statistically significant difference between occupations for the overall sum score, organisational constraints and quantitative workload categories ($p<0.01$). The posthoc tests showed that the difference lied predominantly between public cleansers and waste collectors. The only exception was with quantitative workload which included a significant difference between public cleansers and drivers. Drivers experienced the highest mean of rank

score for interpersonal conflict (98.18). Mechanics had the highest rank score, for the physical symptoms inventory (Table 17).

d) QWIQ scores for the Waste collecting depot sites

Table 18: Comparing QWIQ responses for the Waste collectors per depot site

Categories	Occupation	n	Mean of Rank	H	df	p
Overall Sum Score	Site 1	47	69.55	25.18	1	<0.01
	Site 2	58	39.59			
Interpersonal Conflict	Site 1	47	64.48	13.62	1	<0.01
	Site 2	58	43.70			
Organisational Constraints	Site 1	47	70.11	27.04	1	<0.01
	Site 2	58	39.14			
Quantitative Workload	Site 1	47	62.50	8.37	1	<0.01
	Site 2	58	45.30			
Physical Symptoms Inventory	Site 1	47	58.57	2.99	1	0.08
	Site 2	58	48.48			

The Kruskal-wallis H test showed that there was significant difference between the two depots in all categories except for the physical symptoms inventory. Site 1 showed a higher mean of rank scoring, 10 and greater, for all the categories. The highest and lowest mean of rank scoring was for organisational constraints (Site 1=70.11 and Site 2 = 39.14) (Table 18).

e) QWIQ scores for the Waste collectors divisions

Table 19: Comparing QWIQ responses for the various Waste collectors divisions.

*results of posthoc test differences can be viewed in (Appendix M)

Categories	Occupation	n	Mean of Rank	H	Df	p	Difference*
Overall Sum Score	WC (1)	87	50.94	6.84	2	0.03	1-2
	WC/runner (2)	6	84.50				2-3
	WC FB loader (3)	12	52.17				
Interpersonal Conflict	WC (1)	87	52.06	1.82	2	0.40	
	WC/runner (2)	6	68.33				
	WC FB loader (3)	12	52.13				
Organisational Constraints	WC (1)	87	49.41	7.25	2	0.03	1-2
	WC/runner (2)	6	74.08				
	WC FB loader (3)	12	68.50				
Quantitative Workload	WC (1)	87	52.52	7.23	2	0.03	2-3
	WC/runner (2)	6	82.25				
	WC FB loader (3)	12	41.88				
Physical Symptoms Inventory	WC (1)	87	53.10	0.56	2	0.76	
	WC/runner (2)	6	59.92				
	WC FB loader (3)	12	48.83				

Waste collector/runners (WC/runner) had higher mean of rank scores than the other waste collector divisions in all 5 categories. Significant difference was found between the WC/runners and waste collectors for the overall sum score and organisational constraints (P<0.03). Significance was also found between WC/runners and Waste collector flatbed loaders (WC FB loader) for the overall sum and Quantitative workloads (p<0.03). The WC group had the lowest mean of rank scores for all categories except for Quantitative workload and the Physical symptoms (Table 19).

f) QWIQ Employment Status scores

Table 20: Comparing QWIQ responses for all employees on the basis of Employment

Categories	Occupation	n	Mean of Rank	H	df	p
Overall Sum Score	Permanent	96	60.91	9.78	1	<0.01
	Contracted	38	84.16			
Interpersonal Conflict	Permanent	96	61.71	8.70	1	<0.01
	Contracted	38	82.13			
Organisational Constraints	Permanent	96	59.49	14.51	1	<0.01
	Contracted	38	87.74			
Quantitative Workload	Permanent	96	61.69	7.67		<0.01
	Contracted	38	82.18			
Physical Symptoms Inventory	Permanent	96	67.10	0.04	1	0.85
	Contracted	38	68.50			

Contracted workers had a greater mean of rank scoring for all categories. Significant difference was found for all categories with the exception of the Physical symptoms inventory ($p<0.01$) (Table 20).

An analysis was done comparing public cleansers in their relative depot sites there were no differences found for the QWIQ questionnaire (Appendix N).The same outcome occurred when analysing the males and females within the public cleansing sector (this was the only sector that had females) (Appendix M).

g) Per Question Analysis (p<0.05)

Table 21: Per question comparison between occupations (only those with p<0.05)

Categories	Occupation	n	Mean of Rank	H	df	p	Difference*
Interpersonal conflict	Q1: How often do you get into arguments with others at work?						
	Public Cleansers (1)	34	62.74	8.57	3	0.04	1-3
	Waste collectors (2)	105	80.97				
	Drivers (3)	11	90.18				
	Mechanics (4)	4	77.00				
Organisational Constraints	Q1: How often do you find it difficult or impossible to do your job because of poor equipment?						
	Public Cleansers (1)	34	48.26	21.65	3	<0.01	1-2
	Waste collectors (2)	105	86.71				
	Drivers (3)	11	72.32				
	Mechanics (4)	4	98.50				
Organisational Constraints Q5	Q5: How often do you find it difficult or impossible to do your job because of lack of equipment or supplies?						
	Public Cleansers (1)	34	43.22	28.89	3	<0.01	1-2
	Waste collectors (2)	105	88.56				
	Drivers (3)	11	73.32				
	Mechanics (4)	4	90.13				
Quantitative Workload	Q1: How often does your job require you to work very fast?						
	Public Cleansers (1)	34	45.65	24.39	3	<0.01	1-2 1-3
	Waste collectors (2)	105	86.82				
	Drivers (3)	11	87.73				
	Mechanics (4)	4	75.50				
Quantitative Workload	Q5: How often do you have to do more work than you can do well?						
	Public Cleansers (1)	34	61.53	13.59	3	<0.01	1-2
	Waste collectors (2)	105	81.43				
	Drivers (3)	11	102.77				
	Mechanics (4)	4	40.50				
Physical Symptoms Inventory Q7	During the past 30 days have you had Headaches?						
	Public Cleansers (1)	34	92.97	9.55	3	0.02	1-3
	Waste collectors (2)	105	72.97				
	Drivers (3)	11	68.23				
	Mechanics (4)	4	90.50				
Physical Symptoms Inventory Q1	During the past 30 days have you had your heart pounding when not exercising?						
	Public Cleansers (1)	34	81.50	11.52	3	<0.01	2-4 3-4
	Waste collectors (2)	105	75.70				
	Drivers (3)	11	70.00				
	Mechanics (4)	4	111.25				

Table 21 shows the significant differences in responses per question for the different occupation groups. Drivers compared to other groups, often argue with other people colleagues and outsiders, there was significant difference when compared to public cleansers ($p<0.05$). Waste collectors responded highly in their struggle to complete their work due to lack of equipment and supplies ($p<0.05$). Waste collectors and Drivers had significantly higher responses when it came to the temporal nature of their work, in comparison to public cleansers ($p<0.05$). Public cleansers, when compared to the other occupations, rated their occurrence of headaches to occur more frequently, and being significantly higher than the drivers ($p<0.05$). The mechanics responded in experiencing arbitrary heart accelerations or poundings, even when they were not exercising ($p<0.05$).

4.3.2.2 NASA Task Load Index (NASA-TLX)

a) NASA-TLX Average scores within each category per occupation

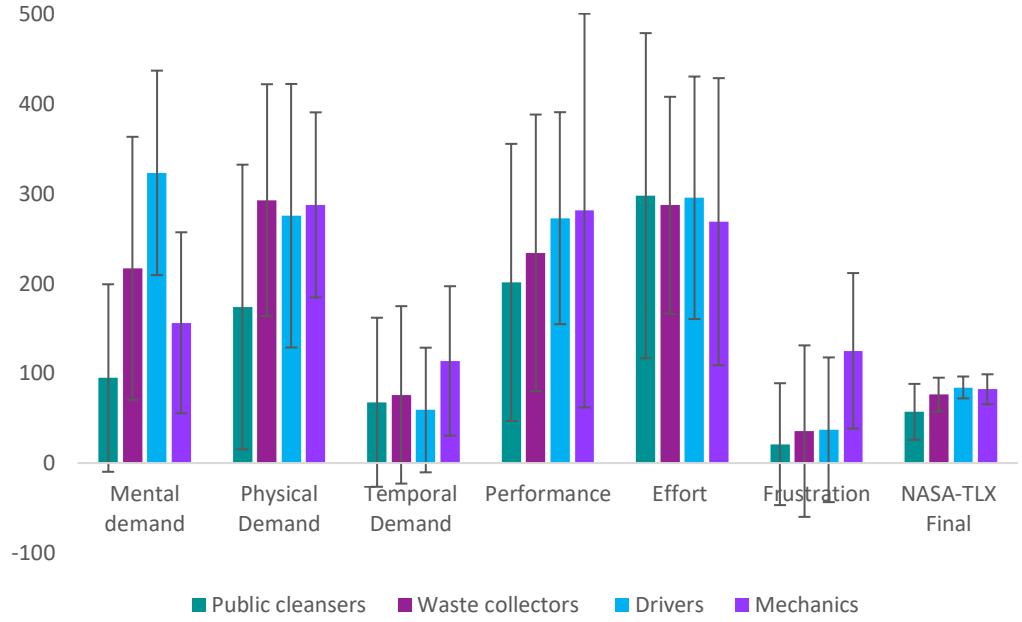

Figure 32: NASA-TLX average sum scores per category between occupations

Figure 32 displays that in terms of how workers perceive their work, drivers identified their work as mostly cognitively demanding in comparison to all the other workload demands (323.18 ± 113.85). Waste collectors perceived their work as predominantly physically demanding (292.71±129.18); whereas public cleansers deemed their work as more effortful than physically demanding (297.79±181.02). Mechanics were the one

occupation having displayed a very steep frustration response towards their work in relation to the other occupations. In addition, Mechanics perceived they had to hasten their work speed, and felt the most satisfied with their output. This was shown through their temporal demand and performance scores (113.75±83.20 and 281.25±219.26); however the performance SD scores also shows that there is disparity in this satisfaction rating.

b) NASA-TLX scores between Occupations

Table 22: Comparison of Occupational scores for the NASA-TLX, Kruskal Wallis ANOVA

* results of posthoc test differences can be seen Appendix P

Categories	Occupation	n	Mean of Rank	H	df	p	Difference*
NASA TLX Overall Sum	Public Cleansers (1)	34	53.41	14.97	3	<0.01	1-2
	Waste collectors (2)	105	82.13				1-3
	Drivers (3)	11	102.86				
	Mechanics (4)	4	90.88				
Mental Demand	Public Cleansers (1)	34	45.84	27.39	3	<0.01	1-2
	Waste collectors (2)	105	84.16				1-3
	Drivers (3)	11	114.68				
	Mechanics (4)	4	69.50				
Physical Demand	Public Cleansers (1)	34	51.31	15.28	3	<0.01	1-2
	Waste collectors (2)	105	85.26				
	Drivers (3)	11	82.14				
	Mechanics (4)	4	83.63				
Temporal Demand	Public Cleansers (1)	34	70.26	2.72	3	0.44	
	Waste collectors (2)	105	79.49				
	Drivers (3)	11	71.36				
	Mechanics (4)	4	103.75				
Performance	Public Cleansers (1)	34	69.01	2.34	3	0.51	
	Waste collectors (2)	105	78.59				
	Drivers (3)	11	88.64				
	Mechanics (4)	4	90.38				
Effort	Public Cleansers (1)	34	82.96	0.76	3	0.86	
	Waste collectors (2)	105	75.77				
	Drivers (3)	11	79.09				
	Mechanics (4)	4	72.25				
Frustration	Public Cleansers (1)	34	74.66	6.57	3	0.09	
	Waste collectors (2)	105	76.60				
	Drivers (3)	11	79.45				
	Mechanics (4)	4	120.00				

Significant difference was found in the overall NASA TLX scoring ($p<0.05$), the posthoc displayed this significance residing between the public cleansers and waste collectors (1-2) and between public cleansers and drivers (1-3). There was a significant difference in perceived mental and physical demands between waste collectors and public cleansers. The greatest mean of rank difference was between public cleansers and drivers for mental demand (45.84 and 114.68) ($p<0.005$). Out of all of the occupations, drivers had the highest mean of rank scoring which was attributed to job frustration (120). The mean of rank for drivers and mechanics showed that both groups were more contented with their work efforts (performance) (88, 90) compared to waste collectors and public cleansers. Public cleansers in relation to the others, perceived their work as very effortful (mean of rank =82) (Table 22) .

c) NASA-TLX scores for the public cleansing depot sites.

Table 23: Comparing NASA-TLX responses for the public cleansers per depot site.

* results of posthoc test differences can be seen Appendix Q

Categories	Occupation	n	Mean of Rank	H	df	p	Difference*
NASA TLX Overall Sum	Site 3 (1)	10	15.50	14.82	2	<0.01	2-3
	Site 4 (2)	9	8.44				
	Site 5 (3)	15	24.27				
Mental Demand	Site 3 (1)	10	18.75	7.50	2	0.02	2-3
	Site 4 (2)	9	9.94				
	Site 5 (3)	15	21.20				
Physical Demand	Site 3 (1)	10	18.45	8.59	2	0.01	2-3
	Site 4 (2)	9	9.50				
	Site 5 (3)	15	21.67				
Temporal Demand	Site 3 (1)	10	19.45	8.07	2	0.02	2-3
	Site 4 (2)	9	9.61				
	Site 5 (3)	15	20.93				
Performance	Site 3 (1)	10	13.95	12.67	2	<0.01	1-3
	Site 4 (2)	9	10.39				2-3
	Site 5 (3)	15	24.13				
Effort	Site 3 (1)	10	14.60	3.89	2	0.14	
	Site 4 (2)	9	14.50				
	Site 5 (3)	15	21.23				
Frustration	Site 3 (1)	10	17.00	4.72	2	0.09	
	Site 4 (2)	9	13.50				
	Site 5 (3)	15	20.23				

Site 4 and 5 had displayed stark differences in their responses. Site 5 had the highest scorings in all categories, whereas Site 4 had the lowest mean rankings. Significant difference was seen in between these two sites for the sum and 4 of the subcategories. Site 5's performance rating was significantly higher than both Site 3 and Site 4 ($p<0.01$) (Table 23).

c) NASA-TLX scores for the Waste collectors per depot site

Table 24: Comparing NASA-TLX responses for the Waste collectors per depot site

Categories	Occupation	n	Mean of Rank	H	df	p
NASA TLX Overall Sum	Site 1	47	56.82	1.34	1.00	0.25
	Site 2	58	49.91			
Mental Demand	Site 1	47	45.40	5.33	1.00	0.02
	Site 2	58	59.16			
Physical Demand	Site 1	47	61.68	7.05	1.00	0.01
	Site 2	58	45.97			
Temporal Demand	Site 1	47	56.01	0.84	1.00	0.36
	Site 2	58	50.56			
Performance	Site 1	47	51.96	0.10	1.00	0.75
	Site 2	58	53.84			
Effort	Site 1	47	53.24	0.01	1.00	0.94
	Site 2	58	52.80			
Frustration	Site 1	47	57.39	3.18	1.00	0.07
	Site 2	58	49.44			

Significant differences between waste collectors between the two sites was evident in the perceived mental and physical work demands ($p<0.05$). Site 1 employee responses suggested that their work required greater physical exertion, in contrast to Site 2 workers where they deemed their work to be more mentally taxing than physically. Site 1 having a higher mean rank physical demand response, also displayed a higher scores in the effort and frustration category (Table 24).

d) NASA-TLX scores for the Waste collectors divisions

Table 25: Comparing NASA-TLX responses for the various Waste collectors divisions site.

* results of posthoc test differences can be seen Appendix R

Categories	Occupation	n	Mean of Rank	H	df	p	difference
NASA TLX Overall Sum	WC (1)	87	53.81				2-3
	WC/runner (2)	6	78.25	8.62	2	0.01	
	WC FB loader (3)	12	34.50				
Mental Demand	WC	87	55.68				
	WC/runner	6	43.67	4.08	2	0.13	
	WC FB loader	12	38.25				
Physical Demand	WC (1)	87	49.05				1-2
	WC/runner (2)	6	90.75	12.15	2	<0.01	
	WC FB loader (3)	12	62.79				
Temporal Demand	WC (1)	87	54.86				
	WC/runner (2)	6	59.25	4.16	2	0.12	
	WC FB loader (3)	12	36.42				
Performance	WC (1)	87	54.49				
	WC/runner (2)	6	36.58	2.07	2	0.35	
	WC FB loader (3)	12	50.42				
Effort	WC (1)	87	54.89				
	WC/runner (2)	6	59.08	4.39	2	0.11	
	WC FB loader (3)	12	36.25				
Frustration	WC (1)	87	51.71				
	WC/runner (2)	6	71.83	4.40	2	0.11	
	WC FB loader (3)	12	52.96				

Waste collector/runners had the highest overall task load sum score (78.25). The Kruskal-wallis H test showed that there was significant difference between waste collection divisions for physical demands ($p<0.01$). The posthoc analysis showed that the perceived physical demands of WC/runners and waste collectors differed significantly ($p<0.01$) (Table 25).

e) NASA-TLX Employment status scores

Table 26: Comparing NASA-TLX responses for all employees on the basis of Employment

Categories	Occupation	n	Mean of Rank	H	df	p
NASA TLX Overall Sum	Permanent	96	65.13	1.27	1	0.26
	Contracted	38	73.50			
Mental Demand	Permanent	96	69.10	0.58	1	0.45
	Contracted	38	63.45			
Physical Demand	Permanent	96	62.91	4.80	1	0.03
	Contracted	38	79.11			
Temporal Demand	Permanent	96	63.90	2.93	1	0.09
	Contracted	38	76.59			
Performance	Permanent	96	69.42	0.84	1	0.36
	Contracted	38	62.64			
Effort	Permanent	96	69.15	0.63	1	0.43
	Contracted	38	63.33			
Frustration	Permanent	96	64.68	3.12	1	0.08
	Contracted	38	74.62			

For permanent and contracted staff members, the Kruskal-wallis analysis showed that significant difference between the groups was only observed for physical demands ($p<0.03$). Contracted workers had higher mean of rank scorings with the exception of the mental demand, performance and effort categories (Table 26).

An analysis was done comparing male and female employees, there were no differences found for the NASA-TLX (Appendix O); however 2 of the categories (Frustration and Performance), unlike the rest, there was mean of rank difference 3<.

CHAPTER V: DISCUSSION

The objectives of this study were to determine the level of strain placed on the worker due to the work demands. To determine this, methods quantifying the outputs on a physical and perceptual level were investigated. This study was designed to be comprehensive by investigating the physical and perceptual risk factors amongst waste workers in the Tshwane Municipality.

The findings of the study are discussed in conjunction with the literature from various developing and developed countries. This section begins with the response to the hypotheses, summarising the occupation's outputs for both physical and perceptual workload. The discussion will then further justify the reasoning for the hypothesis status in accordance with the results and observation findings.

5.1. RESPONSE TO THE HYPOTHESES

5.1.1. Hypothesis 1: Physical workload

The hypothesis regarding physical workload stated that job demand would have an effect on the various occupation groups.
The results from the REBA, RULA and RAMP 2 assessments show a difference between the various occupants. Thus, the alternative hypothesis is tentatively accepted.

5.1.2. Hypothesis 2: Perceptual workload

The hypothesis regarding perceptual workload stated that job demand would have an effect on the various occupation groups.
The results from the NASA-TLX and QWIQ questionnaires show a difference between the various occupations. Thus, the alternative hypothesis is tentatively accepted.

5.2. PHYSICAL WORKLOAD

Round bin waste collection was the collection type with the highest risk of MSD development and injury that remained constantly high amid all the risk assessments. Truck bag and Flatbed bag collection scorings were similar, however, the scorings were not consistent when outputted in RAMP tool, having generated truck bag collections to be of greater risk than flatbed collectors. Public cleansers, according to REBA and RULA was of equivalent risk as Truck and Flatbed collecting. Contrarily the RAMP tool, displayed outputs opposing REBA and RULA, scoring public cleaners to have the least risk amongst the occupation groups. 2 -wheeled bin collection, had remained to be moderate risk throughout all the risk assessments. These results corroborate with literature findings that lifting tasks were more detrimental than pushing and pulling (Çakit, 2015; Kuijer & Frings-Dresen, 2004). However, previous studies had shown when comparing the lifting of various materials (e.g., bags, dollies, 2-wheeled bins), the frequency, coupling and posturing related to bag lifting was found to be the most strenuous of them all (Çakit, 2015; Fulton, 2013; Kuijer & Frings-Dresen, 2004; P. Kuijer et al., 2000; P. P. F. M. Kuijer & Sluiter, 2010). The results contradicted these findings, having shown that round bin collection posed the most risk and workload strain resulting from the weight, fullness, coupling, and posturing.

5.2.1. Waste collectors

When pertaining to the full arm and wrist, round bin collectors for the 3 assessments (REBA, RULA and RAMP 2) have the highest wrist risk, followed by truck bag collectors, and then followed by flatbed bag collectors. The collection task posture form is very similar for these three and is a part of the reason why the risk is so high. All 3 of the occupations are carrying and lifting-based. A high injury risk is forthcoming for round bin collectors due to having to repetitively lift bins having an accounted weight between 4-24kgs each, which dependent on the quantity of household refuse disposed is half the lifting weight of bags carried by the flatbed and truck bag collectors (3-10kg and 1.8-9kgs, respectively). These weights are within the acceptable ‘constant load’ range stipulated by NIOSH (Waters et al. 1993), with the exception of round bin collection which had accounted for a bin weighing over 23kgs. However, NIOSH also recommends this weight to be lifted under ideal worker-task conditions presuming the worker is lifting in the sagittal plane, repetitive lifting is not intensive, the handle

couplings are good and the height of the coupling (vertical displacement) is greater than 25cm from the ground (Waters et al. 1993). For waste collectors the stooping technique was used during lifting; with the plastic bags, the coupling was not ideal, and bags were slippery and may tear, forcing the worker to carry that load in an awkward posture. Lifting has often been associated with back pain but also causes upper-body muscle strain. When picking up round bins and plastics, lifting from the ground or waist height to shoulder height and above projected different movements for different refuse weights. Particularly when the round bins were full, collectors would move slower due to the heaviness, and the horizontal distance of the bin in relation to the worker was much closer. With the plastic bags, workers would lengthen their arms, and flex their elbows to lift the load, using the momentum during lifting and their trunk would use the swing in the trunk rotation to assist the initial momentum to throw the bag into the trucks. Chen (2000) who studied upper body effects recognised and explained a similar lifting style when assessing workers with loads greater than 15kgs. His finding showed that in lifting techniques that had higher [shoulder or above shoulder] ending height, workers had assumed the stooping position, using the back extensor muscles to produce a higher load acceleration to assist the lack of arm and shoulder strength.

The images of the truck and flatbed bag collectors (Figure 12, Figure 15, Figure 16) show evidence that unlike in the NIOSH guidelines, lifting motions for these two collection types involve torso twisting, humeral rotation and great horizontal and vertical displacement on the transverse plane. Even though transverse plane movement for lifting is not biomechanically ideal, the trunk and shoulder rotation in this movement is adopted to help generate more power (Asgari, Sanjari, & Esteki, 2017). The disadvantage of this technique with waste workers is their unpredictable load weighting conditions. Workers prior to lifting visually predict the weight of the refuse bags to come. If the worker underestimates the bag weight and picks up the bag in an awkward transverse posture, a consequential imbalance of trunk or back muscle recruitment can cause an instant stress peak, which if not causing imminent strain, may lead to an overuse strain injury. However, in relation to reported perceived shoulder and lower back pain, there were very few waste collectors who reported pain. This concurs with the findings of (Fulton, 2013) who had only 2 of his 9 participants report shoulder or back pain.

The two-wheeled bins weighed between 9-31kgs. The average initial force was 164.4N and 89.9N (Suburb 1 vs Suburb 2, Table 12).The mean continuous force average was much less approximately 57N and 43.7N. The force and bin weighting in comparison to other studies is low, but the frequency of pushing and pulling bins was quite high (15-32 bins per hour). In a workday, approximately 7936kg of waste is handled (using the peak bin/hr (32) x max weight (31) x 8hr shift). With these results, 2-wheeled bin collection is within acceptable ISO pushing and pulling standards of 10 000kgs per 8hr shift. This result is also lower than the pushing found in other international studies: Kuijer, Frings-dresen, Looze, Visser, & Beek (2000) being approx. 11 000kgs in the 1995 study, and ±12 000kgs for study comparison in the year 2000. Shoulder discomfort has been strongly associated with pushing and pulling tasks (Kuijer & Frings-Dresen, 2004). Collectors would execute the double one-handed bin push or pull (or push two bins with a bin in each hand) (Figure 17 – right image), this decreased their travel frequency and time spent which is advantageous since their work is time sensitive. This method is not ergonomically safe, but given the time constraints and energy expended throughout the day, the double one-handed push/pull saves time and preserves physiological stress indicating delayed fatigue.

5.2.2. Public Cleansers

The mean age of public cleansers (42.0 ±10.5) was higher than those in India and Egypt (37.3±9.1 and 37.9 ± 8.8) ((Ewis et al., 2013; Salve & Chokhandre, 2016). Showing the relatively high age workforce, although having shown in the back arm and neck areas, the risk was not as high as the other occupations. The results indicated that of all the occupation groups, public cleansers were found to have the most exposure to all the physical symptoms. Symptoms such as headaches and fatigue has a high prevalence report (47% and 38%). Bleck & Wettberg (2012) state that the exposure to gases and emissions from waste and dumpsites is one of the causes for headache and nausea experience. Physical workload overload can result in excessive fatigue (Bagherifard et al., 2022).

They showed that 29% of workers experienced eye strain, this concurred with results found in street sweepers from Egypt, 21% of them having experienced eye irritations (Ewis et al., 2013). The observation and work familiarisation found that this was as a

result of dirt exposure primarily that can occasionally appear harshly through the winds, sun exposure, and/or substance-related odours. Harsh winds were experienced frequently and sporadically within the CBD and town centres. This was as a result of the wind tunneling effect. The public cleansers made effort to complete their workday before 12pm. Unlike with most the analyses where their perceived workload was significantly lower than the other occupations, when it came to temporal demand they averaged on part with waste collectors (Figure 32) Public cleansers chose to complete their work early due to the increase in heat temperature which has been found to tire and dehydrates workers doing physically demanding tasks. Narayanan, Saladi, & Fox (2010) provide evidence supporting this statement, stating that the sun's ultraviolet rays reach their peak between 10 am and 4 pm. Heat exposure a person's energy consumption and metabolism, resulting in them feeling fatigued (Narayanan, Saladi, & Fox (2010). 12% of workers experienced diarrhea, similarly 8% of street sweepers in Vietnam also experienced diarrhea (Nguyen et al., 2003, cited in Ewis et al., 2013). A higher percentage of workers in Egypt experienced diarrhea (21%), having analysed the stool found that parasitic infestations dwelling in the intestine (Ewis et al., 2013).

Public cleansers unlike the other occupations with the exception of plastic bag collectors were found to use a wide range of wrist motions. This included radial and ulnar deviation, hyperextension, flexion and pronation. The picking sticks required upper arm force for task completion, whereas the tongs, created discomfort over time due to the stiffness of the steel and pinch grip movements.

5.2.3. Drivers

Lower back pain has been heavily researched and has been reported to be of high prevalence amongst truck drivers (Shin & Jeong, 2020; Ramroop, Shaik, & Govender, 2004; Spielholz et al., 2008). In this study a low response of only 18% of drivers had experienced back pain in the past month. A South African research study completed on refuse truck drivers in Durban found that 79% of truck drivers experienced back pain, in the past 12 months, 64% rated positively within the past week, and 51% had experienced pain the day they had completed the questionnaire (Ramroop et al., 2004). Having analysed the two reports, comparable factors that Ramroop et al. (2004) of which some factors had significance are referred to below. Height: Ramroop et al.

(2004) found that weight and height did not prove to have a significant impact on the development of LBP, in spite of this there were some similarities and differences namely, the mean height of Durban truck drivers was 169.3mm and 169.9 in Pretoria drivers. Weight: Pretoria drivers weighed less than the drivers in Durban at 68.2 1kg ±7.7 (Pretoria), and 72.53kg ±12.9 and 72.16 ± 10.94 (for Durban drivers who experienced back pain; vs those who has no back pain, respectively).

The observation-based assessment (Figure 22, Figure 23 and Figure 24) showed the placement of the driver in relation to the controls and operational functions. The non-experienced driver who took part complained of discomfort in the leg, neck and back areas. The elongated seating, alongside the minimal seat padding and lack of a backrest, are two of the reasons discomfort was caused in the lower back. The physical force required from the leg and arms for the clutch, and the handbrake was the mentioned main influencer for pain residing in those areas. The anterior neck tilt when operating the control units is an awkward neck posture that can strain the shoulders and neck muscles over time. The mix of all of the operations in relation to the strain caused in certain areas of the body concurs with Ramroop et al. (2004) findings, having found a significant relationship between lower back pain and the operational reach of the controls required to drive a refuse truck ($p<0.05$).

5.2.4. Mechanics

To compare the mechanics' perceived workload, one other study was found to have used the NASA-TLX to quantify the workload of mechanics. The car repair mechanics, researched by Prabaswari and Utomo (2020), were used as a reference point. The results for each demand criterion are laid side by side to compare the results from both investigations as such: waste vehicle mechanics (Figure 32); car repair mechanics (Prabaswari and Utomo, 2020). The results revealed Mental demand (156.25; 305); Physical demand (287.5; 191); Temporal demand (113.75; 254); Performance (281.25; 160); Effort (268.75; 286) and Frustration (125.00; 56) accordingly. The physical demand and frustration were higher than the mental demand for waste mechanics in comparison to car repair mechanics and was the highest rating of all the demands. Some of the reasons attributing this are the lack of mechanical resources, poor vehicle maintenance and postures undertaken to weld and fix certain areas. Unlike in repair

shops, there are no mechanical lifters that could elevate the trucks to inspect vehicle damages from beneath, imposing them to awkward bent postures. The high-performance scoring indicates that their job requires both cognitive decision-making requirement and physical requirements.

5.3. LOWER BACK PAIN AND PERCEPTUAL WORKLOAD

Elders and Burdorf (2001), in their study of scaffolding workers, suggested that there was strong correlation between low back disorders and ergonomic risk factors like trunk twisting, heavy physical work, frequent bending and forceful movements. The results concur with this statement due to the high physical demands needed in waste collecting. The three risk assessment tools assessed Round Bin and Truck bag lifting forms were the most high risk due to factors such as twisting, heavy bin weights and trunk loading. From the results, the postural effect of the task demands on the back in isolation, REBA and RULA showed a correlation in extreme and awkward trunk postures assumed between the garbage lifting occupations/tasks (i.e. round bin, truck bag, and flatbed bag lifting), this correlation was particularly strongly with flatbed bag lifting. The RAMP tool however refutes the correlation found between the flatbed workers, and this is a result of the time spent and frequency of the task. Although flatbed workers twist, bend and comparably do more overhead throws which require more energy; they only spend 2-3 hrs of their day under these work conditions where the other waste collection groups spend 6-12 hrs depending.

There has been a lot of literature isolating factors such as weight, stature and/or BMI and their contribution to lower back pain. The correlation between these factors amongst drivers has been described above, however there was a hope to gain insight from literature to compare the outputs in relation to this study. The information would have been used for cross-comparisons particularly between symptoms relating to the back, neck or other pains. Unfortunately, the demographic information regarding weight and stature was only found in relation to drivers and public which has been detailed in the paragraphs prior.

In terms of perceived or recently experienced back pain participant feedback, mechanics had the highest percentage having 50% of the workforce experiencing back

pain. The mechanics had to bend to weld vehicle parts, repairing the machinery beneath and within the vehicle predisposing them to awkward trunk postures. For public cleansers, 29% of the workforce reported backaches, which is relatively low in relation to other but not all studies. Public cleansers in Egypt had a low response rate of approx. 8% experienced back pain (Ewis et al., 2013).

The results of this study showed that only 19% of the waste collectors experienced backaches (Figure 29). This response percentage is much lower than that of other studies. Ziaei, Alireza, Abdoli-Eramaki and Ghaem (2018), 63% of their investigated waste collection group reported having felt discomfort or experienced lower back pain. On a slightly lower percentage, Jerie (2016) found that 42.5% of informal waste collectors experienced chronic back pain. This was calculated by determining the mean number of complaints from waste workers based in 6 different towns in Zimbabwe. Results from a study in Taiwan compared 2 groups in assessing the prevalence of back pain: Group 1 included waste workers (collectors and drivers), whereas Group 2 included office workers. 42% of the population in Group 1 complained of back pain whereas only 21% experienced it in Group 2. This is an interesting contradiction to other studies. The study contradicts the research conducted on the prevalence of lower back pain amongst waste collectors (Jerie, 2016; P. Kuijer et al., 2000; Yang et al., 2001; Ziaei et al., 2018). A possible reason for this contradiction is that PSI specifically asks if the sensations of back pain had been experienced within the past 30 days. The other studies have not indicated within their articles if the lower back symptoms of waste collectors were contemptuous or within a longer time frame e.g, within the past year (Ewis et al., 2013; Ramroop et al., 2004; Yang et al., 2001). Previous research has shown that extensive standing and walking were strongly associated with lower back pain development (Garcia et al., 2016; Li et al., 2009), these results demonstrate that perhaps the dynamic and gross movement tasks associated with waste collecting is a possible reason to why pain was not experienced. The findings of Lu, Waters, Krieg and Werren (2014) concurred with this disconnect in LBP association with the MMH tasks involved in machine dryer manufacturing workers. Their inputs suggested that the cumulative load findings did not account for rest times and job rotations in their case. Our study accounted for rest times but not job rotations.

5.4. PERCEPTUAL WORKLOAD

The overall QWIQ and NASA-TLX sum scores showed that there was a significant difference in the perception of work between waste collectors and public cleansers, as well as between public cleansers and drivers (only for the NASA-TLX). When workers were asked about quantitative workload factors such as ‘how much’ work or ‘how quick’ they need to work to accomplish their task in the QWIQ questionnaire, significant differences were found in the responses of the public cleansing group in relation to the waste collection group ($p<0.01$) and in relation to the driving group ($p<0.01$). This was further explained by the significant differences in mental and physical demand NASA-TLX outputs between these 3 groups. Drivers and public cleansers showed differences in mental demand requirements ($p<0.01$); whereas waste collectors perceived their job to demand significantly higher physical and mental resources, compared to public cleansers ($p<0.01$).

5.4.1. Physical and Mental Demand

Between the three occupations, Drivers had the highest mean of rank when it came to the overall NASA-TLX and the mental workload scoring. Drivers and waste collectors showed scorings significantly higher scoring of public cleansers. The situational awareness and alertness of their surroundings as they move home-to-home and town-town is one of the influencing factors pertaining to their work-related mental demand (Endsley, 2020). The mental resources demanded of drivers is consistent with previous literature (Endsley, 2020; Ramroop et al., 2004). In addition to this, drivers had shown high means for physical demand, performance and effort. These findings correlate with Galy, Paxion, & Berthelon (2018) who found that when driving effort is estimated high, the mental and physical demand are also high. This high mental and performance result was also found in Galy, Paxion, & Berthelon (2018) findings, having suggested that driving performance has a strong association with germane load. Germane load is the cognitive processing, construction of thought and integration of information to create strategies that optimise driving performance.

The results indicated that waste collectors not only had a significantly higher physical demand, but of mental demand as well. The perceived physical demand is consistent with physical workload analysis. Some studies have found that when workers engaged

in tasks that are mentally demanding whilst having to execute lifting tasks, increased spinal tissue loading and the prevalence of lower back pain was evident for particular personality types (Marras, 2012). Situational awareness factors, vigilance and a degree of germane loading are mental demand factors that the observational study found had applied to waste workers as well. There is little research done on the mental demands of workers with regard to the situational processing when collecting bins. Waste workers needed to be vigilant when hanging on the trucks and be aware of civilians wanting to pick fights or throw objects at them. The mental and physical workload combination studies conducted on individuals or waste workers doing MMH tasks included laboratory-based cognitive assessments. Some of these have explored negative environmental effects on spinal loading for different personality types (Marras, Ferguson, Burr, Davis, & Gupta, 2004 cited in Marras, 2012); another study assessed the effects of Stroop tests on spinal loading (Splittstoesser, 2012 cited in Marras, 2012). Cognition has often been used in the context of perceived exertion levels whilst doing manual tasks (Li et al., 2009; Marcora, 2018) In response to this, the findings of this research breach a perceived mental demand aspect in relation to the job demands and physical workload done in real-time by waste workers. This significantly high mental demand aspect of waste workers is a surprising feature not identified in the research as of yet.

5.4.2. Public cleanser depot comparison

The results showed that site 4 workers had significantly lower perceptions scorings for the PSQI results in comparison to the other depots (Table 23). This output was intriguing, unlike the waste collectors where the disparities in the various depot sites were strongly associated with the contractual status of the employee if not the organisation (i.e. insourcing vs outsourcing and permanent vs contracted); most of the public cleansers were permanent employees contracted directly with the municipality (n=23 of 34). From the observation, the task demands, and the physical workload factors were coherent between the depots, with the exception of physical location. The one evident difference the observation found was the difference in leadership and autonomy between the sites. Based on the findings, site 4 workers were not heavily supervised unlike at site 3 and 5, and were entrusted by the supervisor to supervise themselves. The significantly low mental, physical, temporal demand and performance

response of site 4, infers that the workers perceived the job demands and physical workload at depot site 4 to not be as taxing in comparison to the other sites. Workers were also found to have fixed and crafted their own litter-picking tools (Figure 10). Workers could do their work as they pleased, as long as their demarcated areas were clean upon inspection. These behavioural factors elicited by the workers in relation to the NASA-TLX responses for site 4 show evidence of greater autonomy being given to the site 4 workers. This autonomy and supervisory trust in worker to do the work as necessary are characteristics of a laissez-faire leadership style (Chaundhry & Javed, 2012).

5.4.3. Waste collection Divisions comparison

An analysis was done between waste collectors (including round bin, truck bag 2-wheeled collectors), waste collection runners, and flatbed collectors ($p<0.01$). `Waste collection runners experienced a significantly higher QWIQ scoring in relation to the other two divisions (Table 19). Organisational constraints and quantitative workload were the factors causing this difference. The job of waste collection runners required them to run ahead of the truck to set up the bins for when the truck and collectors on the truck arrived. This group experienced very few rest breaks, often the lean individuals were selected to take on the job. Running from home to home is physiologically straining, they needed to also fulfil their job effectively enough to not reduce the temporal nature of the bin collection activities that follow.

5.4.4. Physical symptoms

The results showed that all the occupation groups had experienced high percentages of fatigue and tiredness. This is supported by previous literature showing findings that fatigue has a strong relationship with occupations that encompass high job demands (MacDonald, 2003). Particularly in the waste sector, research has shown that the physical symptoms experienced are as a result of consistent exposure to odours of decomposing and hazardous substances (Abedin & Jahiruddin, 2015; Eskezia, Aderaw, Ahmed, & Tadese, 2016; Ewis et al., 2013; Lin et al., 2021). The eyestrain experienced by waste collectors and public cleansers is as a result of the winds blowing fragments of particles of different kinds directly into the eye (Kawakami & Kogi, 2005). Due to the majority of the physical symptoms being under 20%, contrary

to other papers that found waste collectors and public cleansers in particular had the same symptoms having a being rated over 40% by the individual workers (Bleck & Wettberg, 2012; Ncube et al., 2017). Mechanics showed that for 4 symptoms at least half the group experienced symptoms, namely headaches, tiredness, backaches and heart pounding when not exercising. However, personal health-related and not necessarily work-related factors were observed with the mechanics group that may have influenced these results. The small number of mechanics also requires for their results to be handled with caution.

5.5. ORGANISATIONAL FACTORS

5.5.1. Equipment and supply constraints

A significant difference was found between waste collectors and public cleansers with regard to organisational constraints ($p<0.01$). The per question analysis (Table 21), showed that akin to the mechanics, the lack of and poor supply of equipment significantly impacted the waste workers in comparison to the public cleansers. This factor immersed itself in a multitude of ways: (1) unlike the public cleansers, most of the waste collectors interviewed complained and had been witnessed of having and not being supplied physical protective equipment. (2) Due to the specific scheduling of household waste collections by area day to day, the demand and lack of flexibility in work hours, when the climate conditions became unfavourable, particularly on rainy days, waste collectors were still required to complete the job according to the schedule, whereas public cleansers were dismissed. One of the reasons for their dismissal was due to the excessive water collection over refuse that collects in the bags. (3) Waste collectors also complained ill supply of brooms, sweepers and dustpans to clean the refuse that falls out when lifting, carrying or during the loading process. The remaining refuse odourises, creating a foul smell amongst residents, the municipality then receives complaints and redirects it for them to attend to.

The organisational constraints outputs found for mechanics on the QWIQ questionnaire, that the mean response rating was high for mechanics between 17.25 (Figure 27). The response survey found that the mechanics had the highest mean of rank, having perceived their job efficacy and degree of accomplishment to be greatly affected by the lack of and poor state of equipment (90.13 and 98.50) (Table 21). The

aforementioned factors also influenced their experience of the work as mentioned before, part of the reason being that they have to innovate ways of maintaining and repairing the vehicles even though they do not have feasible supplies. Prabaswari and Utomo (2020) suggest that working conditions are a feature that strongly propel an employee towards job satisfaction or job annoyance towards. The working conditions and lack of supplies for a job like a mechanic could be a strong suggestive indicator to the noticeably higher frustration NASA-TLX rating given by the mechanics in comparison to the other occupations (Table 22). In addition, when compared to the other occupation groups, mechanics were only required to work 'on demand', thus when a vehicle broke down and need fixing. Mechanics were only found on the contracted worker sites, and the vehicles were needed daily, thus a quick repair turn-around is expected of them.

5.5.2. The effects on insourced versus outsourced waste collectors

The difference in task types and area location validates the significant differences found in the perceptual workload assessments between sites 1 and 2, particularly with mental ($p=0.02$) and physical demands ($p=0.01$) (Table 24). In conjunction with this, the work observation showed that insourced waste collectors (site 2) had completed routes where the households had 2-wheeled bin refuse disposal, with the collection areas being predominantly in metropolis or suburban areas. The outsourced collectors (site 1) collected from households with diverse refuse disposal, from round bins to various plastic bags, baskets and 2-wheeled bins. The areas also varied from town centres to suburbs, rural areas, and informal Settlements.

The context in which the two sites differ is important, the reason being that the insourced collectors deemed their work to require more mental than physical resources. Working in the Pretoria central business district in particular requires the waste collectors to be more cognisant of their own safety, the safety of civilians, and obstructions ahead and behind them and evaluate strategies amongst themselves to better optimise their work operations. 2-wheeled bins although do raise some concerns of strain in certain body segments i.e. the upper arm, back and back, the results have shown that the other collection types are of greater physical strain on the workers (Table 14, Table 15, Table 16). The significantly higher physical exertion rating of outsourced collectors also expounds the physical workload results, showing that bin

and bag lifting tasks within the waste collection process have been measured as being both objectively and subjectively strenuous. “Open-ended workload” is a concept that affected the site 1 workers more than those of site 2. (Macdonald, 2003) describes it as an effect of people believing they need to work until they’ve completed the task(s) required inverse to them doing work within the prescribed work hours. The work hours in the case of outsourced workers are often a matter of choice, but of task completion.

5.5.3. Permanent vs contracted employment status

Differing from Insourcing and outsourcing, contacted and permanent workers were found only within the waste collection and public cleansing sectors. These were individuals who were either hired permanently or contractually by either the insourced or outsourced site. In terms of physical demand, a significant difference was found between these two groups. Contracted workers felt they needed and were being pushed to work harder. This perception is a combination or work-related stress factors which are agreeably justified through the significant differences found in the QWIQ job stressor subscales. However, a major factor outside of the measures is their need for job security. A significant difference was found with regard to the overall QWIQ scoring between these two groups, and for all the subscales excluding the physical symptoms. This concurs with the literature findings that illustrate the evidence of contracted workers earning lower wages, having minimal benefits and having to carry a greater work intensity (Ryan, Furneaux, Pink, & Brown, 2005).

5.5.4. Other Psychosocial factors

In the waste sector, communication between workers and superiors is a major player in work efficiency and accomplishment. This social component affects a worker’s satisfaction and appraisal. the interpersonal relationship responses identified that communication and relationships are a factor affecting all occupations and their perception of work (Figure 27). Drivers had the highest scoring, followed by waste collectors and mechanics. This social component using QWIQ assesses interpersonal relations within the boundary of staff members but particularly for waste collectors (and waste workers) is not constricted to workers, but community members as well. The social demand required from workers is undermined factor although is often a situational occurrence, can affect the worker at a dispositional level. This could lead to

a decrease in performance, ian ncrease in work disgruntle and a decrease job satisfaction (Chaundhry & Javed, 2012).

5.6. LIMITATIONS

Finding participants and approval to conduct research was a tedious process, thus a limited number of voluntary participants were found. Fulton (2013) experienced the same within his study and referred to the complexity at an organisational level for managers and supervisors to demarcate paid working time to permit workers to participate within a scientific investigation. The interviews and questionnaire were met with contempt and language barriers, having translators assist in this process made this project more successful than anticipated. There were however 2-3 languages that neither of the translators knew, but tried to explain the questions in practical and visual ways.

A limitation of the procedure was the early collection of the perceptual load before the physical workload. In having engaged in the interview processes first, there was no insight given of the different waste collection types (i.e. round bin vs flatbed vs round bin). The workers were asked to fill in their occupation in the form which resulted in them only defining themselves as waste collectors, or few specifying themselves as runners or flatbed collectors. If waste collectors could have been categorised in similarly to how they were categorised in the physical workload assessment, greater indication of the perceived based on the identified collection forms would have been of immense value. The disadvantage of this would be the false reflection being that waste collectors only collect one bin type per day, whereas in reality, although one bin type might be most dominant based on the area, they will be carrying bins of different forms. That cannot necessarily be differentiated within the perceptual load assessment unless there is a way of limiting and controlling worker waste handling.

Environment and worker job demands although are the features associated with waste work made it difficult to continue using certain tools whilst observing and engaging workers on work tasks, for example the Borg RPE scale. The RPE scale was initially utilised for the first-round participants of PHASE 2 data collection, however the workers really struggled to understand the rating scale in relation to their own exertion. The

work pacing and constant movement, the decision-making process of rating became distracting for the workers whilst on duty and was found to be mentally perplexing for others. This was an unanticipated obstacle which emerged during the process, and that the RPE tools was removed from the study.

For the occupations analysed, the PSI couldn't compare the pain allocated to different bodily areas in order to further support the results displayed by the REBA, RULA and RAMP tools. As an example, the high-risk result output from the REBA REULA and RAMP upper arm lifting posture for the flatbed loaders couldn't be measured on a subjective level with the QWIQ or NASA-TLX. Upper arm pain is an area of concern but was not effectively addressed. Bodily discomfort should be investigated as a symptom. The Borg Body Discomfort scale or the Nordic Musculoskeletal Questionnaire would be an appropriate assistive subjective tool to assess observed work strain in relation to subjective work strain.

A limitation of the RAMP 2 assessment is its lack of a quantitative calculation in interpreting the results of the worker perceived workload and discomfort question. However, the perceived workload section does gives insight into perceptual workload areas that need to be investigated further.

For the BMI recording, participants were asked to remove accessories, anything in their pockets and removable jackets. This recording for a more accurate anthropometric BMI measurement; participants removing their boots, and wearing minimal clothing would have been ideal. The interviews and demographic data could only be conducted during the early hours of the morning prior to work commencement or after hours. Thus, cold weather early hours of the morning and lack of appropriate facilities to take anthropometric measurements, constrained the amount of clothing taken off before it became uncomfortable for the employee.

The methodological tool choices were constrained by Covid-19 pandemic, thus observation-based assessments and questionnaires and self-reports were the permissible tools that did not contravene the South African Covid-19 regulations at the time. Direct biomechanical and physiological tools would give greater detail into the body's response to strain by measuring the changes in hormones, muscle activity,

organ activity and many more. Below is a list of some of the tools that were not facilitated in investigation due to the social distancing obligation enforced during Covid-19:

The *heart rate monitor* would give an indication of physiological strain experienced by the employee (Chai et al., 2019). Unfortunately, the study was undergone during the second wave peak of the pandemic in South Africa, thus physical contact tools would put the observer and the employee at greater risk of disease contraction.

The *Electroencephalogram (EEG)* has a version condensed to a headband, or a device with wire attachments places upon the scalp (Boksem, Meijman, & Lorist, 2005). The EEG is the gold standard tool for assessing cognitive and physiological workload factors such as fatigue and attention. Slow, high amplitude waves indicate a decrease in alertness, whereas quick low amplitude waves indicate high alertness (Boksem et al., 2005). For this study it would have been a good measurer of mental stress and fatigue onset associated with the monotonous tasks. Due to Covid-10, physical contact on participants was prohibited.

VO2max is the respiratory output. The output can be derived from heart rate, which can either be done manually either by feeling the participants pulse or using a heartrate monitor. The study utiliseed the formula VO2max = 15 x (HRmax/HRrest) which provides an output in ‘mL/kg/min’. This formula however although used is not the most accurate. A lab-based treadmill run, with the participant having latched a mask on to their face with attached to a gas analysing machine, is the gold standard for VO2max testing. The study done was field-based, thus resulting in the inability to do the accurate test, the no-contact during Covid hindered the latter from being used as well.

The interviews and demographic data could only be conducted during the early hours of the morning prior to work commencement or after hours. The sample size for the public cleansers, drivers and mechanics were small. The small size was due to the fact that the research site only employed a small number of these workers but also due to the voluntary nature of the study.

CHAPTER VI: CONCLUSION

6.1. CONCLUSION

This chapter concludes the study report. From this study, it can be concluded that:
The nature of the demands of the job affected the physical and perceptual load of waste workers. The differences in the job requirements also recruited different physical and perceived demands. The main findings are discussed below.

Round bin collectors were found to have the highest risk of developing musculoskeletal disorders and injury due to the material handling i.e. baskets and round bins that sometimes had no handles, as well as the bin weight (between 4-23kgs) and vertical lifting distance for them to empty the bin onto the truck. Upper arm, shoulders and lower back where found to be the main body segments of strain attributed to this collection form.

This research study concurred with literature with regards to the mental demand of drivers ($p<0.05$), having them experience high levels of mental processing and alertness whist driving the truck in various areas. An unexpectedly high mental workload required of waste workers was a new finding to the literature. Previous studies conducted analysed the physiological and biomechanical associations in relation to waste collection. The cognitive findings have been limited to lab based experiments and simulations. The mental demand findings of this study has highlighted the need to assess the perceived mental resources straining and affecting the waste collector at work.

The mechanics were only found on the outsourced depot site, thus their placement and generalizability to make inferences or comparative research in other municipalities internationally in the waste sector is not clear. This was the first study that, to the researcher's knowledge that has investigated the perceived workloads of mechanics in the waste sector.

6.2. RECOMMENDATIONS

For future investigative studies in the field, the researcher should conduct a pre-screening of the workspace they plan to investigate before commencing the research study. The tools chosen for one's study are inferred from literature found in previous studies. However, the tools used for those studies might not meet the aims and objectives desired for one's own research. Due to this having been a descriptive, explorative study primarily, its objective was to place waste work in the South African context, and determine workload. A pre-screening would also assist in the complicated factors involved with procedures, processes, rules and regulations set by the government as well as public and private companies. Gaining approval for this research study was the biggest hurdle. Having an understanding of the context prior will alleviate many problems that could have been prevented in this study.

For a better statistical analysis, a larger sample size would be ideal for future studies. A recommendation for the perceptual question added in RAMP 2 is to be used in conjunction with validated and reliable perceptual tools. Future studies should use physiological measures in addition to biomechanical and cognitive/perceptual measures in understanding the workload for various occupations.

A more detailed investigation of the job demands affecting physical workload of mechanics and drivers would be ideal for future studies. The poor number of participants for these two groups could not generate accurate quantitative results.

With regards to the work of waste collectors in particular, 2 wheeled waste collection was the least taxing of all the collection types, thus an enforcement of 2 wheeled bins to be the primary disposal form for households, sectional titles, small and big homed suburbs as well as townships and informal settlements.

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APPENDICES

Appendix A: Ethical clearance letter

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Human Ethics sub-committee
Rhodes University Ethical Standards Committee
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8055
f: +27 (0) 46 603 8822
e: ethics-committee@ru.ac.za

www.ru.ac.za/research/research/ethics
NHREC Registration no. REC-241114-045

01/10/2020

Lerato RATSHEFOLA

Email: g15r5129@campus.ru.ac.za

Review Reference: 2020-1603-4682

Dear Dr. Swantje Zschernack

Title: Quantifying Workload of Municipal Waste Workers

Principal Investigator: Dr. Swantje Zschernack

Collaborators: Ms. Lerato Ratshefola,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Ethics Committee (RU-HEC). Your Approval number is: 2020-1603-4682

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated.

Sincerely,

Prof Arthur Webb

Chair: Rhodes University Human Ethics Committee, RU-HEC

cc: Mr. Siyanda Manqele - Ethics Coordinator

Appendix B: City of Tshwane Approval Letter

CITY OF TSHWANE
IGNITING EXCELLENCE

City Strategy and Organizational Performance

Room CSP22 | Ground Floor, West Wing, Block D | Tshwane House | 320 Madiba Street | Pretoria | 0002
PO Box 440 | Pretoria | 0001
Tel: 012 358 7423
Email: NosiphoH@tshwane.gov.za | www.tshwane.gov.za | www.facebook.com/CityOf Tshwane

My ref: **Research Permission/ Ratshefola**
Contact person: **Pearl Maponya**
Section/Unit: **Knowledge Management**

Tel: 012 358 4559
Email: PearlMap3@tshwane.gov.za
Date 07 February 2020

Lerato Ratshefola
57 Cheltenham Heights
Saddlebrook Estate
Midrand
6184

Dear Ms Lerato Ratshefola

RE: QUANTIFYING SUBJECTIVE AND OBJECTIVE WORKLOADS IN MUNICIPAL WASTE COLLECTORS.

Permission is hereby granted to Ms Lerato Ratshefola, Master Degree candidate in Human Kinetics and Ergonomics at Rhodes University (RU), to conduct research in the City of Tshwane Metropolitan Municipality.

It is noted that the main aim of the study is to quantify biomechanical, physiological and perceptual workloads of waste collectors. The City of Tshwane further notes that all ethical aspects of the research will be covered within the provisions of RU Research Ethics Policy. You will be required to sign a confidentiality agreement with the City of Tshwane prior to conducting research.

Relevant information required for the purpose of the research project will be made available as per applicable laws and regulations. The City of Tshwane is not liable to cover the costs of the research. Upon completion of the research study, it would be appreciated that the findings in the form of a report and or presentation be shared with the City of Tshwane.

Yours faithfully,

PEARL MAPONYA (Ms.)
DIRECTOR: KNOWLEDGE MANAGEMENT

Appendix C: Informed Consent

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PARTICIPANT INFORMED CONSENT

INFORMED CONSENT DECLARATION

(Participant)

Project Title: QUANTIFYING WORKLOAD IN MUNICIPAL WASTE WORKERS

Lerato Ratshefola from the Department of Human Kinetics and Ergonomics, Rhodes University has requested my permission to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

I am aware that:

1. The purpose of the research project is to measure the physical and cognitive workload efforts expended in the occupation of waste collecting, sweeping, driving or recycling.

2. The Rhodes University has given ethical clearance to this research project and I have seen/ may request to see the clearance certificate.

3. By participating in this research project I will be the benefiting through gaining more knowledge of the workload placed on my body from doing the work that I do. I will also be contributing on a global scale, towards the information on waste workers on a South Africa context. The municipality would benefit by understanding the challenges faced by their workers and the research will highlight the tasks that pose the highest workload risk to you as an employee.

4. I will participate in the project by being observed carrying out my normal daily work routine. The researcher will also be video recording my work movements. I will also be answering questions in the questionnaire.

5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences.

6. I will not be compensated for participating in the research.

7. There may be risks associated with my participation in the project. I am aware that

   a. the following risks are associated with my participation:
      - I may feel uncomfortable being observed and video recorded.
      - I may also feel embarrassed when completing the questionnaires. `Where I am answering questions probing one's perception of work, as well as personal measurements such as weight and height.

   b. The following steps have been taken to prevent the risks:

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To prevent any participant from the risk of feeling uncomfortable, participation is completely voluntary. The researcher will be making an effort to make a setting where participants are free to make a choice to participate or decline.

8. The researcher intends publishing the research results in the form of thesis. However, confidentiality and anonymity of records will be maintained and that my name and identity will not be revealed to anyone who has not been involved in the conduct of the research.

9. I will receive feedback via WhatsApp regarding the results obtained during the study.

10. Any further questions that I might have concerning the research or my participation will be answered by Lerato Ratshefola, number: 0815090640, email: g15r5129@campus.ru.ac.za. (Or by my Supervisor, Swantje Zschernack, email: s.zschernack@ru.ac.za)

11. By signing this informed consent declaration I am not waiving any legal claims, rights or remedies.

12. A copy of this informed consent declaration will be given to me, and the original will be kept on record.

13. Request to take pictures, video and voice recording for this study.

I, ... have read the above information / confirm that the above information has been explained to me in a language that I understand and I am aware of this document's contents. I have asked all questions that I wished to ask and these have been answered to my satisfaction. I fully understand what is expected of me during the research.

I have not been pressurised in any way and I voluntarily agree to participate in the above-mentioned project.

Research Feedback: Would you like feedback or the results of the research study? If **YES**, please fill in the below. A WhatsApp of the information shall be sent to you on completion of the study. If **NO,** please leave this section out.

Cellphone [WhatsApp] number: .....

.....	.....	.....
Participants signature	**Witness**	**Date**

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix D: OHSA Ergonomic Risk Assessment

Ergonomic Assessment Checklist	**Date**	**Activity Assessed**	
Risk Ratting (circle one) **High Medium Low** *See Notes on bottom of form to obtain the Rating*	**Organization**		**Point of Contact**
	Personnel Observed		
	BLDG NO/Location		**ROOM/AREA**

Ergonomic Assessment Checklist

Risk Factors	**Yes**	**No**
1. Have any shop workers been previously diagnosed with any of the following CTD's: Carpal tunnel, Tendonitis, Tenosynovitis, De Quervain's disease, Trigger Finger, White finger, Hand Arm Segmental Vibration Syndrome, Muscle strains, or Back ailments?		
2. Have there been any worker complaints concerning ergonomic issues?		
3. Do employees perform high repetition tasks? (100 reps/hour to 2000 per/day)		
4. Do the employee's routine tasks require repeated heavy lifting? (>20 lbs) or occasional heavy lifting (>50 lbs)		
5. Are employees using awkwardly designed tools, which cause the worker to operate the tool outside of a neutral position for an extended period of time? (> 1 hour)		
6. Do employees perform tasks with an awkward head or neck position for an extended period of time? (1 to 3 hours)		
7. Do employees perform tasks that require awkward back angles to be held for extended periods of time (2 to 3 hours)? i.e…hunching, bending, or squatting		
8. Do employees perform tasks with an awkward elbow angle for an extended period of time (1 to 3 hours) or with extreme force application?		
9. Do employees perform tasks with an awkward elbow abduction angle for an extended period of time (1 to 3 hours) or with extreme force application?		
10. Do employees perform tasks with an awkward wrist flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
11. Do employees perform tasks with an awkward wrist extension angle for an extended period of time (1 to 3 hours) or with extreme force application?		
12. Do employees perform tasks with an awkward back/hip flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
13. Do employees perform tasks with an extreme reaching distance for an extended period of time (1 to 3 hours) or with extreme force application?		
14. Do employees perform tasks with an odd work station height (either standing or sitting) for an extended period of time (1-3 hours) or with extreme force application?		
15. Are high impact tools used routinely? i.e., riveters, bucking bars, or impact wrenches		
16. Are high vibration producing tools used routinely? i.e., die grinders, sanders, weed eaters		
17. Do employees perform tasks at an extreme height (high or low) for an extended period of time (1 to 3 hours) or with extreme force application?		
18. Are there any other areas of concern either from your observations or employee complaints?		

*Note if there is a **Yes** checked in any block please use page two to give a brief explanation of what the activity is or what the worker complaint was.

High Risk: If you answered Yes to #1 (and the shop has done nothing to fix it), if Yes to #2 or 3 and two other Yes's in #'s 4 through 15, or if Yes to six or more in #'s 4 through 15.
Medium Risk: If you answered Yes to #1 (and the shop has made changes), if Yes to #2 or 3 and one other Yes in #'s 4 through 15, or if Yes to three to five in #'s 4 through 15.
Low Risk: If no Yes's in #'s 1, 2, or 3 and less than 3 Yes's in #'s 4 through 15.

Appendix E: RAMP 1

RAMP I (v1.03) © Linda Rose & Carl Lind. 2017. Unit for Ergonomics. KTH Royal Institute of Technology. Sweden. **2**

RAMP I - Checklist for screening physical risks for manual handling

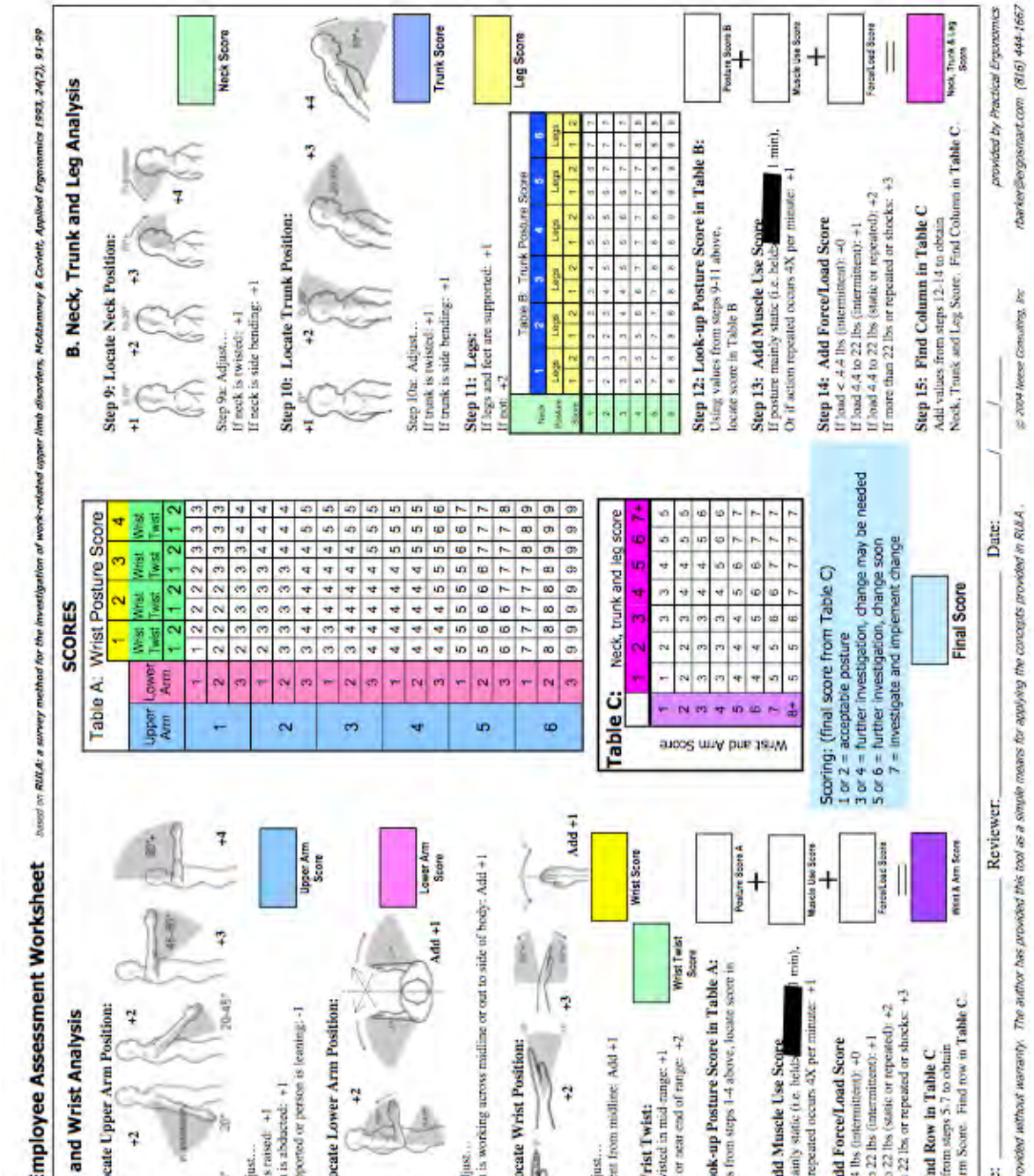
Mark the "Yes" or "No" boxes for the statements corresponding to the questions.	Yes	No	Comment:
1. Postures			
1.1 Does work occur often or for a long time* in any of the following unfavourable postures?			
** often = about 100 times per work day or more*			
** a long time = about 30 minutes per work day or more*			
head bent backwards			
back/upper body bent or twisted - forwards, backwards or towards the side			
arm almost or fully streched forwards (the hand more than about 45 cm from the spine)			
hand above shoulder height or below knee height			
hand/arm brought outwards to the side (to the right or to the left)			
1.2 Does work occur in any of the following unfavourable postures about 1 hour per work day or more?			
head clearly twisted or bent - forwards or towards a side			
hand clearly bent upwards, downwards or towards a side			
legs or feet have insufficient space, or the surface is unstable or with a slope			
2. Work movements and repetitive work			
2.1 Does work occur in any of the following ways?			
the work cycle is shorter than 30 seconds			
the work cycle is between 30 seconds and 5 minutes			
similar work movements are repeated more than 1/10 up to half of the work cycle time			
similar work movements are repeated more than half of the work cycle time			
If "No" on all in 2.1, go to 3. **If "Yes"** on any in 2.1, answer 2.2 below.			
2.2 How long time of the working day does such work occur? Choose one alternative.			
the work or similar work tasks are carried out between 1 and 4 hours of the work day			
the work or similar work tasks are carried out for more than 4 hours of the work day			
3. Lifting work			
3.1 Does lifting of loads occur? **If "No"**, go to 4.			
3.2 How heavy are the loads and how often are they lifted?			
less than 3 kg			
- more than 100 times per work day			
3-7 kg			
- more than 40 times per work day			
more than 7 kg - 14 kg			
- more than 20 times per work day			
more than 14 kg - 25 kg			
- more than 5 times per work day			
more than 25 kg			
3.3 Do the lifts generally occur in any of the following unfavourable postures?			
back/upper body clearly bent			
back/upper body clearly twisted			
hand above shoulder height			
hand below knee height			
hand outside forearm distance			
arm clearly brought outward (to the right or to the left)			
lifting/holding with overhand grip (palm facing downward)			
one-hand lift where the load exceeds 6 kg			
lifting while seated where the load exceeds 7 kg			
4. Pushing and pulling work			
4.1 Does pushing and pulling work occur? **If "No"**, go to 5.			
4.2 How large is the exerted force in the pushing or pulling work?			
the starting force (the force to start the object moving) exceeds 150 Newton			
the starting force (the force to start the object moving) exceeds 300 Newton			
the continuous force (the force to keep the object moving) exceeds 100 Newton			
the continuous force (the force to keep the object moving) exceeds 200 Newton			

Continued on the next page

Continued RAMP I - Checklist for screening physical risks for manual handling	Yes	No	Comment:
4.3 Does the pushing and pulling work generally occur in any of the following unfavourable conditions?			
the gripping height clearly deviates from elbow height			
the work is carried out with the back/upper body clearly twisted			
the force is exerted towards the side or upwards (i.e. not straight forwards or backwards)			
the force is exerted with one hand			
the pushing or pulling is carried out often (approx. more than 100 times per work day)			
the pushing or pulling distance exceeds 30 meters			
4.4 Are load carriers with 1-2 wheels (e.g. two-wheel cart) or similar used, under the following condition?			
the employee bares the whole or part of the load, and the load weight exceeds 100 kg			
5. Influencing factors			
5.1 Influencing physical factors hand/arm - do the following occur? The times refer to "per work day".			
the employee is exposed to hand-arm vibrations more than 20 minutes (10 for strongly vib)			
the employee is exposed to hand-arm vibrations more than 90 minutes (60 for strongly vib)			
warm or cold objects are handled manually			
the hand is used as an impact tool often or a long time*			
holding hand tools weighing more than 2.3 kg for more than 30 minutes			
holding precision tools weighing more than 0.4 kg for more than 30 minutes			
5.2 Other physical factors - do the following occur? The times refer to "per work day".			
the employee is exposed to whole-body vibrations more than 1 hour			
the employee is exposed to whole-body vibrations more than 6 hours			
the visual conditions are insufficient for the task			
the work is carried out in hot or cold temperatures or in draughty environments			
standing or walking on a hard surface more than half of the work day			
prolonged sedentary work without possibility to change to do the work standing up			
prolonged standing work without possibility to change to do the work sitting down			
kneeling/squatting more than 30 times or more than 30 minutes			
5.3 Work organisational and psychosocial factors - do the following occur?			
there is no possibility to influence at what pace the work is performed			
there is no possibility to influence the work setting or how the work shall be carried out			
it is often difficult to keep up with the work tasks			
the employees often work rapidly in order to be able to take a longer break			
there is no possibility for recovery time during the work (other than formal breaks)			
6. Reports on physically strenuous work			
6.1 Do documented reports exist on physically strenuous tasks (near misses, incident reports, journal notes, or other) when carrying out the work task?			
6.2 If **"Yes"** on 6.1 , what type of work that has led to this? If **"No"**, go to 7.			
lifting			
holding/carrying			
pushing/pulling			
pushing with hand or fingers			
other (please note)			
7. Perceived physical discomfort **Ask five people who perform this work task**			
7.1 Are there parts of the work which lead to physical discomfort (e.g. in muscles or joints) during the work day? Answer "Yes" if any employee experiences such discomfort.			
7.2 If **"Yes"** on question 7.1, which is the worst task?			
Person 1: _____			
Person 2: _____			
Person 3: _____			
Person 4: _____			
Person 5: _____			

Comment:

Appendix F: RULA



REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

Step 1a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

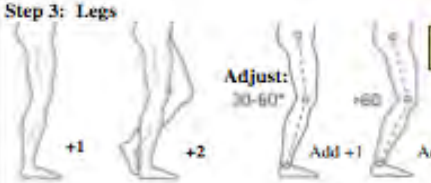
Neck Score

Step 2: Locate Trunk Position

Step 2a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs



Leg Score

Step 4: Look-up Posture Score in Table A

Using values from steps 1-3 above, locate score in Table A

Posture Score A

Step 5: Add Force/Load Score

If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score

Step 6: Score A, Find Row in Table C

Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C

Score A

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A		Neck 1				Neck 2				Neck 3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B		Lower Arm 1			Lower Arm 2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

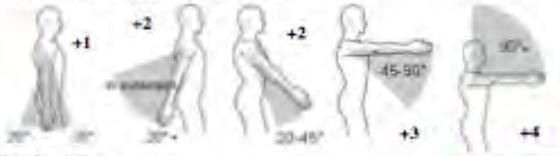
Score A (score from table A +load/force score)	Table C: Score B, (table B value +coupling score)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + Activity Score

Final REBA Score

B. Arm and Wrist Analysis

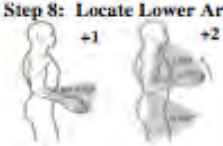
Step 7: Locate Upper Arm Position:



Step 7a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

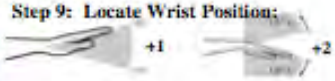
Upper Arm Score

Step 8: Locate Lower Arm Position:



Lower Arm Score

Step 9: Locate Wrist Position:



Wrist Score

Step 9a: Adjust…
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B

Using values from steps 7-9 above, locate score in Table B

Posture Score B

Step 11: Add Coupling Score

Well fitting Handle and mid rang power grip, *good: +0*
Acceptable but not ideal hand hold or coupling acceptable with another body part, *fair: +1*
Hand hold not acceptable but possible, *poor: +2*
No handles, awkward, unsafe with any body part, *Unacceptable: +3*

Coupling Score

Step 12: Score B, Find Column in Table C

Add values from steps 10 &11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score

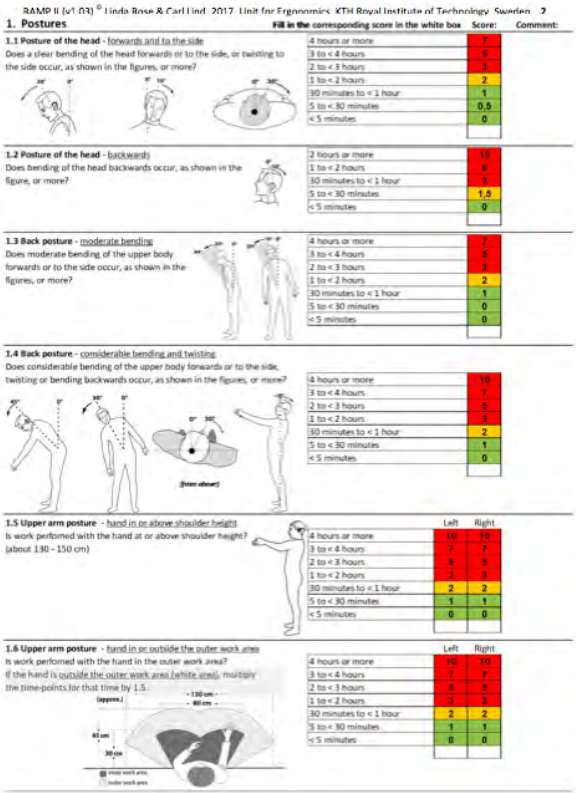
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Task name: _____ Reviewer: _____ Date: _____/_____/_____

This tool is provided without warranty. The author has provided this tool as a simple means for applying the concepts provided in REBA .

provided by Practical Ergonomics
rbarker@ergosmart.com (816) 444-1667

Appendix H: RAMP 2



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1. Postures — Fill in the corresponding score in the white box — Score: — Comment:

1.1 Posture of the head - forwards and to the side
Does a clear bending of the head forwards or to the side, or twisting to the side occur, as shown in the figures, or more?

4 hours or more	7
3 to < 4 hours	5
2 to < 3 hours	3
1 to < 2 hours	2
30 minutes to < 1 hour	1
5 to < 30 minutes	0,5
< 5 minutes	0

1.2 Posture of the head - backwards
Does bending of the head backwards occur, as shown in the figure, or more?

2 hours or more	10
1 to < 2 hours	6
30 minutes to < 1 hour	3
5 to < 30 minutes	1,5
< 5 minutes	0

1.3 Back posture - moderate bending
Does moderate bending of the upper body forwards or to the side occur, as shown in the figures, or more?

4 hours or more	7
3 to < 4 hours	5
2 to < 3 hours	3
1 to < 2 hours	2
30 minutes to < 1 hour	1
5 to < 30 minutes	0
< 5 minutes	0

1.4 Back posture - considerable bending and twisting
Does considerable bending of the upper body forwards or to the side, twisting or bending backwards occur, as shown in the figures, or more?

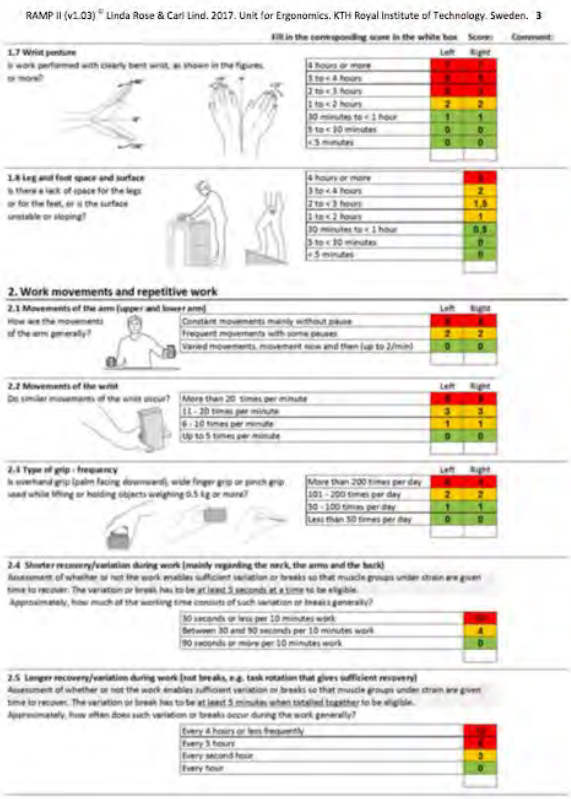
4 hours or more	10
3 to < 4 hours	7
2 to < 3 hours	5
1 to < 2 hours	3
30 minutes to < 1 hour	2
5 to < 30 minutes	1
< 5 minutes	0

1.5 Upper arm posture - hand in or above shoulder height
Is work performed with the hand at or above shoulder height? (about 130 - 150 cm)

	Left	Right
4 hours or more	10	10
3 to < 4 hours	7	7
2 to < 3 hours	5	5
1 to < 2 hours	3	3
30 minutes to < 1 hour	2	2
5 to < 30 minutes	1	1
< 5 minutes	0	0

1.6 Upper arm posture - hand in or outside the outer work area
Is work performed with the hand in the outer work area?
If the hand is outside the outer work area (white area), multiply the time-points for that time by 1.5.

	Left	Right
4 hours or more	10	10
3 to < 4 hours	7	7
2 to < 3 hours	5	5
1 to < 2 hours	3	3
30 minutes to < 1 hour	2	2
5 to < 30 minutes	1	1
< 5 minutes	0	0



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Fill in the corresponding score in the white box — Score: — Comment:

1.7 Wrist posture
Is work performed with clearly bent wrist, as shown in the figures, or more?

	Left	Right
4 hours or more	7	7
3 to < 4 hours	5	5
2 to < 3 hours	3	3
1 to < 2 hours	2	2
30 minutes to < 1 hour	1	1
5 to < 30 minutes	0	0
< 5 minutes	0	0

1.8 Leg and foot space and surface
Is there a lack of space for the legs or for the feet, or is the surface unstable or sloping?

4 hours or more	5
3 to < 4 hours	2
2 to < 3 hours	1,5
1 to < 2 hours	1
30 minutes to < 1 hour	0,5
5 to < 30 minutes	0
< 5 minutes	0

2. Work movements and repetitive work

2.1 Movements of the arm (upper and lower arm)
How are the movements of the arm generally?

	Left	Right
Constant movements mainly without pause	5	5
Frequent movements with some pauses	2	2
Varied movements, movement now and then (up to 2/min)	0	0

2.2 Movements of the wrist
Do similar movements of the wrist occur?

	Left	Right
More than 20 times per minute	5	5
11 - 20 times per minute	3	3
6 - 10 times per minute	1	1
Up to 5 times per minute	0	0

2.3 Type of grip - frequency
Is overhand grip (palm facing downward), wide finger grip or pinch grip used while lifting or holding objects weighing 0.5 kg or more?

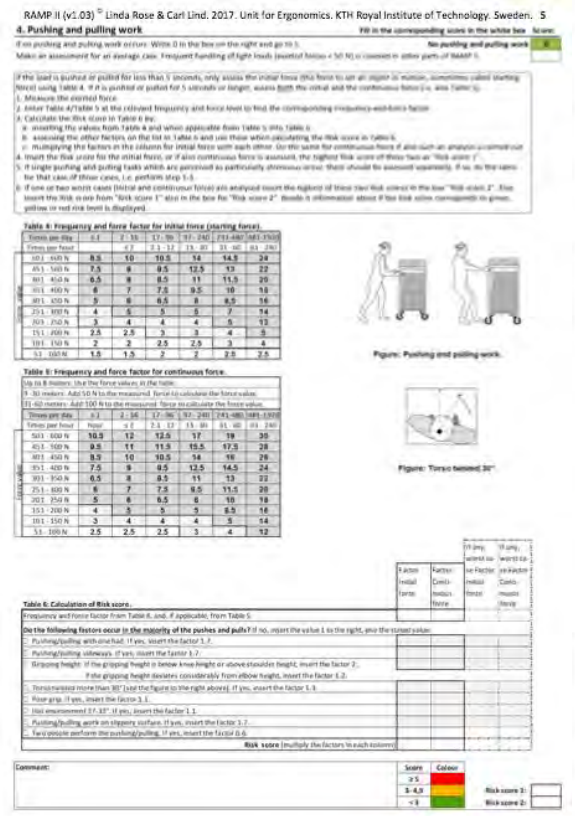
	Left	Right
More than 200 times per day	5	5
101 - 200 times per day	2	2
50 - 100 times per day	1	1
Less than 50 times per day	0	0

2.4 Shorter recovery/variation during work (mainly regarding the neck, the arms and the back)
Assessment of whether or not the work enables sufficient variation or breaks so that muscle groups under strain are given time to recover. The variation or break has to be at least 5 seconds at a time to be eligible.
Approximately, how much of the working time consists of such variation or breaks generally?

30 seconds or less per 10 minutes work	10
Between 30 and 90 seconds per 10 minutes work	4
90 seconds or more per 10 minutes work	0

2.5 Longer recovery/variation during work (not breaks, e.g. task rotation that gives sufficient recovery)
Assessment of whether or not the work enables sufficient variation or breaks so that muscle groups under strain are given time to recover. The variation or break has to be at least 5 minutes when totalled together to be eligible.
Approximately, how often does such variation or breaks occur during the work generally?

Every 4 hours or less frequently	10
Every 3 hours	6
Every second hour	3
Every hour	0



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4. Pushing and pulling work — Fill in the corresponding score in the white box — Score:

If no pushing and pulling work occurs: Write 0 in the box on the right and go to 5.
Make an assessment for an average case. Frequent handling of light loads (exerted forces < 50 N) is covered in other parts of RAMP II.

If the load is pushed or pulled for less than 5 seconds, only assess the initial force (the force to set an object in motion, sometimes called starting force) using Table 4. If it is pushed or pulled for 5 seconds or longer, assess both the initial and the continuous force (i.e. also Table 5).
1. Measure the exerted force.
2. Enter Table 4/Table 5 at the relevant frequency and force level to find the corresponding frequency-and-force factor.
3. Calculate the Risk score in Table 6 by:
   a. inserting the values from Table 4 and when applicable from Table 5 into Table 6.
   b. assessing the other factors on the list in Table 6 and use those when calculating the Risk score in Table 6.
   c. multiplying the factors in the column for initial force with each other. Do the same for continuous force if also such an analysis is carried out.
4. Insert the Risk score for the initial force, or if also continuous force is assessed, the highest Risk score of these two as "Risk score 1".
5. If single pushing and pulling tasks which are perceived as particularly strenuous occur, these should be assessed separately. If so, do the same for that case, i.e. perform step 1-3.
6. If one or two work cases (initial and continuous force) are analysed insert the highest of these two Risk scores in the box "Risk score 2". Also insert the Risk score from "Risk score 1" also in the box for "Risk score 2". Beside it information about if the Risk score corresponds to green, yellow or red risk level is displayed.

Table 4: Frequency and force factor for initial force (starting force).

Times per day	0.1 - 1	2 - 10	11 - 30	31 - 240	241-480	481-1920
Times per hour	< 0.1	0.1 - 1	1.1 - 5	5.1 - 40	41 - 80	81 - 320
60 - 100 N	8.5	10	10.5	14	14.5	24
45.1 - 60 N	7.5	9	9.5	12.5	13	22
30.1 - 45.0 N	6.5	8	8.5	11	11.5	20
15.1 - 30.0 N	6	7	7.5	9.5	10	18
10.1 - 15.0 N	5	6	6.5	8	8.5	16
7.6 - 10.0 N	4	5	5	6	7	14
5.1 - 7.5 N	3	4	4	4	5	12
2.6 - 5.0 N	2.5	2.5	3	3	4	8
1.1 - 2.5 N	2	2	2.5	2.5	3	4
0.1 - 1.0 N	1.5	1.5	2	2	2.5	2.5

Table 5: Frequency and force factor for continuous force.
Up to 8 meters: Use the force values in the table.
9 - 30 meters: Add 50 N to the measured force to calculate the force value.
31 - 60 meters: Add 100 N to the measured force to calculate the force value.

Times per day	0.1 - 1	2 - 10	11 - 30	31 - 240	241-480	481-1920
Times per hour	Hour	< 0.1	0.1 - 1.1	1.2 - 15	15.1 - 30	31 - 240
50.1 - 100 N	10.5	12	12.5	17	19	30
40.1 - 50.0 N	9.5	11	11.5	15.5	17.5	28
30.1 - 40.0 N	8.5	10	10.5	14	16	26
25.1 - 30.0 N	7.5	9	9.5	12.5	14.5	24
20.1 - 25.0 N	6.5	8	8.5	11	13	22
15.1 - 20.0 N	6	7	7.5	9.5	11.5	20
10.1 - 15.0 N	5	6	6.5	8	10	18
7.6 - 10.0 N	4	5	5	5	8.5	16
5.1 - 7.5 N	3	4	4	4	5	14
0.1 - 5.0 N	2.5	2.5	2.5	3	4	12

Figure: Pushing and pulling work.

Figure: Torso twisted 30°

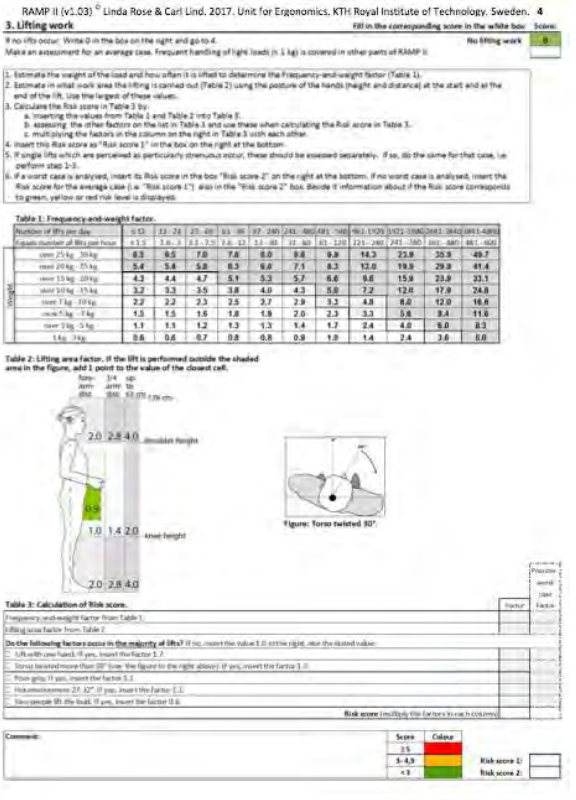
Table 6: Calculation of Risk score.

Factor	Initial force	Continuous force	If yes, multiply with factor	If yes, multiply with factor
Frequency and force factor from Table 4, and, if applicable, from Table 5				
Do the following factors occur in the majority of the pushes and pulls? If no, insert the value 1 to the right, also the stated value:				
- Pushing/pulling with one hand. If yes, insert the factor 1.7.				
- Pushing/pulling sideways. If yes, insert the factor 1.7.				
- Gripping height: If the gripping height is below knee height or above shoulder height, insert the factor 2. If the gripping height deviates considerably from elbow height, insert the factor 1.2.				
- Torso twisted more than 30° (see the figure to the right above). If yes, insert the factor 1.9.				
- Poor grip. If yes, insert the factor 1.1.				
- Hot environment 27-32°. If yes, insert the factor 1.1.				
- Pushing/pulling work on slippery surface. If yes, insert the factor 1.2.				
- Two people perform the pushing/pulling. If yes, insert the factor 0.6.				
Risk score (multiply the factors in each column)				

Comment:

Score	Colour
≥ 5	
3 - 4,9	
< 3	

Risk score 1:
Risk score 2:



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3. Lifting work — Fill in the corresponding score in the white box — Score:

If no lifts occur: Write 0 in the box on the right and go to 4.
Make an assessment for an average case. Frequent handling of light loads (< 1 kg) is covered in other parts of RAMP II.

1. Estimate the weight of the load and how often it is lifted to determine the Frequency-and-weight factor (Table 1).
2. Estimate in what work area the lifting is carried out (Table 2) using the posture of the hands (height and distance) at the start and at the end of the lift. Use the largest of these values.
3. Calculate the Risk score in Table 3 by:
   a. inserting the values from Table 1 and Table 2 into Table 3.
   b. assessing the other factors on the list in Table 3 and use those when calculating the Risk score in Table 3.
   c. multiplying the factors in the column on the right in Table 3 with each other.
4. Insert this Risk score as "Risk score 1" in the box on the right at the bottom.
5. If single lifts which are perceived as particularly strenuous occur, these should be assessed separately. If so, do the same for that case, i.e. perform step 1-3.
6. If a worst case is analysed, insert its Risk score in the box "Risk score 2" on the right at the bottom. If no worst case is analysed, insert the Risk score for the average case (i.e. "Risk score 1") also in the "Risk score 2" box. Beside it information about if the Risk score corresponds to green, yellow or red risk level is displayed.

Table 1: Frequency-and-weight factor.

Number of lifts per day	≤ 10	11 - 24	25 - 60	61 - 96	97 - 240	241 - 480	481 - 960	961-1920	1921-2880	2881-3840	3841-4800
Equals number of lifts per hour	≤ 1.5	1.6 - 3	3.1 - 7.5	7.6 - 12	13 - 30	31 - 60	61 - 120	121 - 240	241 - 360	361 - 480	481 - 600
Weight: over 25 kg - 30 kg	6.3	6.5	7.0	7.8	8.0	8.8	9.9	14.3	23.8	35.9	49.7
over 20 kg - 25 kg	5.4	5.4	5.8	6.3	6.6	7.1	8.3	12.0	19.9	29.8	41.4
over 15 kg - 20 kg	4.3	4.4	4.7	5.1	5.3	5.7	6.6	9.6	15.9	23.9	33.1
over 10 kg - 15 kg	3.2	3.3	3.5	3.8	4.0	4.3	5.0	7.2	12.0	17.9	24.8
over 7 kg - 10 kg	2.2	2.2	2.4	2.5	2.7	2.9	3.3	4.8	8.0	12.0	16.6
over 5 kg - 7 kg	1.5	1.5	1.6	1.8	1.8	2.0	2.3	3.3	5.6	8.4	11.6
over 3 kg - 5 kg	1.1	1.1	1.2	1.3	1.3	1.4	1.7	2.4	4.0	6.0	8.3
1 kg - 3 kg	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.4	2.4	3.6	5.0

Table 2: Lifting area factor. If the lift is performed outside the shaded area in the figure, add 1 point to the value of the closest cell.

Figure: Torso twisted 30°

Table 3: Calculation of Risk score.

	Factor	Possible worst case factor
Frequency-and-weight factor from Table 1		
Lifting area factor from Table 2		
Do the following factors occur in the majority of lifts? If no, insert the value 1.0 to the right, also the stated value:		
- Lift with one hand. If yes, insert the factor 1.7.		
- Torso twisted more than 30° (see the figure to the right above). If yes, insert the factor 1.9.		
- Poor grip. If yes, insert the factor 1.1.		
- Hot environment 27-32°. If yes, insert the factor 1.1.		
- Two people lift the load. If yes, insert the factor 0.6.		
Risk score (multiply the factors in each column)		

Comment:

Score	Colour
≥ 5	
3 - 4,9	
< 3	

Risk score 1:
Risk score 2:

5. Influencing factors

Fill in the corresponding score in the white box. Score: Comment:

5.1 Influencing physical factors hand/arm - do the following occur? The times refer to "per work day".

	Yes	No	Score	Comment
a. The employee is exposed to hand-arm vibrations more than 20 minutes (10 for strongly vib).	2	0		
b. The employee is exposed to hand-arm vibrations more than 90 minutes (60 for strongly vib).†	4	x		
c. Warm or cold objects are handled manually.	2	0		
d. The hand is used as an impact tool often or a long time*	2	0		
e. Holding hand tools weighing more than 2.3 kg for more than 30 minutes.	2	0		
f. Holding precision tools weighing more than 0.4 kg for more than 30 minutes.	2	0		

5.2 Other physical factors - do the following occur? The times refer to "per work day"

a. The employee is exposed to whole-body vibrations more than 1 hour.	2	0		
b. The employee is exposed to whole-body vibrations more than 6 hours.†	4	x		
c. The visual conditions are insufficient for the task.	2	0		
d. The work is carried out in hot or cold temperatures or in draughty environments.	2	0		
e. Standing or walking on a hard surface more than half of the work day.	2	0		
f. Prolonged sedentary work without possibility to change to do the work standing up.	2	0		
g. Prolonged standing work without possibility to change to do the work sitting down.	2	0		
h. Kneeling/squatting more than 30 times or more than 30 minutes.	2	0		

5.3 Work organisational and psychosocial factors - do the following occur?

a. There is no possibility to influence at what pace the work is performed.	2	0		
b. There is no possibility to influence the work setting or how the work shall be carried out.	2	0		
c. It is often difficult to keep up with the work tasks.	2	0		
d. The employees often work rapidly in order to be able to take a longer break.	2	0		

† If you want to answer "No" on 5.1b or 5.2b, enter an "x" in the white answering box to the right.
*** Here "often" means about 100 times per working day or more and "a long time" about 30 minutes per work day or more.**

6. Reports on physically strenuous work

6.1 Documented reporting on physically strenuous work

Do documented reports exist of physically strenuous tasks (e.g. incident reports) when carrying out the work task?

	Yes	No	Score	Comment
Documented reporting	2	0		

6.2 Type of work that has led to reporting

If "Yes" on 6.1, mark (with an x) in the table below what type of work that has led to this. Else, go to 7.

lifting	
holding/carrying	
pushing/pulling	
pushing with hand or fingers	
other (please note)	

7. Perceived physical discomfort

Preferably ask five people who perform this work task.

7.1 Perceived physical discomfort

Are there parts of the work which lead to physical discomfort (e.g. in muscles or joints) during the work day?
Answer "Yes" if any employee experiences such discomfort.

	Yes	No	Score	Comment
Discomfort in muscles or joints	2	0		

7.2 If "Yes" on 7.1, which is the worst task?

Preferably state answers from five employees in the table below.

Person 1:
Person 2:
Person 3:
Person 4:
Person 5:

Comment:

APPENDIX: RESULTS TABLE

RAMP II (version 1.02)© Results table (pdf-version)

Ordered by:	**Date:**		
Assessed by:	**Risk/action level and score**		
Assessment of:	**Red=R Yellow=Y Green=G**	**Score**	**Comment**
1. Postures			
1.1 Posture of the head - forwards and to the side			
1.2 Posture of the head - backwards			
1.3 Back posture - moderate bending			
1.4 Back posture - considerable bending and twisting			
1.5 Upper arm posture - hand in/above shoulder height*			
1.6 Upper arm posture - hand in/outside outer work area*			
1.7 Wrist posture*			
1.8 Leg and foot space and surface			
2. Work movements and repetitive work			
2.1 Movements of the arm*			
2.2 Movements of the wrist*			
2.3 Type of grip*			
2.4 Shorter recovery/variation			
2.5 Longer recovery/variation			
3. Lifting			
3.1 Lifting (average case)			
3.1 Lifting (worst case)			
4. Pushing and pulling			
4.1 Pushing and pulling (average case)			
4.2 Pushing and pulling (worst case)			
5. Influencing factors			
5.1 influencing physical factors hand/arm			
a+b. Hand-arm vibrations			
c. Manually handling of warm or cold object			
d. Hand used as impact tool			
e. Holding hand-tools weighing > 2.3 kg, > 30 min			
f. Holding precision tools weighing > 0.4 kg > 30 min			
5.2 Other physical factors			
a+b. Whole body vibrations			
c. Insufficient visual conditions			
d. Hot, cold or draughty environment			
e. Prolonged standing or walking on hard surfaces			
f. Prolonged sitting			
g. Prolonged standing			
h. Kneeling/squatting			
5.3 Work organizational and psychosocial factors			
a. No possibility to influence the work pace			
b. No possibility to influence the work setting			
c. Difficulties in keep up with the work tasks			
d. Employees work rapidly in order to take longer breaks			
6. Reports on physically strenuous work			
6.1 Documented reporting on physically strenuous work			
6.2 Type of work that has led to reporting:			
7. Perceived physical discomfort			
7.1 Perceived physical discomfort			
7.2 The worst task:			
*Insert the highest score from left or right side (hand/arm)			
Summary of the assessment			
Number of red assessments - High risk/action level			
Number of yellow assessments - Risk/action level			
Number of green assessments - Low risk/action level			
Total score			

Appendix I: Demographic Information

Participant Name & Surname :_____

Participant Code # (researcher will fill-in):_____

Demographics Questionnaire:

Age: _____ **Sex:** Male Female

Race:

- ☐ White
- ☐ Black
- ☐ Coloured
- ☐ Asian
- ☐ Other:_____

Education: What is the highest level of school you have completed? *If currently studying, what have you completed thus far?*

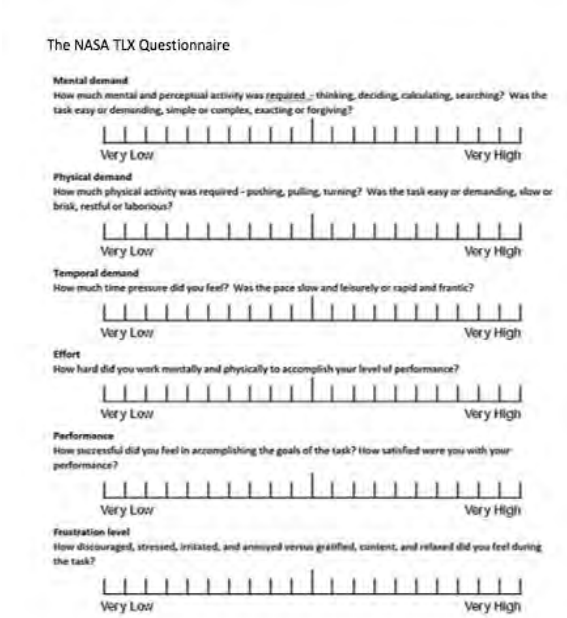
- ☐ No schooling completed
- ☐ Nursery school to Primary School
- ☐ High school but did not finish
- ☐ Finished High school, diploma or similar education (for example: GED)
- ☐ Diploma or University Degree accomplished

Anthropometry:

Weight (kgs)_____

Height (cm)_____

Appendix J:NASA TLX



The NASA TLX Questionnaire

Mental demand
How much mental and perceptual activity was required - thinking, deciding, calculating, searching? Was the task easy or demanding, simple or complex, exacting or forgiving?

Very Low — Very High

Physical demand
How much physical activity was required - pushing, pulling, turning? Was the task easy or demanding, slow or brisk, restful or laborious?

Very Low — Very High

Temporal demand
How much time pressure did you feel? Was the pace slow and leisurely or rapid and frantic?

Very Low — Very High

Effort
How hard did you work mentally and physically to accomplish your level of performance?

Very Low — Very High

Performance
How successful did you feel in accomplishing the goals of the task? How satisfied were you with your performance?

Very Low — Very High

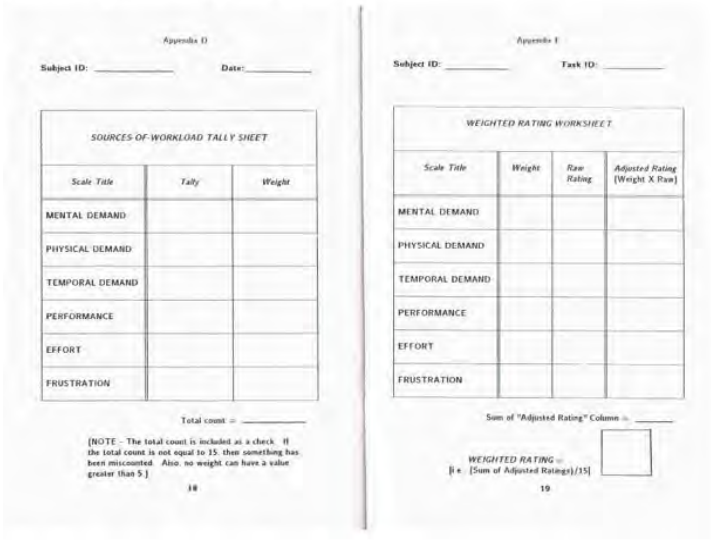
Frustration level
How discouraged, stressed, irritated, and annoyed versus gratified, content, and relaxed did you feel during the task?

Very Low — Very High

EFFORT OR PERFORMANCE	TEMPORAL DEMAND OR FRUSTRATION
TEMPORAL DEMAND OR EFFORT	PHYSICAL DEMAND OR FRUSTRATION
PERFORMANCE OR FRUSTRATION	PHYSICAL DEMAND OR TEMPORAL DEMAND
PHYSICAL DEMAND OR PERFORMANCE	TEMPORAL DEMAND OR MENTAL DEMAND

FRUSTRATION OR EFFORT	PERFORMANCE OR MENTAL DEMAND
PERFOMANCE OR TEMPORAL DEMAND	MENTAL DEMAND OR EFFORT
MENTAL DEMAND OR PHYSICAL DEMAND	EFFORT OR PHYSICAL DEMAND
FRUSTRATION OR MENTAL DEMAND	

Questionnaire Researcher analysis Sheet:



Appendix O

Subject ID: _____ Date: _____

SOURCES-OF-WORKLOAD TALLY SHEET

Scale Title	Tally	Weight
MENTAL DEMAND		
PHYSICAL DEMAND		
TEMPORAL DEMAND		
PERFORMANCE		
EFFORT		
FRUSTRATION		

Total count = _____

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)

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Appendix P

Subject ID: _____ Task ID: _____

WEIGHTED RATING WORKSHEET

Scale Title	Weight	Raw Rating	Adjusted Rating (Weight X Raw)
MENTAL DEMAND			
PHYSICAL DEMAND			
TEMPORAL DEMAND			
PERFORMANCE			
EFFORT			
FRUSTRATION			

Sum of "Adjusted Rating" Column = _____

WEIGHTED RATING = _____
(i.e. [Sum of Adjusted Ratings]/15)

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Appendix K: QWIQ

Interpersonal Conflict At Work Scale, ICAWS

	Never	Rarely	Sometimes	Quite Often	Very Often
1. How often do you get into arguments with others at work?					
2. How often do other people yell at you at work?					
3. How often are people rude to you at work?					
4. How often do other people do nasty things to you at work?					

Organizational Constraints Scale, OCS

How often do you find it difficult or impossible to do your job because of ... ?	Less than once per month or never	Once or twice per month	Once or twice per week	Once or twice per day	Several times per day
1. Poor equipment or supplies.					
2. Organizational rules and procedures.					
3. Other employees.					
4. Your supervisor.					
5. Lack of equipment or supplies.					
6. Inadequate training.					
7. Interruptions by other people.					
8. Lack of necessary information about what to do or how to do it.					
9. Conflicting job demands.					
10. Inadequate help from others.					
11. Incorrect instructions.					

Quantitative Workload Inventory, QWI

	Less than once per month or never	Once or twice per month	Once or twice per week	Once or twice per day	Several times per day
1. How often does your job require you to work very fast?					
2. How often does your job require you to work very hard?					
3. How often does your job leave you with little time to get things done?					
4. How often is there a great deal to be done?					
5. How often do you have to do more work than you can do well?					

Physical Symptoms Inventory, PSI. This is the original 18-item version with yes/no response format.

During the past **30 days** did you have any of the following symptoms? If you did have the symptom, did you see a doctor about it? **During the past 30 days did you have?**	No	Yes, but I didn't see doctor	Yes, and I saw doctor
1. An upset stomach or nausea			
2. A backache			
3. Trouble sleeping			
4. A skin rash			
5. Shortness of breath			
6. Chest pain			
7. Headache			
8. Fever			
9. Acid indigestion or heartburn			
10. Eye strain			
11. Diarrhea			
12. Stomach cramps (Not menstrual)			
13. Constipation			
14. Heart pounding when not exercising			
15. An infection			
16. Loss of appetite			
17. Dizziness			
18. Tiredness or fatigue			

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SCORING OF THE ICAWS, OCS, QWI, AND PSI

Interpersonal Conflict at Work Scale, ICAWS. Each of the four items has five response choices, numbered from 1 to 5. Sum the responses to each item, which will yield a total score from 4 to 20.

Organizational Constraints Scale, OCS. Each of the 11 items has five response choices, numbered from 1 to 5. Sum the responses to each item, which will yield a total score from 11 to 55.

Quantitative Workload Inventory, QWI. Each of the 5 items has five response choices, numbered from 1 to 5. Sum the responses to each item, which will yield a total score from 5 to 25.

Physical Symptoms Inventory, PSI. For the 18-item version each item has three response choices, ranging from 1 to 3. The **have symptom** score is computed by adding the number of 2 responses, and the **doctor symptom** score is computed by adding the number of 3 responses. The **total symptom** score is the sum of the other two scores, or the sum of all 2 and 3 responses. The possible range is 0 to 18 for each scale, but the total symptom score must be the sum of the other two scales. For the 12-item version, there are five response choices, ranging from 1 (not at all) to 5 (every day). Sum responses to all of the items into a total score, which can range from 12 to 60.

Appendix L: Number of participants per occupation group recruited in each Depot.

Table 27: Number of participants per occupation group recruited in each Depot.

Depot	*Participants per Depot*	*Public Cleansers*	*Waste Collectors*	*Drivers*	*Mechanics*	*Total*
B	10	10	-	-	-	-
K	9	9	-	-	-	-
L	16	15	-	-	-	-
A	62	-	47	11	4	-
P	58	-	58	-	-	-
Total	154	34	105	11	4	154

Appendix M: Posthoc (Difference) QWIQ Analyses – Occupational Comparison

Table 28: Sum Total

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.01	0.54	1.00
Waste collectors (2)	*0.01		1.00	1.00
Drivers (3)	0.54	1.00		1.00
Mechanics (4)	1.00	1.00	1.00	

Table 29: Organisational Constraints

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.00	0.29	1.00
Waste collectors (2)	*0.00		1.00	1.00
Drivers (3)	0.29	1.00		1.00
Mechanics (4)	1.00	1.00	1.00	

Table 30: Quantitative Workload

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.00	*0.00	1.00
Waste collectors (2)	*0.00		1.00	0.84
Drivers (3)	*0.00	1.00		1.00
Mechanics (4)	1.00	0.84	1.00	

	Waste Collector	Waste Collector Runner	Waste Collector Flatbed Loader
Waste Collector		0.095	1
Waste Collector Runner	0.095		*0.021
Waste Collector Flatbed Loader	1	*0.021	

Appendix N: QWIQ Public cleansers @ various depot sites

Table 31: Comparing QWIQ responses for the public cleansers per depot site

Categories	Occupation	n	Mean of Rank	H	df	p
Overall Sum Score	Site 3	10	15.50	0.59	2	0.74
	Site 4	9	18.67			
	Site 5	15	18.13			
Interpersonal Conflict	Site 3	10	18.10	0.38	2	0.83
	Site 4	9	16.00			
	Site 5	15	18.00			
Organisational Constraints	Site 3	10	13.50	2.66	2	0.27
	Site 4	9	17.67			
	Site 5	15	20.07			
Quantitative Workloads	Site 3	10	15.30	0.71	2	0.70
	Site 4	9	18.22			
	Site 5	15	18.53			
Physical Symptoms Inventory	Site 3	10	17.65	0.30	2	0.86
	Site 4	9	18.83			
	Site 5	15	16.6			

Appendix O: NASA-TLX gender responses

Table 32: Comparison NASA-TLX responses between Males and Females

Categories	Sex	n	Mean of Rank	H	df	p
Overall Sum Score	F	12	21.00	2.30	1	0.13
	M	22	15.59			
Interpersonal Conflict	F	12	17.50	0.18	1	1.00
	M	22	17.50			
Organisational Constraints	F	12	17.92	0.03	1	0.86
	M	22	17.27			
Quantitative Workloads	F	12	21.63	3.26	1	0.07
	M	22	15.25			
Physical Symptoms Inventory	F	12	22.04	4.01	1	0.05
	M	22	15.02			

Appendix P: Posthoc (Difference) NASA-TLX Analyses – Occupational Comparison

Table 33: Posthoc for NASA TLX Final Score

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.0045	*0.001	0.073
Waste collectors (2)	*0.0045		0.369	1
Drivers (3)	*0.001	0.369		0.151
Mechanics (4)	0.073	1	0.151	

Table 34: Posthoc for Mental Demand

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.031	*0.0005	0.098
Waste collectors (2)	*0.031		0.095	1
Drivers (3)	*0.0005	0.95		0.9
Mechanics (4)	0.098	1	0.9	

Table 35: Posthoc for Physical Demand

	Public Cleansers (1)	**Waste collectors (2)**	**Drivers (3)**	**Mechanics (4)**
Public Cleansers (1)		*0.022	0.078	0.069
Waste collectors (2)	*0.022		0.095	0.97
Drivers (3)	0.078	0.95		0.99
Mechanics (4)	0.069	0.97	0.99	

Appendix Q: Posthoc (Difference) NASA-TLX Analyses – PC Depot Sites

Table 36: Posthoc for NASA TLX Final Score

	Site 3	Site 4	Site 5
Site 3		0.369	0.093
Site 4	0.369		*0.0005
Site 5	0.093	*0.0005	

Table 37: Posthoc for Mental Demand

	Site 3	Site 4	Site 5
Site 3		0.163	1
Site 4	0.163		*0.022
Site 5	1	*0.022	

4.4.1.3.2.1 Physical Demand Post hoc
Table 38: Posthoc for Physical Demand

	Site 3	Site 4	Site 5
Site 3		0.151	1
Site 4	0.151		*0.011
Site 5	1	*0.011	

4.4.1.3.2.2 Temporal Demand Posthoc
Table 39: Posthoc for Temporal Demand

	Site 3	Site 4	Site 5
Site 3		0.095	1
Site 4	0.095		*0.021
Site 5	1	*0.021	

4.4.1.3.2.3 Performance Posthoc

Table 40: Posthoc for Performance

	Site 3	Site 4	Site 5
Site 3		1	*0.037
Site 4	1		*0.003
Site 5	*0.037	*0.003	

Appendix R: Posthoc (Difference) NASA-TLX Analyses – WC Divisions (ref. Table 14)

4.4.1.4.1 NASA-TLX final score posthoc

Table 41: Posthoc for NASA-TLX Total

	Waste Collector	**Waste Collector Runner**	**Waste Collector Flatbed Loader**
Waste Collector		0.095	1
Waste Collector Runner	0.095		*0.021
Waste Collector Flatbed Loader	1	*0.021	

Table 42: Posthoc for Physical Demand

	Waste Collector	**Waste Collector Runner**	**Waste Collector Flatbed Loader**
Waste Collector		*0.002	1
Waste Collector Runner	*0.002		0.098
Waste Collector Flatbed Loader	1	0.098	

Appendix 4: Comparison NASA-TLX responses between Males and Females

Categories	Sex	n	Mean of Rank	H	df	p
NASA TLX Overall Sum	F	12	18.75	0.29	1	0.59
	M	22	16.82			
Mental Demand	F	12	17.38	0.00	1	0.96
	M	22	17.57			
Physical Demand	F	12	17.42	0.00	1	0.97
	M	22	17.55			
Temporal Demand	F	12	17.04	0.04	1	0.84
	M	22	17.75			
Performance	F	12	20.17	1.35	1	0.25
	M	22	16.05			
Effort	F	12	18.04	0.06	1	0.81
	M	22	17.20			
Frustration	F	12	19.29	1.09	1	0.30
	M	22	16.52			