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Cover Photo

Transport Industry Risk Factors

Transport industry risk factors include fatigue, musculoskeletal disorders and extreme stress. Truck drivers have high rates of work-related injury and illness compared to other Australian workers, while bus drivers are prone to verbal abuse and physical abuse.

- **Fatigue.** Driver fatigue in the transport industry is a potentially significant risk. The main causes of driver fatigue are not getting enough sleep, driving at times when you are normally asleep like at night or early in the morning, and being awake for a long period of time.
- **Musculoskeletal disorders.** A significant number of injuries relate to musculoskeletal disease (MSD): the types of injuries that occur from prolonged exposure to MSD risk factors such as manual handling – loading trucks, hitching trailers – and ergonomics – driving a heavy vehicle with large numbers of gear changes and static driver seating position over several hours of the working day.
- **Stress Management.** Driving a heavy vehicle can be a difficult task – manoeuvring a 30 metre long, 40-tonne truck through multilane roads and across huge distances requires skill and competency. Time demands, long hours alone on the road and load specifics like handling dangerous goods all contributes to a driver's stress levels.

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https://www.rrp.com.au/transport-industry-risk-factors/

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Article Submission

The World Safety Journal (WSJ) is a quarterly refereed journal (ISSN: 1015-5589) that includes original full-length papers, review articles and case studies on the most recent outcomes of advanced research in any occupational safety and health fields.

All articles shall be written in concise English and typed with a minimum font size of 12 point. Articles should have an abstract of not more than 300 words. Articles shall be submitted as Times New Roman print and presented in the form the writer wants published. On a separate page, the author should supply the author's name, contact details, professional qualifications, current employment position, a brief bio, and a photo of the author. This should be submitted with the article.

Writers should include all references and acknowledgments. Authors are responsible for ensuring that their works do not infringe on any copyright. Failure to do so can result in the writer being accountable for breach of copyright. The accuracy of the references is the author's responsibility.

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Articles should be referenced according to the Publication Manual of the American Psychological Association ,7th ed.

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Transport Industry Psychosocial Risks and Controls

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KEYWORDS

Psychosocial work hazards
Transport workers
Mental health
Job stress
Risk control

ABSTRACT

The purpose of this research was to better understand the psychosocial hazards that could affect Australian transport workers, including road, rail, and shipping transport workers, and to develop a framework for psychosocial risk control measures for this population of workers. Data was collected from peer reviewed journal articles, web sites, and from industry partners that included Healthy Heads in Trucks and Sheds, Steering Minds, Tracksafe Foundation, Oz Help Foundation and the National Road Safety Partnership Program, as well as from Australian transport companies. Psychosocial hazards, health effects, and risk control measures were identified and a framework for psychosocial risk control measures developed. Recommendations are made to improve the management of psychosocial factors in the transport industries.

1. INTRODUCTION

Work-related psychosocial hazards are hazards that arise from, or relate to, the design and management of work, the work environment or plant, or workplace interactions and behaviour that may cause psychological harm (Western Australian Work Health and Safety (General) Regulations 2022 and Work Health and Safety (Mines) Regulations 2022, r 55A and 55B).

The McKell Institute in Queensland (Australia) from December 2022 to the end of February 2023, surveyed 1,036 transport workers either through a face-to-face interview or online interview. Results indicated that 76% of the respondents were concerned with their low pay with 45% struggling to afford to pay for food and their household living expenses as they were earning less than the minimum wage, and 74% of the respondents reported having to work long hours to make enough money to survive. Only 4% of the participants strongly agreed that they had job security. Of the 1,036 research participants 43% stated that they had been involved in a work-related accident and 55% reported experiencing threatening or abusive behaviour at work. Thirty six percent had experienced work-related injuries or work-related physical health issues, while 52% reported work-related stress, anxiety, or other work-related mental health issues (Reinhard, 2023). Pritchard et al. (2023) had similar findings and provided an explanation of financial stressors, particularly for casual workers and

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immigrant drivers (temporary visa holders) who were paid a minimum wage with no sick leave. For transport workers who have to hire their truck over the last 5 years there have been higher truck rental costs and overheads. There has also been lower profitability of loads resulting in some trucks being driven 24/7 with no roadside stop to be competitive to gain work. Truck drivers are only paid for items delivered and are not paid for waiting to unload their vehicle time, and waiting time could be more than 3 hours, which impacted their take home pay (Pritchard et al., 2023). Driving trucks is the most common work for Australian males, with one in 33 men being a driver (Van Vreden, et al, 2022).

Safe Work Australia (2023a) reported that between 2003 and 2021, 1076 road and rail drivers had been killed at work in Australia. This was the highest occupation for work related fatalities. Workers' compensation claims for serious injuries between 2008/09 and 2020/21 were 99,177 for road and rail drivers and during this period there were 1,802 workers' compensation claims for mental stress (Safe Work Australia, 2023b). The median time lost from mental health condition claims in 2020-21 (34.2 working weeks) was more than four times the median time lost across all claims (8.0 working weeks). The median compensation paid for mental health condition claims in 2020‑21 ($58,615) was close to four times the median compensation paid across all claims ($15,743) (Safe Work Australia, 2023d). Workplace mental health conditions are one of the costliest forms of workplace injury as they lead to significantly more time off work and higher compensation paid when compared to physical injuries and diseases (Safe Work Australia, 2023d).

Changing workplace health and safety regulations, legislation and codes of practices have placed psychological health and safety as an important topic on workplace agendas. Traditionally the focus of workplace mental health approaches has been on intervening once an employee has developed a mental illness or supporting a return to work. The future approach to psychological health and safety will necessitate comprehensive organisational planning. Successful approaches require integrated frameworks to ensure promotion of mentally healthy work practice, prevention of psychosocial hazards, early intervention of developing mental health problems, and compassionate management of mental illness at work. Everyone has a role in managing psychosocial risks and in Western Australia these duties are set out in the Work Health and Safety Act (2020) and Regulations (2022).

This research was undertaken to better understand the psychosocial hazards that could affect transport workers, including road, rail and shipping transport workers, and to develop a framework for psychosocial risk control measures for this population of workers.

2. RESEARCH METHODS

2.1 Research aims

In 2023 research was commissioned by Toll Global Express with the aim of identifying:

- psychosocial hazards which may cause psychological or physical harm to transport workers,
- risks to the health or safety of transport workers from psychosocial hazards,
- risk control measures that are being implemented in industry to eliminate or minimise the risks.

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2.2 Study population

The study population were Australian transport companies and road, rail, and shipping transport workers. Transport work is hard work with long, sedentary hours, shift work, fatigue and sleep deprivation which can take their toll on the health and wellbeing of professional drivers. Drivers in the transport industry commonly report problems such as insecure employment, loneliness, depression, chronic sleeping problems, excessive fatigue, and work stress from long hours and separation from family (Amoadu et al., 2023).

2.3 Data collection

To identify information to be able to achieve the research aims information was collected from peer reviewed journal articles, web sites including government web sites, and from industry partners that included Healthy Heads in Trucks and Sheds, Steering Minds, Tracksafe Foundation, Oz Help Foundation and the National Road Safety Partnership Program, as well as from transport companies. Industry organisations programs reviewed included Australia Post's Early matched care program, Work ready, Project me, Psychosocial working groups; Qube's Qube care, Zero harm policy, EAP Services; Linfox's Healthy Fox program, Core program, LEAP Program and DHL transport company's Mental health driver safety training, Fit for work, Fit for life and DHL4HER.

3. RESULTS AND DISCUSSION

3.1 Industry review

The transport and logistics industry contributes 5% of GDP to the Australian Economy and employs over half a million people. In Australia 72% of the freight is carried by road (Chalmers, et al., 2021). Transport and logistics workers had the highest rate of compensation claim for work related mental disorders. Job insecurity is common in the transport industry, and this is stressful to professional drivers and impacts on sleep quality, insomnia and sleep disorders. This in turn causes drivers to work long hours with few recovery periods and may result in perilous behaviour on the road which include speeding and overloading, to meet employment contract expectations (Amoadu et al., 2023).

When interviewing drivers and their family members researchers at Monash University (2021) identified seven key areas that impacted on truck drivers physical and mental health. These were access to healthy food, exercise, and having enough sleep; stress of being on the road; quality of personal relationships; access to parking and rest facilities; conditions in their workplace; the regulations and policies that they had to follow, and the attitudes of people to truck drivers.

A meta-analysis conducted by Guest, et al. (2020) identified that ill-health risk factors for truck drivers included long working hours, long periods of time sitting with reduced opportunities for physical activity, irregular shift patterns, sleep deprivation, limited availability of healthy food, low levels of work control and intense work demands. Truck drivers were found to have chronic time pressures compounded by traffic conditions and delivery schedules to be met.

A study by Pritchard et al., (2020), was conducted by interviewing 17 truck drivers (who came from all Australian States and Territories), and 9 family members of the drivers. Results were analysed using NVivo software to identify the main answer themes of factors that impacted transport workers. Truck drivers most important issue was the lack of availability of good fresh food when they were travelling and needed to stop for a meal. Drivers found it difficult when there were full parking bays, dangerous

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roads and they had to use dirty facilities. In terms of coping with the stress of their work drivers were reported by family members to go home with a lack of tolerance for other people ('short fuse'), not realising that this was due to their mental health. Drivers reported having difficulty in dealing with angry managers who did not respect them, and with members of the public who did not respect them and what they did for their work. Many of the drivers had relationship issues associated with being away from home due to work commitments. A work-related problem was that regulations (laws) meant that drivers were required to rest when alert and drive when sleepy. They wanted the ability to manage their own rest breaks (Pritchard et al., 2020),

Ill health in transport workers can be caused by vibration exposure which can damage muscles, joints and tendons, noise which can destroy the ability to hear, and by lifestyle factors such as working under the influence of alcohol or illegal drugs (HSE Global, 2023). For transport workers the most common ill health effects of their work were psychological distress (50%), chronic pain (44%), obesity (54.4%), poor general health (30%), overweight (25.2%), musculoskeletal disorders (44%), hypertension (25.8%) (Van Vreden et al., 2022; Useche, et al., 2019), sleep apnoea (26%) (Garbarino et al., 2018), hypersomnolence (excessive tiredness, Tucker et al., 2018), chronic fatigue (Ren et al., 2023), respiratory conditions including lung cancer, gastrointestinal disorders, metabolic syndrome, anxiety, depression (Useche, et al., 2019), cardiovascular diseases, (HSE Global, 2023) and reduced life expectancy (Guest et al., 2020). Research by Xia et al, (2021) found that 74.7% of transport drivers reported having a physical medical condition while 22.6% reported having a mental health condition. In 2022 there were 67 fatalities in the Australian transport industry, and this was the Australian industry that had the most work-related fatalities [34% of the work-related fatalities; 9.5 fatalities per 100,000 workers] (Safe Work Australia, 2023d)

A study by Xia, et al., (2021) identified that nearly half of the transport drivers had experienced at leasst one workplace violence incident in the past 12 months with verbal abuse being the most common violence. After construction workers, truck drivers were the most likely workers to commit suicide (OzHelp Foundation, 2020). Milner et al. (cited in Case, Alabakis, Bowles & Smith, 2020) examined coronial data relating to road and rail driver suicides in Australia between 2001 and 2010 and identified that there were 513 suicides among drivers within the study period.

3.2 Psychosocial hazards

According to regulation 55A of the Work health and safety general regulations in Western Australia (Department of Mines, Industry Regulation and Safety, 2022) a psychosocial hazard is a hazard that arises from, or relates to, the design or management of work or a work environment or plant at work or workplace interactions or behaviours and may cause psychological harm.

Workplace hazards that can cause psychosocial harm include organisational factors such as having poor organisational change management (Amoadu et al., 2023), inadequate reward and recognition for work performed [e.g., day pay rate, kms pay, job rate pay, contractual penalties if time slots are missed] (Workplace Health and Safety Queensland, 2020) and poor organisational justice. Safe Work Australia (2023c) provides examples of poor organisational justice as blaming workers for things that aren't their fault, or they can't control; not accommodating workers' reasonable needs; poor handling of workers information (e.g. not keeping personal information private); policies or procedures that are unfair, biased or applied inconsistently; failing to appropriately address (actual or alleged) issues (e.g. inappropriate or harmful behaviour such as bullying), and decision-making processes that are poor or which workers aren't told about.

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Job related psychosocial hazards can include lack of role clarity, role conflict (Tucker et al., 2018), work demands [such as time pressure and traffic delays] (Van Vreden et. al., 2022), emotional demands of the job (Dogbla et al., 2023), role overload (Tucker et al., 2018)], irregular work schedules, working long hours, job insecurity, and low job control (Amoadu et al., 2023). Workplace Health and Safety Queensland, (2020) describes problems with job control as occurring due to delays while waiting for the vehicle to be loaded or unloaded; lack of exclusion for truck drivers during unloading activities; time pressure; customer having unrealistic expectations about delivery times; sales deliverables incompatible with delivery requirements and legislation affecting the drivers breaks, which can be incompatible with schedules and can cause additional delays. Parikka (2023) reported that due to labour shortges and time pressures it was difficult for drivers to stop work to obtain the rest that they required to prevent fatigue.

Work behaviour psychosocial hazards can be the worker having poor support from supervisors and co-workers (Amoadu et al., 2023), having to deal with bullying, harassment, violence, aggression, conflict, or poor interpersonal relationships at work (Dogbla et al., 2023). Workplace Health and Safety Queensland, (2020) describes some of the common causes of aggression to transport workers as being poor communication and cooperation between parties and unsafe interactions with members of the public. Work environment psychosocial hazards can include having a poor physical environment (such as driving in bad weather conditions or dealing with other drivers' unsafe actions), experiencing traumatic events [such as motor vehicle accidents with cries for help from severely injured individuals and seeing mutilated bodies] (van Vreden et. al., 2022) or having remote work or isolated work (HSE Global, 2023). Having remote or isolated work can result in truck drivers having limited opportunities to exercise, poor sleeping arrangements, and limited access to nutritious food (van Vreden et. al., 2022). Transport drivers can spend long hours working on their own.

For the transport industry Workplace Health and Safety Queensland (nd.) reported 6 main types of psychosocial hazards. The first was low job control due to transport workers having limited choice of shifts, hours worked, ability to take scheduled breaks and limited choices over work deadlines, such as delivery times, particularly when there were unavoidable traffic delays. The second was high and low job demands due to demanding time pressures for pick up and deliveries, driving for extended periods of time without adequate rest causing fatigue, potential for monotonous dull work and exposure to traumatic events such as on road accidents and fatalities. The third type of hazard was having poor support due to being geographically dispersed and having reduced access to supervisor and coworkers' support, loading and unloading site design, poor site traffic management, lack of mechanical aids, poorly designed access and egress, load restraint problems such as inadequate or inconsistencies with customer loading and unloading restraint methods and time scheduling associated with customer demands and unforeseen delays. The next psychosocial hazard reported was low job clarity that may be caused by role conflict when attempting to meet client contract expectations and having inconsistencies in the work health and safety systems and requirements between their employer and clients. The fifth was poor organisational justice that could be perceived because of unfairness in the allocation of work shifts, differing work standards and requirements across the supply chain. The last type of psychosocial hazard described was poor relationships due to interpersonal conflicts (Workplace Health and Safety Queensland, nd.).

Internal to the organisation factors that can contribute to causing psychosocial harm include leadership. This is affected by the leaders (1) style and direction, (2) expectations and accountability, (3) psychological and social support, (4) involvement and influence in the organisation and (5) civility and respect shown. Another factor internal to the organisation is the organisational culture that is driven by the company mission, values and beliefs, the amount of openness and trust shown, management

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systems and processes and the care shown for employee health and wellbeing. The final factor internal to the organisation that can contribute to psychosocial harm is the behaviour of individuals. Behaviour includes individual competencies and abilities, individuals' growth and development goals, engagement, work-life balance and commitment to individual health and wellbeing goals and lifestyle (HSE Global, 2023).

Factors in the community environment can also cause psychosocial harm and include the economy (economic performance, Dogbla et al., 2023), labour market, inflation, competition and supply, the political environment (e.g., public opinion and performance) and social factors, such as housing supply and affordability, health system, lifestyle choices, recreational pursuits and behaviours (HSE Global, 2023).

In workplaces ways to identify psychosocial hazards occurrence include talking to workers, reviewing sick leave and annual leave to identify if there are any trends that indicate possible stress related causes. Interviews and a workplace survey can be conducted to identify psychosocial hazards.

Other ways to identify psychosocial hazards causing ill health effects include assessing if any areas of the business have higher levels of sick leave, if employees are using annual leave or long service leave for mental health conditions, if there are any workers' compensation claims for psychological injuries, and for the workplace employee assistance program if there are any trends or usage associated with mental health or stress related conditions.

It can be checked if there are in industrial related records any disputes associated with job stress or dissatisfaction, if there are complaints or grievances that are of a stress or mental health related manner and if issues have been raised formally in meetings or informally in relation to workload or changes to work roles.

It can be determined if there are any issues associated with excessive overtime or with fatigue, stress or working hours, if there are any departments reporting issues of under staffing, fatigue, or employee burnout, and if any department managers are reporting having too much work, conflicting time and work demands, or inappropriate behaviour.

It can also be assessed if workers are displaying signs of concern, being on edge or if any departments are having conflict or tension. Other way to identify psychosocial hazards in transport workplaces are included in the Safe Work Australia (2022) Code of Practice on Managing psychosocial hazards at work.

3.3 Survey results

A summary of the main psychosocial hazards in the Australian transport industry identified in the review of the following published literature are included in table 1.

This review identified that the most common psychosocial hazard identified from primary and secondary sources was job demands (89%, 8/9), followed by low job control (78%, 7/9) and the health-related impact of the work (68%, 6/9).

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Table 1. Psychosocial hazards identified from primary and secondary sources.

Psychosocial Hazard	Resource (Primary and Secondary)								
	The Physical and mental health of Australian Truck Drivers (J.A)	Psychosocial work factors, road traffic accidents and risky driving behaviours in low and middle income countries. A scoping review	Occupational Risk Factors by Sectors: An Observational Study	Role stressors in Australian Transport and logistics workers: psychosocial implications	Sleep and Mental Health in Truck Drivers: Descriptive review of the Current and Proposal of Strategies for Primary Prevention	Industry specific Psychosocial Hazards and Factors - Transport industry	Physical and Mental Impacts on safety in the transport supply chain	5 Health and Safety Issues in the Transportation Industry	Mental illness in the transport industry- NRS
My Organisation									
Poor Organisational Justice	☐	☒	☐	☒	☐	☒	☒	☐	☐
Poor Change Management	☐	☐	☐	☐	☐	☐	☐	☐	☐
Inadequate Reward and Recognition	☐	☒	☐	☐	☐	☐	☒	☐	☐
My Role									
Low Job Control	☐	☒	☒	☒	☒	☒	☒	☐	☒
Job Demands	☒	☒	☒	☒	☒	☒	☐	☒	☒
Lack of Role Clarity	☐	☐	☐	☒	☐	☒	☐	☐	☒
My Team									
Poor Support	☐	☒	☐	☐	☒	☒	☒	☐	☒
Conflict, Poor Relationships	☐	☒	☒	☐	☐	☒	☐	☐	☒
Bullying and Harassment	☐	☐	☐	☐	☐	☐	☒	☐	☐
My Environment									
Poor Physical Environment	☒	☐	☐	☐	☐	☐	☒	☒	☐
Traumatic events or material	☒	☐	☐	☐	☐	☐	☐	☐	☐
Remote or Isolated Work	☒	☒	☐	☐	☒	☐	☐	☐	☐
Violence and Aggression	☐	☐	☐	☐	☐	☐	☒	☐	☐
Other									
External Factors Health related impact of the work	☒	☒	☒	☒	☒	☐	☒	☐	☐

In table 2 are the results of published research where data was collected through interviews with transport workers.

Through interviews conducted as part of research studies it was identified by one third of the studies that the most reported psychosocial hazards for transport workers were inadequate rewards and recognition, job demands, poor team support, experiencing traumatic events, having remote / isolated work, and the health-related impacts of the work.

Information was sourced from professional transport organisations that included Healthy Heads in Trucks and Sheds, Steering Healthy Minds, Oz Help Foundation, Track Safe Foundation, and the National Road Partnership Program. Information from these organisations and four companies on psychosocial hazards that affected transport workers are included in table 3.

Table 3 shows that all (100%) of the professional organisations and companies reviewed described the work provided to the transport workers as having an impact on their health. The next most described psychosocial hazard was having poot team support (78%, 7/9) followed by having high job demands (56%, 5/9)

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Table 2. Psychosocial hazards identified through interviews

Psychosocial Hazard	Resource (Industry Insight and Intelligence)						
	Uneven Wear – Health and wellbeing of professional truck drivers from interviews	Psychosocial work factors, road traffic accidents and risky driving behaviours in low and middle income countries. A scoping review	Driving Health Determinants Impacting health and performance of truck drivers – Telephone Survey	Driving health Study – Survey of the physical and mental health of Australian professional drivers	Contextualising the effectiveness of EAP intervention on Psychological Health	Understanding Work Stressors	
My Organisation							
Poor Organisational Justice	☐	☒	☐	☐	☐	☐	☐
Poor Change Management	☐	☐	☐	☐	☐	☐	☐
Inadequate Reward and Recognition	☒	☒	☐	☐	☐	☐	☐
My Role							
Low Job Control	☐	☐	☐	☐	☐	☐	☐
Job Demands	☒	☒	☐	☐	☐	☒	☐
Lack of Role Clarity	☐	☐	☐	☐	☐	☐	☐
My Team							
Poor Support	☒	☒	☐	☐	☐	☐	☐
Conflict, Poor Relationships	☐	☐	☐	☐	☐	☐	☐
Bullying and Harassment	☐	☐	☐	☐	☐	☐	☐
My Environment							
Poor Physical Environment	☒	☐	☒	☐	☐	☐	☐
Traumatic events or material	☐	☐	☐	☐	☒	☒	☐
Remote or Isolated Work	☒	☒	☐	☐	☐	☒	☐
Violence and Aggression	☐	☐	☒	☐	☐	☐	☐
Other							
External Factors Health related impact of the work	☐	☐	☒	☒	☐	☐	☐

Table 3. Psychosocial hazards identified by professional transport worker organisations and in industry

Psychosocial Hazard	Resource (Industry Partners and Competitors)								
	Healthy Heads in Trucks and Sheds	Steering Healthy Minds	Oz Help Foundation	Track Safe Foundation	National Road Safety Partnership Program	Qube	Australia Post	DHL	Linfox
My Organisation									
Poor Organisational Justice	☐	☐	☐	☒	☐	☐	☒	☒	☒
Poor Change Management	☐	☐	☐	☒	☐	☐	☒	☐	☐
Inadequate Reward and Recognition	☐	☐	☒	☒	☐	☐	☒	☐	☐
My Role									
Low Job Control	☐	☒	☒	☒	☐	☐	☒	☐	☐
Job Demands	☒	☒	☒	☒	☐	☐	☒	☐	☐
Lack of Role Clarity	☒	☒	☐	☒	☐	☐	☐	☐	☐
My Team									
Poor Support	☐	☒	☒	☒	☐	☒	☒	☒	☒
Conflict, Poor Relationships	☐	☐	☐	☒	☐	☐	☒	☐	☐
Bullying and Harassment	☐	☐	☐	☒	☐	☒	☒	☐	☐
My Environment	☐	☐	☐	☒	☐				
Poor Physical Environment	☐	☐	☒	☒	☐	☐	☐	☐	☐
Traumatic events or material	☒	☒	☒	☒	☐	☐	☐	☐	☐
Remote or Isolated Work	☒	☐	☐	☒	☐	☐	☐	☐	☐
Violence and Aggression	☐	☒	☒	☒	☐	☐	☐	☐	☐
Other	☒	☐	☐	☒	☐	☐	☒	☐	☐
Excessive Behaviours (drugs, alcohol and Gambling)	☒	☐	☐	☐	☐	☒	☐	☒	☐
Health related impact of the work	☒	☒	☒	☒	☒	☒	☒	☒	☒

3.4 Psychosocial risk control measures being implemented in industry

Company One

A review conducted for psychosocial hazards at company one identified that the organisation had inadequate rewards and recognition for staff and poor change management. Staff reported having lack of role clarity, low work control and high job demands. In the work teams there was poor support, bullying and harassment. When an assessment of the work environment was conducted it was found that there was violence and aggression.

To meet risk control legal requirements company one developed programs to promote psychosocial health. Their first program was to form Psychological Safety working groups. Employees who were members of these working groups conducted psychosocial risk assessments and implemented risk control measures for any hazards identified. Program 2 was called Leadership@Post. This program is a multi-year commitment to strengthening leadership. Program 3 was to ensure that employees were work ready. This involved ensuring that any employee injured at work received prompt medical treatment and was provided with suitable work restrictions if this was required. Program 4 was early matched care that was designed to reduce secondary psychological injuries. Program 5 was called ProtectMe. This program is a career and personal development program for female staff members to give them the tools to build resilience, self-awareness, and career agility.

Company one now has a Stretch Reconciliation Action Plan to deliver indigenous (Aboriginal) employee parity. This plan is in action and includes inclusive recruitment, supporting indigenous education pathways, partnerships, and indigenous emerging leaders. Company one promotes and supports using indigenous traditional place names. Company one has a Rainbow Peer Support Group to support Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual (LGBTQIA+) workers. The company one Inclusion Plan involves delivering on the company commitment to create an inclusive organisation for people with disabilities. The company one educational programs are designed to raise awareness, combat stigma, and build leadership capability to support psychological wellbeing. These programs have been reviewed and are now being expanded.

Company Two

The review at company 2 identified two hazards, one was poor organisational justice and the other was poor team support. To improve psychosocial health for employees this company has developed and implemented 4 programs. The first was called Healthy Company 2 Program. The 1st program was developed to connect team members with the tools and resources to help them make healthy mental and physical lifestyle choices. The program addressed 4 key topics. (1) Mental health. Mentally healthy minds in uncertain times webinars, mind fit workshops, Mental Health First Aid course, Employee Assistance Program and having a Mental Health Awareness Month. (2) General Health. This included having a vaccination program, bowel cancer prevention program, cancer awareness program, quit smoking programs, sun safety awareness and skin checks, men's health campaign and discounted private health insurance. (3) Nutrition. Educational workshops on nutrition, nutrition tip sheets, and the Avner's Foundation Remember September program. (4) Fitness and strength. Injury prevention fitness passport, correct move motivate challenge, and movement programs.

The 2nd program was a core company program and contained a series of safety topics that were designed to promote the company desired safety culture. These presentations have been given to all company teams over a 12-month period using existing meeting structures or toolbox talks at the workplace. The 3rd program, a site-specific program, was designed to provide intensive support to selected facilities. The site-specific program included an assessment of current processes and procedures, team surveys about safety culture, a 2 day 'illuminate' training program to upskill site leaders in safety tools that they could use to promote a positive safety culture and to develop site specific safety culture plans. An employee assistance program for employees and their families to improve their mental and physical health and wellbeing was the 4th program.

Company Three

Hazards identified by the review at company 3 were poor organisational justice, poor team support and employee excessive behaviours that included the excessive use of alcohol, illegal drugs, and excessive gambling. Company 3's risk control programs were (1) Fit for work. Fit for life. This program encouraged employees to take care of their health and wellbeing. (2) Mental health driver safety training, which helped employees to learn resilience techniques and safe driving techniques. (3) The 4Her program was developed to encourage more women to consider a career in logistics and placed a heavy focus on nurturing the existing company female talent.

Company Four

Hazards identified by the Company 4 review were poor organisational justice, poor team support and bullying and harassment by team members. To deal with these hazards company 4 partnered with an employee assistance service provider to deliver evidence based practical solutions to increase accountability for personal wellbeing of the workforce, to improve employee health, happiness, and life satisfaction. A platform called Company Care was developed to create healthy workplaces and a culture of wellness. The company required everyone employed by the company to take responsibility, accountability, and care in interactions while at work. This platform included health promotion, increased awareness promotion of positive wellbeing, preventing and minimising the occurrence of work-related illnesses or injury and providing early intervention and support if these did occur. It included monitoring and prevention developing mechanisms and processes developed in consultation with workplace teams to monitor and prevent illnesses and injuries. The platform was also used to analyse job design to reduce risks and enhance protective factors. This company had a Zero Harm Policy to manage risks. In this policy the key focus areas were people, community, customers, the environment, plant and equipment.

Healthy Heads in Trucks and Sheds

Members of the professional transport organisation, Healthy Heads in Trucks and Sheds, identified the main psychosocial hazards as being transport drivers having lack of role clarity, high job demands, doing remote or isolated work, personal and home factors as well as addiction to alcohol, illegal drugs and excessive gambling.

The Mission of Healthy Heads in Trucks and Sheds is to create psychologically safe, healthy, and thriving working environments for truck drivers, distribution centre and warehouse staff, and other road transport workers. To achieve this mission and to promote risk control measures for the identified psychosocial hazards this organisation has developed and implemented a National Mental Health and Wellbeing Road map; guidelines for mental health and wellbeing strategies; handbooks for people leaders and the workforce and has a nutrition program called sharing the load and physical wellbeing.

To improve transport workers psychosocial health this organisation promotes driving awareness and reducing stigma; building mental health literacy through education; developing industry specific resources and by being an advocate for evidencing and profiling transport industry workers mental health needs and recommending solutions. Healthy Heads in Trucks and Sheds is working proactively to prevent or reduce the impact of mental health and wellbeing risk factors and, as a protection measure, to enhance workers strengths and capabilities and encourage early help seeking behaviour. It is promoting transport organisations to positively supporting and managing all mental health and wellbeing concerns, regardless of their cause.

Steering Healthy Minds

Psychosocial hazards identified by members of the organisation called Steering Healthy Minds, were having poor organisational support, lack of role clarity, high job demands but low job control, witnessing traumatic events, experiencing violence and aggression and doing remote or isolated work.

The mission of Steering Healthy Minds is to have a transport sector in which people are safe and healthy in their work. To achieve this mission and promote risk control measures for the identified hazards Steering Healthy Minds provides Mental Health First Aid (MHFA) and MHFA Engaging Leaders courses, and mental health peer to peer support. The transport sector Mental Health 1st Aid course was evaluated by researchers from the Central Queensland University (2022). The evaluation found that management were keen to support this program and considered it effective. Other workers reported that there needed to be better dissemination of information about the program throughout industry, that there was difficulty in workers obtaining the 12 hours required to attend the course and that in some organisations there was a lack of trust in management. Steering Healthy Minds is promoting ground support for transport workers who may be experiencing mental health concerns, normalising discussion on mental health issues in the transport industry so that it can be discussed in the same way as physical injuries and is supporting transport organisations to establish peer to peer mental health programs for workers.

Charmers et al. (2021) conducted research in which a questionnaire was completed by 60 heavy vehicle truck drivers who lived in Sydney, Australia. Statistical analysis of the answers was undertaken through a correlation analysis using SPSS. Analysis of answers identified a positive association between depression and alcohol use ($p = 0.044$), number of accidents while driving ($p = <0.004$) and number of hours driving per shift ($p = <0.001$). Anxiety was positively associated with the number of hours spent driving a week ($p = <0.001$) and the number of accidents experienced while driving ($p = 0.039$). Prolonged working hours are associated with raised salivary cortisol and raised cortisol levels are associated with depression. Drivers with depressive symptoms have difficulty in attention completing driving tasks as they have reduced arousal and activation of the somatic nervous system (Charmers et al., 2021). Current Western Australian Government Guidelines (2020) for commercial heavy vehicle drivers (regulation 3.132) allow heavy vehicle drivers to work 168 hours in a 14-day period that can include 17-hour work shifts. Research by Dinh et al., (2017) found that working more than 39 hours a week produced a decline in mental health. The research by Charmers et al. (2021) found that social interaction was negatively correlated with anxiety. Heinrichs et al., (2003) identified that as social interaction increases there is a biological suppression of the hypothalamic–pituitary– adrenal axis which results in a dampened cortisol effect, and this decreases stress. Long term positive social support was found by (Heinrichs et al., 2003) to have a significant anxiolytic effect, resulting in increased oxytocin release, and reduced cortisol release. This is a reason for the link between greater social support and reduction in anxiety as production of oxytocin is an underlying biological mechanism for the stress-protective effects of positive social interactions. Risk control measures suggested to decrease truck drivers' depression and anxiety included changing the rostering system to allow truck drivers to work better hours, providing toolbox talks and education about the effects of excessive alcohol consumption, and improving social support for truck drivers such as having a buddy system (Charmers et al., 2021).

Transport workers are employed in all Australian States and Territories. As a risk control measure, governments in Australia have included as a workplace legal responsibility, identifying, assessing, and controlling work related psychosocial hazards. Australian governments have developed Codes of Practice for managing psychosocial work-related hazards. Codes of Practice are not a legal requirement but provide guidance for employers and employees and are the minimum requirements expected to be

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met by a court of law. Table 4 includes information about the relevant legislation and codes of practice in Australia used to manage psychosocial hazards in workplaces.

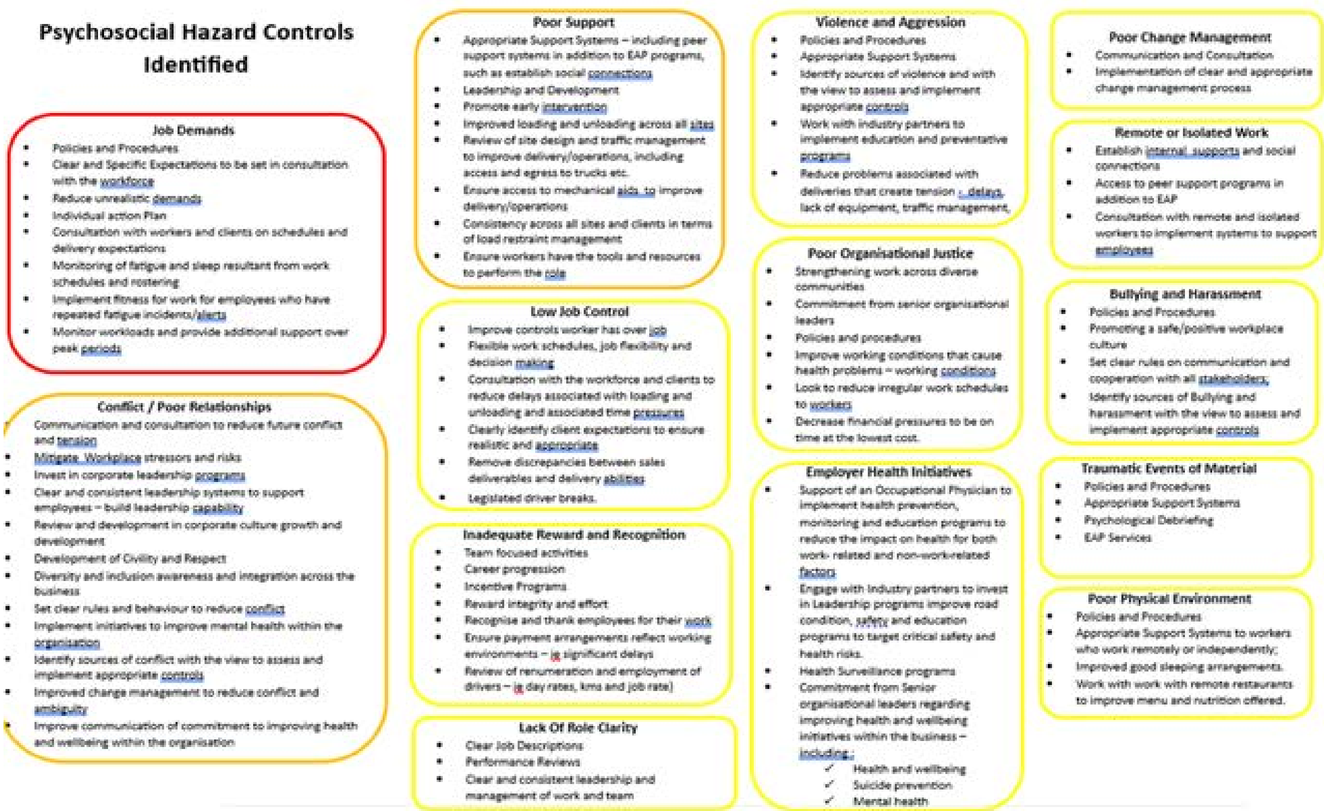
Table 4. Psychosocial Health Legislation and Codes of Practice in Australia

	WA	QLD	NSW	VIC	SA	NT	TAS	ACT
Code of Practice (COP) Status	Active Dec-22	Active April-23	Active Oct-22	Proposed TBC	No COP	Active July 2023	Active Dec-22	No COP
Associated Regulations Status	Dec-22	WHS 2011	Oct 22	April 2023	No State Regulation	Jan 2023	Dec-22	July 2022
Legislation	March-22	Oct-22	Oct-22	2004 OHS Act	2012 WHS Act	2011 WHS Act	2012 WHS Act	2011 WHS Act
Legislation/ COP Specifics	COP: Psychosocial hazards in the workplace COP: Violence and aggression in the workplace COP: Workplace Behaviour COP: Mentally Healthy workplaces for FIFO workers	COP: Managing the risk of psychosocial hazards at work **WHS Regulation** Section 55A COP: Preventing and managing fatigue in the workplace **Guide:** Preventing and responding to workplace bullying.	COP: Managing psychosocial hazards at work COP: How to manage work health and safety risks **WHS ACT**: Section 274	**Guide:** Preventing and managing work-related stress: A guide for employers **Document:** Understanding mental health in the workplace. **Fact Sheets:** Fatigue, Bullying, Work-related Violence, Stress	**Checklist:** Psychological health safety checklist **Checklist:** Wellbeing Safety Scan Mental Health Act 2009 **Guide:** Preventing and responding to work-related violence guide **Resource:** People at Work	COP: How to manage work health and safety Risks	**Resource:** People at Work **Resource:** Head4Work **Campaign:** 2019 Safety is Everything campaign	**Strategy:** Managing Work- Related Psychosocial Hazards 21-23. **Plan:** Managing Work-Related Violence and Aggression Plan 21-23 **Plan:** Managing Work-Related Sexual Harassment Plan 21-23 **Policy:** Compliance and Enforcement Policy 20-24
Reference to Safe Work Australia (SWA) and other organisations	References risk management process adapted from SWA	**SWA Guidance:** The health and safety duty of an officer. **SWA Guide:** How to determine what is reasonably practicable to meet a health and safety duty. **SWA Guide** preventing and responding to workplace bullying.	**SWA** Principles of Good Work Design **SWA** Work-related psychological health and safety: A systemic approach to meeting your duties		**SWA:** Psychological health and safety and bullying in Australian workplaces. **SWA:** Preventing psychological injury under work health and safety laws. WorkCover QLD	**SWA:** Work related psychological health and safety: A systemic approach to meeting your duties. **SWA Guide:** Preventing and responding to workplace bullying.	**SWA:** Psychosocial health and safety and bullying in the workplace Report. WorkCover QLD RU, OK?	**SWA:** how to manage work health and safety risks code of practice. **SWA:** work-related psychological health, a systematic guide to meeting your duties. **SWA:** preventing psychological injury under WHS Laws

Table 4 shows that it is a legal requirement to manage psychosocial hazards in the workplace in Western Australia, Queensland, New South Wales, Northern Territory, Tasmania and in the Australian Capital Territory. Managing psychosocial hazards is not specifically included in the Victorian or South Australian law. Western Australia has four Codes of Practice related to managing psychosocial hazards while Queensland, New South Wales, and the Northern Territory each have one.

In the framework below for psychosocial risk control measures for the transport industry the most common hazards identified were job demands (red box, high risk), followed by conflict, poor relationships, and poor support (orange box, medium risk). The remaining risks documented in table 5 (yellow boxes) were deemed as lower risk psychosocial hazards in the Australian Transport industry as they occurred less often. All psychosocial hazards have appropriate risk control measures to be implemented included in this framework. Based on risk control measures identified from primary, secondary, industry and professional organisations the following table of risk control measures for psychosocial hazards has been developed.

Table 5.



As a risk control measure for transport workers experiencing traumatic events Bouzikos, et al., (2022) recommended having peer support from other transport workers who had previous similar experiences a as it appeared that employee assistance programs had a lack of information to effectively implement primary prevention strategies for psychological distress, depression, anxiety and for post-traumatic stress disorder. Research conducted by Bryant (2023) agreed with this as it was found that well-meaning employee assistance programs may not help and could result in harm if people are provided with early debriefing when their stress hormones are highly active as debriefing can consolidate their trauma memories. Bryant (2023) reported that providing psychological first aid through peer support was a better option as this does not encourage people to disclose their emotional response to the trauma but provides them with someone to talk to and support as required.

Pritchard et al., (2023) conducted 17 interviews with Australian truck drivers to identify personal the coping strategies that drivers used to deal with mental health issues. The first coping strategy identified was to have connections with family, work colleagues, friends and with trained professionals as required. Other personal coping strategies used included appreciating the moment, being grateful for what they had, being optimistic, having a high level of internal locus of control, having mental toughness, and having resilience.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The first research aim was to identify psychosocial hazards which may cause psychological or physical harm to transport workers. Conclusions related to this aim are that the main psychosocial hazards for transport workers were high job demands, dealing with conflict, poor relationships, poor support, low job control, poor organisational justice, lack of role clarity, poor workplace change management, and having a poor physical environment. Other important psychosocial hazards identified were transport workers having to deal with violence and aggression, bullying and harassment, witnessing or being part of traumatic events, having remote or isolated work, and having inadequate rewards and recognition for their work.

The next research aim was to identify risks to the health or safety of transport workers from psychosocial hazards. Conclusions were that psychosocial hazards could cause psychological distress, poor general health, hypertension, hypersomnolence, chronic fatigue, anxiety, depression, suicide, and other mental and/or physical health conditions. In relation to safety, it was concluded that if transport workers were not well then, they were more likely to be less alert and have accidents that may injure or kill themselves or other people.

The final research aim was to identify risk control measures that are being implemented in industry to eliminate or minimise the risks. The risk control measures used in industry are documented in 3.4 in this paper. It was concluded that risk control measures being implemented in industry can be grouped into 5 main categories. Category (1) were mental and physical health promotion programs. (2) Employee assistance programs, mental health first aid, and other programs that provided employees with support once they had mental health problems. (3) Programs that promoted a culture of care and a positive workplace safety culture. (4) Programs that helped employees to learn resilience techniques, self-awareness, career agility and (5) programs that included analysing job design to reduce risk and enhance protective factors. The 5th category of programs looked at eliminating the risk of psychosocial hazards and it was concluded that this was an effective risk control measure.

4.2 Recommendations

It is recommended that to optimise employee health and minimise psychosocial hazards in the workplace a person-centred approach should be used and psychosocial hazards in the workplace should be identified. The Safe Work Australia (2022) Code of Practice Managing psychosocial hazards at work is useful to do this. It is recommended that transport companies should aim to improve safety and not harm employees' physical or mental health, improve social and emotional wellbeing of their employees, prevent work related causes of mental and other work related illnesses, focus on early detection and appropriate intervention if work related illnesses occur and improve employee access to high quality services and employee support if this is required to deal with employee psychosocial or other work related issues. The amount of work and the hours of work that transport workers perform should be realistic (not cause fatigue) and appropriately paid for, while still maintaining company profitability.

In the workplace it is recommended that managers and workers respect each other. It is essential that there is commitment from top management to eliminating psychosocial hazards in their workplace, promote and resource mentally healthy workplaces. Employees have firsthand experience of work-related psychosocial hazards so management should consult with, and listen to, employees when determining risk control measures. Other recommendations are for transport companies to determine what is currently in place to eliminate or minimise psychosocial hazards and look at what future initiatives are already planned. Transport companies should then decide what information they can use to assist them to identify psychosocial hazards for their company, to determine what risk control measures are best for their business, determine implementation strategies, educate employees for change, determine what resources and time frames are required to implement the risk control measures,

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implement the risk control measures and determine how psychosocial risk identification and control processes interplay with employee health management strategies. Once risk control measures have been implemented, they need to be evaluated to ensure that they are effective and to determine any opportunities for improvements to be implemented. Future initiatives can then be planned. There needs to be ongoing communication of company commitment, plans and actions to employees, clients, and other stakeholders in relation to minimising the occurrence of psychosocial hazards.

Transport workers are also affected by government decisions. The government needs to listen to transport workers' concerns, particularly in relation to fatigue management regulations which are not effective. Governments are recommended to have safe, well-maintained roads and rail networks. In relation to having good fresh food it is recommended that drivers map on their route where good fresh food can be purchased and if this is not available, they would need to pack up their own food to eat. In the places that truck drivers need to park premises owners should provide available appropriate parking spaces for deliveries to be made safely.

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A Pilot Study in Healthcare: Salivary Cortisol Levels and Burnout

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KEYWORDS

Stress
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MBI-HSS (MP)

ABSTRACT

This pilot study investigated levels of burnout in non-clinical workers in a healthcare setting and compared them to salivary cortisol concentrations. Mashlach's Burnout Inventory-Human Service Survey for Medical Personnel (MBI-HSS(MP)) was used to evaluate self-perceived levels of burnout. Saliva samples were collected to measure cortisol concentrations at four times during participants' shift. The study included subjects exposed to multiple high-stress factors such as working in a healthcare setting in post-COVID-19 conditions at a major medical center in Southwest Montana. The results revealed a significant correlation (P-value < 0.05) between morning salivary cortisol secretion concentrations and mean survey scores. Significant differences were also found between the three dimensions measured by the MBI-HSS(MP): burnout, depersonalization, and personal achievement, p-value < 0,05. The pilot study has several limitations that should be considered when interpreting results. Findings do suggest that future investigation among this group is warranted. Results may help guide interventions that support the mental health and wellbeing of medical support personnel, reduce stress, and avoid burnout.

1. INTRODUCTION

Stress and burnout are rampant in healthcare. The pandemic created the perfect storm that exacerbated levels of stress among all types of healthcare workers (Shanafelt et al., 2022; Westcar-Gray et al., 2023). Research has revealed that burnout levels in healthcare workers are some of the highest compared to other high-stress industries as a result of the pandemic. In a study comparing the incidents of burnout in physicians and a control population, burnout was present in 37.9% of physicians compared to 27.8% of the control population (Shanafelt et al., 2012). In 2020, the Medscape National Physician Burnout and Suicide Report determined a burnout rate of 43% among physicians (Kane, 2020). Another study, completed by the National Environmental Health Association (2020) investigated stress levels among public health workers and found 74% reported feeling emotionally exhausted and 54% felt burnout. A more recent study in Montana found that 84% of MT environmental health professionals/sanitarians reported feeling moderately or severely stressed

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(Westcar-Gray et al., 2023). In a national study that included 104 organizations and received a robust 20,947 responses that indicated 38% had anxiety or depression, 43% experienced work overload, and 49% reported feeling burnout (Prasad, 2021). Internationally, researchers investigated 1,091 adults in 41 countries using the Perceived Stress Level (PSS-10). The researchers found 76% reported increased worry due to the pandemic (Limcaoco et al., 2020). Investigators reported stress levels at 19.1 on the scale of 0 – 40 indicating moderate stress due to perceived susceptibility to COVID-19. They also found women had higher levels of stress compared to men at 18.3 and 15.6 respectively and the highest levels were among the younger age group less than 30 years and students at 20.4 and 20.7 respectively (Limcaoco et al., 2020).

There is no single-use definition of burnout, but rather it is defined as a multifactor cause and effect (Maslach and Jackson, 1981). Christina Maslach, Ph.D., psychologist, and Susan E. Jackson were the creators of Maslach's burnout inventory, a commonly used psychological assessment tool for occupational burnout in healthcare (Maslach and Jackson, 1981). The survey classifies burnout in three dimensions of mental health: burnout, depersonalization, and level of personal accomplishment (Maslach and Jackson, 1981). Healthcare employees have the potential to experience one or more symptoms due to burnout including exhaustion, emotional distress, feeling negatively toward the job, depression, reduced job performance, medical error, and other severe ailments (Brennan et al., 2019). The symptoms can be triggered by one or more factors including, but not limited to, unmanageable workloads, overloaded schedules, long hours, lack of support from management, high-stress environments, intense psychological demands, negative nurse-physician relationship, and inadequate staffing (Dall'Ora, Ball, Reinius and Griffiths, 2020).

2. BACKGROUND

2.1 Function of Cortisol in the Body and its Role in Stress Research

Cortisol is a biomarker in stress research because it associated with the release of glucose for the sympathetic nervous system's fight or flight response (Mayo Clinic, 2023). Cortisol is a hormone that is naturally secreted by the hypothalamus pituitary axis (HPA-axis) in the body. The hormone functions as a messenger to the rest of the body to facilitate the fight or flight responses (see Figure 1).

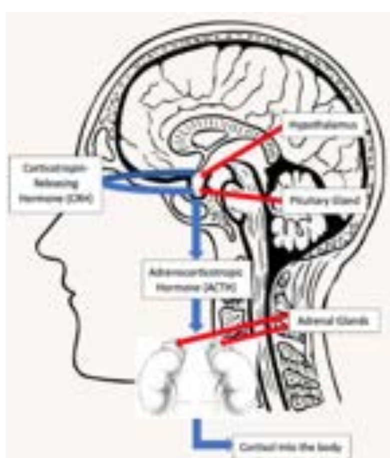

Figure 1. Cortisol Production in the Body

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The hypothalamus secretes corticotropin-releasing hormone (CRH), which is sent back to the pituitary gland. Then, the pituitary gland secretes adrenocorticotropic hormone (ACTH) to the adrenal glands, which signals cortisol to disperse to many organs in the body (Thau et al., 2022). Some organ systems that have respond to cortisol secretion include the nervous, immune, cardiovascular, respiratory, reproductive, musculoskeletal, and integumentary systems (Thau et al., 2022).

The hormone, cortisol, is associated with several human functions and responses and is most commonly referred to as the psychological stress hormone (Cleveland Clinic, 2021). Cortisol is the most abundant endogenous glucocorticoid; these are essential immune responses, but an excess or shortage of secretion can be problematic (McEwen, 2019). Additionally, health impacts can arise even with normal levels of secretion of glucocorticoid, receptors may respond inadequately to the glucocorticoid signals. An impaired glucocorticoid receptor can be a consequence of reduced binding affinity, nuclear translocation, or other dysfunctional transcription interactions (Silverman and Sternberg, 2012).

The disfunction of HPA-axis responsiveness has been linked to many inflammatory responses and illnesses such as Crohn’s disease, irritable bowel syndrome, chronic fatigue syndrome, rheumatoid arthritis, colitis, and other auto-immune disorders (Silverman and Sternberg, 2012). Excess cortisol production is seen in Cushing’s syndrome, which causes adverse responses such as high blood pressure, weight gain, redness in the face, excess hair growth, and other negative effects (Mayo Clinic, 2023). Regular levels of secretion allow the body to regulate circadian rhythm, the body’s use of macronutrients, blood pressure, blood sugar, and energy levels (Johnson et al., 2022). Levels can become irregular or fluctuate greatly in response to several endogenous and exogenous factors including sleep, exercise, stress, medications, and others (Cleveland Clinic, 2021). Cortisol secretion has high temporal variability; levels are typically high in the morning and low in the evening (Thau et al., 2022).

Hypercortisolism is a result of excessive tissue exposure to cortisol, which leading to Cushing’s syndrome if it is sustained (Mayo Clinic, 2023). Hypocortisolism is the opposite effect; it is a deficiency in either the secretion from the HPA-axis or binding at the receptor (Kakiashvili, Leszek and Rutkowski, 2013). The hyper state occurs approximately 6.21/100,000 (Hakami, Ahmed and Karavitaki, 2021). Whereas Addison’s disease is more frequent with a rate of 22.1/1000 (Olafsson and Sigurjonsdottir, 2016). A study published in the Medical Perspective on Burnout showed that acute stress causes high cortisol levels- hypercortisolism- in the blood but decline during chronic stress- hypocortisolism (Kakiashvili, Leszek and Rutkowski, 2013). Another study published by The Physiological Society of Japan and Springer yielded results displaying temporal changes in salivary cortisol levels can indicate work-related stress and recovery, even when diurnal variation and gender differences were accounted for (Nakajima et al., 2012). This study, among others, validate the use of cortisol as a biomarker for stress, as well as acute and chronic stress exposure’s respective effects on high cortisol levels.

There are multiple factors affecting HPA-axis dysfunction and a difference in irregularity with secretion vs. the glucocorticoid receptors. Despite these factors, the literature reveals a strong link between psychological stress and its respective negative physiological responses in the body (Maslach and Jackson, 1981). Burnout is not the same as just feeling stressed in the moment, but due to the characteristic presence of chronic stress. This research aims to investigate the relationship of psychological distress and burnout to cortisol levels. The presence of high levels of burnout creates a priority need for further research for assessment, management, and mitigation.

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2.2 Maslach's Burnout Inventory – Human Service Survey for Medical Personnel

Maslach's Burnout Inventory – Human Service Survey for Medical Personnel (MBI-HSS(MP)) is a 22-question survey designed to evaluates levels of burnout, specifically for individuals working in healthcare. The questions seek to identify and classify a worker's level of burnout through analysis of three dimensions: emotional exhaustion, depersonalization, and personal accomplishment. There are seven response options: 1) never, 2) a few times a year or less, 3) once a month or less, 4) a few times a month, 5) once a week, 6) a few times a week, 7) every day (Maslach and Jackson, 1981).

The survey was designed by Christina Maslach and Susan E. Jackson in 1981 and has been considered a well-researched assessment since its creation (Maslach and Jackson, 1981). In a study completed and published by Cell Press, MBI-HSS(MP) with 282 participants in healthcare during their shift (Pereira et al., 2021). The results were associated with factors commonly recognized for effecting stress levels, such as marital status, weekly workload, sleep duration, drug usage, alcohol consumption, and several others. The comparison between MBI-HSS(MP) and the sociodemographic factors yielded results that confirmed the theoretical model of three dimensions of burnout that make up the structure of MBI-HSS(MP). The study displayed adequate internal consistency for health professionals and similar studies in other countries indicate the same, meaning it maintains validity across cultures (Pereira et al., 2021).

2.3 Study Location and Sample Population

This pilot study was performed at a healthcare facility in Southwest MT. The need to study burnout in Montana is paramount because of the incidence of a more distressed population. In America's Health Rankings from the United Health Foundation, 22.8% of MT adults have reported a diagnosis of depression. This rate is just under 5% less than the state with the highest rates and only sixteen states have higher reported rates (America's Health Rankings, 2023). In the National Vital Statistics Report for 2020, Montana was reported as having the third-highest suicide rate in the United States (Aria et a., 2022). Additionally, it has been ranked in the top five for the last thirty years for suicide rates. Montana has been identified as being at risk for suicide because of multifactor depressive effects. Some factors that may be affecting the rates are vitamin D deficiencies, alcohol consumption as a coping strategy, high altitudes, social isolation, lack of behavioral health services, and several others (Montana Health Alert Network, 2023).

This pilot study was unique due to its location and the healthcare population sampled. Participants did not include physicians or nurses, but support personnel working in the healthcare facility such as administrative workers, construction workers, managers, directors, and supervisors.

3. OBJECTIVES

The main objective of the study was to investigate the relationship between the MBI-HSS(MP) findings and measured cortisol levels.

The specific aims were:

- to assess burnout using the MBI-HSS(MP) survey among this healthcare population.
- to assess cortisol levels using four salivary samples obtained in one day among the same population, and

- to evaluate the relationship between salivary cortisol concentrations and perceived burnout in a healthcare setting.

4. METHODS

4.1 Human Research Approval, Informed Consent, and Privacy

The study protocol was approved by the University Institutional Review Board (IRB). The study population was a group of healthcare workers from a variety of specific jobs at a local healthcare facility. All study subjects were adults employed by the center. Participation was voluntary. Subjects were recruited through a facility manager who emailed an invitation to workers. An informed consent was distributed to all study participants. This included a description of the study expectations, risks of discomfort, benefits to the participants, measures for confidentiality, and participant rights. All participants were required to sign the informed consent form before they could participate in any part of the study. Names were used to match the survey results to the salivary cortisol samples. All personal identifying information was protected and remained within the research team. All information was stored on a password-protected computer in a locked office.

4.2 Verisana Salivary Cortisol Sampling Kits

The team collected salivary cortisol sampling using the Verisana Salivary Cortisol Sampling Kits throughout the workday on four occasions (see Figure 2). The four salivary samples were representative of real-time fluctuations in the HPA-Axis activity (see Figure 3). The salivary samples were obtained at the start of the work shift, two hours, four hours, and eight hours. Each kit contained four vials to collect the saliva at the designated times. Eighteen subjects were asked to spit into the plastic vails, seal them, and return them to the site coordinator who then returned them to the researchers at the university. Samples from all twenty participants were sent to a CLIA-certified lab for analysis. The lab used reverse-transcription polymerase chain reaction (PT-PCR) assay to detect cortisol concentrations (Ayumetrix, 2023).

Figure 2: Salivary Cortisol Sampling Test Kits

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Figure 3. Test tubes for saliva from Salivary Cortisol Sampling Test Kits

4.3 Survey Completion

The MBI-HSS(MP) is a 22-question survey with an anticipated completion time of about 20 minutes. All twenty participants completed the survey at the start of the shift at the same time their first cortisol sample was obtained. The completed survey was returned to the site coordinator and returned to the university. The survey was matched to the cortisol kit and all personal identifiers were removed.

Because the participants were support personnel working in non-clinical settings, seven of the 22 questions specific to clinical setting employees were removed. Additionally, to analyze data, the answers were tied to a score 1-7 where 1=positive outcome and 7=negative outcome. Because of the wording of the questions, some positive outcomes would be associated with the “never” response and others would be negatively associated with the “never” response. Essentially, the range for responses was consistently seven possibilities but flipped for certain questions so the higher score was always related to the negative outcome and the lower scores to the positive outcome.

4.4 Data Analysis

Both the MBI-HSS(MP) scores and cortisol concentrations were entered into excel and sorted for analysis. Then, the research team used Spearman’s Correlation on Minitab to conclude if the correlation between mean survey scores and cortisol concentrations were statistically significance ($p \leq 0.05$). A Games Howell one-way analysis of variance (ANOVA) was conducted for the difference of mean survey scores for each of the three survey dimensions. Finally, linear regression models were created for the association between cortisol concentration at each of the four times and mean survey scores. Each graph displays an equation for the linear regression and an R2 value, which helped the research team understand the percent variation of mean survey score that is explained by the variation of cortisol concentrations.

5. RESULTS

A total of eighteen salivary cortisol kits were received by the research team and sent to the lab for analysis. Of those eighteen, only eight of them were completed correctly and able to be analyzed. The survey was filled out by seventeen participants, eight of which also had salivary cortisol data. Of those that filled out the survey, 47.1% were men and 52.9% were women. Of the salivary samples that were able to be analyzed by the lab, one participant was male and the rest were female.

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Figure 4 displays the difference in mean survey scores for each survey dimension (burnout, depersonalization, and personal achievement). The depersonalization dimension yielded the highest mean score [3.838(3.327, 4.350) and σ=2.113]. The burnout dimension had the second-highest mean score [3.496(3.151, 3.841) and σ=1.899]. The personal achievement dimension yielded the lowest mean score [2.706(2.309, 3.103) and σ=1.640]. The ANOVA used Welch's test first, with null and alternative hypothesis where null hypothesis (H0): All group means are equal and alternative hypothesis (HA): At least one group mean is different from the rest. The Welch's Test revealed p=0.001, therefore, the research team was able to reject the null hypothesis for mean survey scores of each dimension. Finally, the ANOVA displayed a statistically significant difference between personal achievement and burnout, as well as personal achievement and depersonalization with values p=0.009 and p=0.002 respectively.

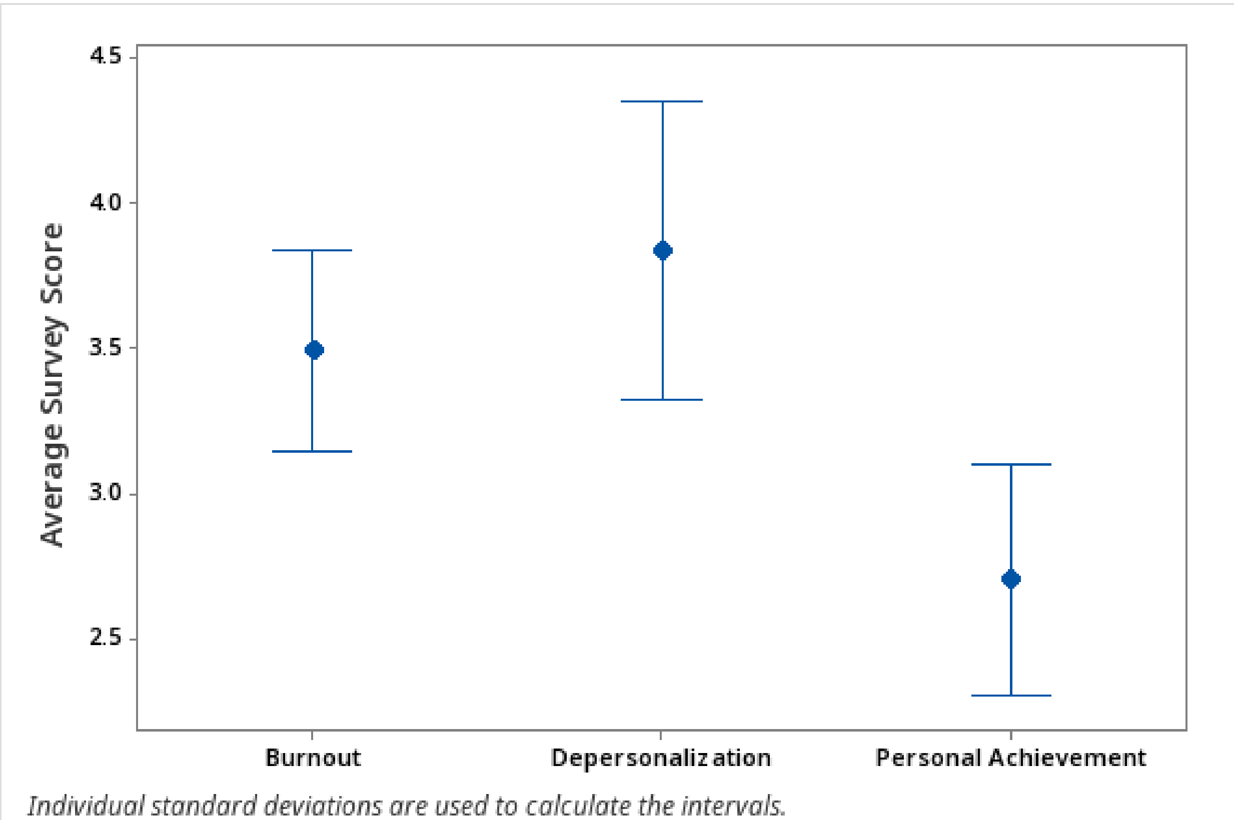

Figure 4. Difference in mean survey scores for each survey dimension from ANOVA

Figure 5 displays the low, medium and high scores of each of the three survey dimensions. The low score category includes responses never and once a year or less, which is associated with numbers one and two. The moderate score category includes responses once a month, a few times per month, and once a week, which is associated with numbers three, four, and five. The high score category included responses a few times a week and every day, which is associated with numbers six and seven. For burnout, scores were 38.7% low, 38.7% moderate, and 22.6% high. For depersonalization, scores were 36.8% low, 32.3% moderate, and 30.9% high. For sense of personal achievement, scores were 55.9% low, 36.8% moderate, and 7.3% high.

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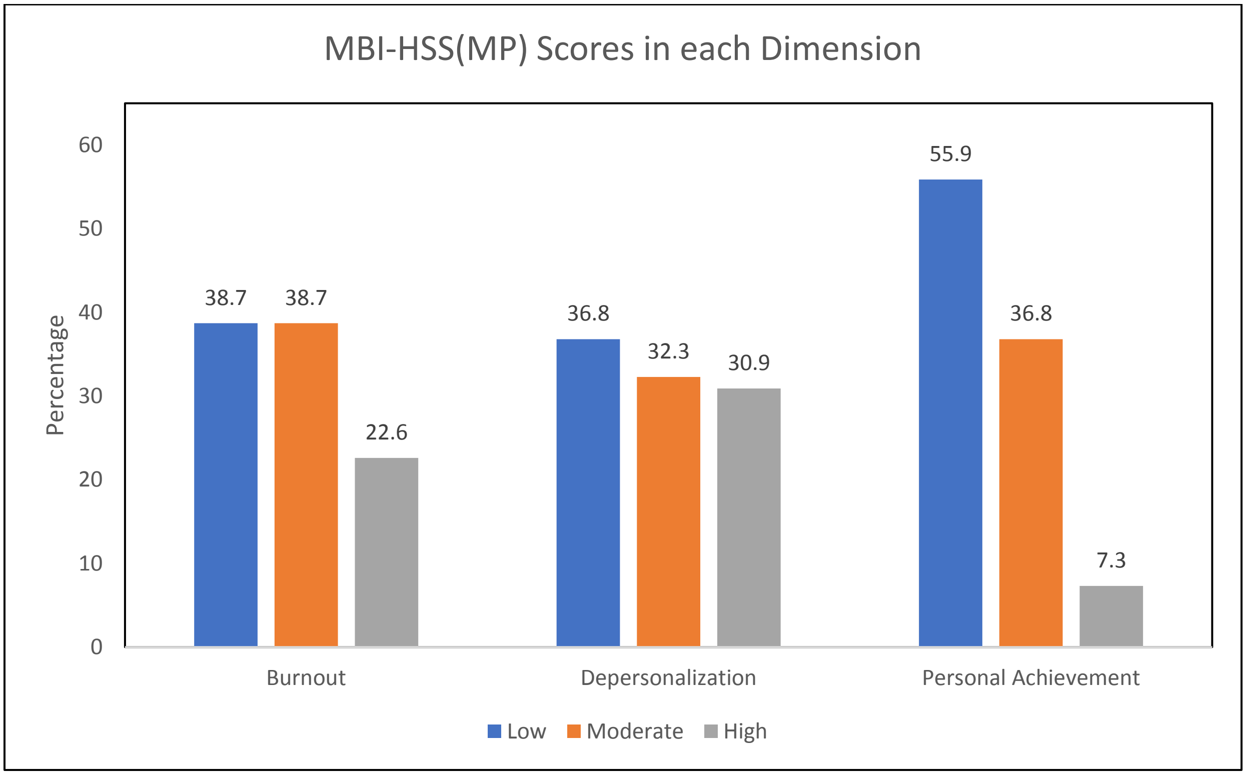

Figure 5. MBI-HSS(MP) low, medium, and high scores for each of the three survey dimensions.

The eight cortisol concentrations that were analyzed for all four times of collection were compared with each respondent's mean survey score. Of that group of eight, three scored in the low range as specified previously ($\bar{X}$=1.73, 1.8, and 1.93). The other five scored in the moderate range as specified previously ($\bar{X}$=2.53, 3.87, 4.27, 4.93, and 5.07).

For each time cortisol concentrations were gathered, there are reference ranges that are considered normal concentration ranges reported by Verisana (see Table 1). Of 32 concentrations (four collection times for eight participants), seven (20.6%) landed outside and above the reported reference ranges. Reference ranges from Verisana are detailed below.

Table 1. Reference ranges of cortisol concentrations for collection times as specified by Verisana

Reference Ranges	Start of Shift	2 hours	4 hours	8 hours
	1.5-9.6 ng/mL	0.6-4.1 ng/mL	0.2-2.3 ng/mL	0.1-1.8 ng/mL

Descriptive statistics were found for each cortisol concentration time: start of shift [3.45 (0, 9) and σ=2.78], two hours [2.15 (0, 4.81) and σ=1.33], four hours [1.39 (0, 3.106) and σ=0.858], and eight hours [1.36 (0, 2.42) and σ=1.06].

Figure 6 shows the mean survey scores compared with each of the four salivary cortisol collection times for eight participants. Each data set is displayed with an equation for its linear regression, as well as an R2 value to show the variation in cortisol concentrations explained by the variation of mean survey scores. The start of shift concentrations and mean survey scores yielded R2=0.7352, which

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showed a high strength of association between the two variables. The correlation was further analyzed with a Pairwise Spearman Correlation test on Minitab. This confirmed the strength of association with a p=0.001, meaning the correlation was statistically significant between the two variables. The rest of the data was not strongly correlated with R2=0.2167 and p=0.471 for two-hour concentrations, R2=0.1363 and p=0.844 for four-hour concentrations, and R2=0.1268 and p=0.649 for eight-hour concentrations.

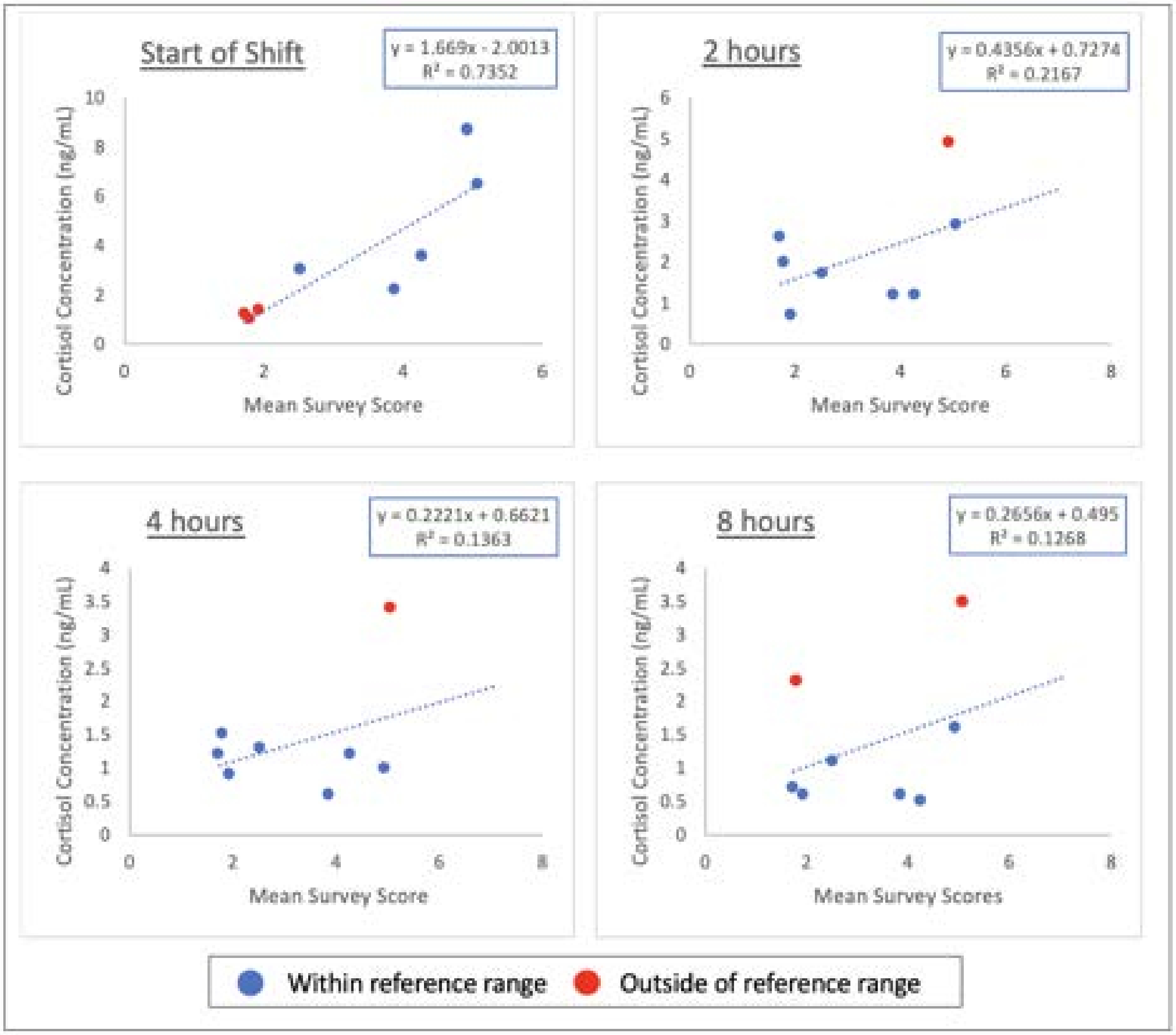

Figure 6. Mean survey scores compared with concentrations at all four times of saliva collection.

6. DISCUSSION

Understanding burnout and the effect it has on the workforce psychologically and physiologically is of high and continually increasing importance. This pilot study was designed to investigate non-clinical healthcare workers in particular and found evidence of burnout, mental and emotional stress, and elevated cortisol levels among the population studied. In a study by Ashill and Rod (2011) who examined burnout in 152 non-clinical personnel in a healthcare setting also found significantly higher scores using the MBI-HSS(MP). The investigators concluded that role ambiguity, role conflict, role

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overload, and interpersonal conflict explained variance in emotional exhaustion and depersonalization, R2 = .42 and R2 = .46 respectively. Pindar et al. (2012) also found burnout in 117 non-clinical personnel with 36.6% reporting emotional exhaustion and 48.4% reporting personalization. The researchers concluded that there was a 72% greater possibility for non-clinical personnel chance to develop burnout. Okuda and colleagues (2019) studied 188 non-medical personnel and found burnout using the MBI-HSS(MP). The team found elevated scores for emotional exhaustion and depersonalization and higher scores for personal accomplishment. Studying the non-clinical workforce in clinical healthcare settings may generate more helpful information for assessment and treatment solutions. This pilot study was comprised of a small sample and has other limitations, therefore conclusions and inferences must be made cautiously.

This pilot study revealed a statistically significant correlation between participants' morning cortisol secretion and mean MBI-HSS(MP) scores. Based on this significance, morning cortisol concentrations may be the most accurate gauge of physiological stress or burnout. This is most likely due to a lack of acute stimulators a person has consumed at this point of the day. Some acute stimulators that can raise levels throughout the day include nicotine, caffeine, alcohol, and dietary energy supplies or lack of sleep (Kudielka, Hellhammer, and Wust, 2009). The lack of significant correlation between survey scores and cortisol concentrations at other times of the day may be due to the consumption of one or multiple acute stimulators. They also may be correlated because the survey was completed at the same time the first salivary sample was given.

Additionally, statistical significance was demonstrated between the survey dimensions of personal achievement and burnout, as well as personal achievement and depersonalization. Based on the data, sense of accomplishment and enjoyment from working with people was high among the majority of participants. Literature indicates that chronic emotional exhaustion leads to burnout, which can greatly reduce one's feelings of personal accomplishment (Pehlivanoğlu and Civelek, 2019). The high levels of feelings of personal accomplishment found in this study may be due to feeling burnt out only in the short term. Okuda et al (2019) found higher scores in personal accomplishment compared to scores for emotional exhaustion. These feelings may also be credited to such a high level of enjoyment from working with people. In all the responses collected, all questions had at least one or more participants experienced it daily except, except for one: high strain from working with people.

The results of this pilot study are consistent with several similar published studies (Okuda, et al., 2019; Oosterholt et al., 2015; Wang 2020). In a study published by BMC Health Services Research, their results weighed similarly among the three survey dimensions, with higher levels of depersonalization and low levels of lacking feelings of personal achievement (Wang, 2020). The study also found that factors such as age, gender, and occupation had statistically significant effect on burnout and depersonalization. It was also found that marital status had a statistically significant effect on personal achievement (Wang, 2020). Due to these confounders, future studies should consider including an additional questionnaire that accounts for these factors.

Another similar study completed in a palliative care facility and published by Cambridge University Press also displayed agreement with the results of this pilot study. There was a significant difference in cortisol secretion between what they determined as burnout and non-burnout groups. They also discovered a high feeling of personal achievement at 69.9% compared to the 55.9% found in this pilot study (Fernández-Sánchez et al., 2018). Oosterholt and colleagues (2015) examined both clinical and non-clinical personnel and found greater burnout among the clinical personnel and less decline in cortisol levels throughout the day among the non-clinical personnel.

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7. LIMITATIONS

Cortisol secretion is a multifactor effect in the human body, meaning levels can be highly variable based on many factors, and the MBI-HSS(MP) survey does not address many of these potential variables that can influence cortisol secretion. Adrenal dysfunction can also vary from proximal or distal factors. Some factors that may affect levels are sleep, diet, exercise level, and medications, as well as several others, and future studies should consider the potential effect of these variables. The factors were not evaluated as covariates.

Additionally, participants were not recruited through a randomized process, making it a convenience sample that may not represent the average healthcare worker. The sample size was small and may be insufficient to make inferences associated with the larger population of non-clinical healthcare workers. The lab analysis reported an error of one percent for the cortisol concentrations. The surveys are self-reported and subject to recall and response bias. Additionally, the sample of MT workers may be different from the general population and prevents generalizing.

Potential Treatments for Burnout

In addition to a lack of methods for assessing burnout, effective treatment for burnout is also unresolved. Treatment is highly dependent the individual and on potentially multiple factors, which makes treatment somewhat of a difficult challenge and is generally managed on a case-by-case basis. However, with sufficient evidence about the prevalence and increasing incidence of burnout, there exists a need to identify evidence-based effective treatments and delivery methods.

There is evidence in the literature and in this pilot study that feelings of personal accomplishment remain high (Okuda et al, 2020). Continuing to create work environments with a high sense of purpose and achievement may limit increased feelings of burnout. Practices such as frequent recognition of contributions or rewarding great work may help maintain and even further improve the workforce's sense of personal achievement. For the dimensions with lower levels, of burnout and depersonalization, some guidance for wellbeing may be helpful for improvement. The National Institute for Occupational Safety and Health (NIOSH) has recently created guidance for total worker health (CDC, 2023). TWH extends consideration beyond safety and health to safety, health, and wellbeing. NIOSH displays a hierarchy of controls of effective strategies specifically for improving worker well-being. NIOSH’s guidance for TWH also includes a worker-wellbeing questionnaire for assessment, as well as an example of a Healthy Work Design and Well-Being Program (CDC, 2022).

In terms of medical treatment, some clinicians have treated patients experiencing hypocortisolism with low doses of cortisol. Trials of different drugs, as well as marijuana for medicinal use, have also displayed positive effects on regulating the HPA-Axis (Kakiashvili, Leszek and Rutkowski, 2013). It has also been suggested that certain dietary supplementation would be helpful in cases where HPA-Axis dysfunction is the result of an insufficiency (Kakiashvili, Leszek and Rutkowski, 2013).

8. CONCLUSIONS

Although there is no doubt that burnout frequently affects workers in healthcare settings, both clinical and non-clinical personnel, addressing the issue remains challenging. The multivariable effects of cortisol secretion and its high temporal variability make cortisol secretion measurements limited but useful for assessing burnout when paired with inventory tools such as MBI-HSS(MP). The literature

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has indicated that chronic and acute stress may have opposite effects from each other on cortisol secretion (Kakiashvili, Leszek and Rutkowski, 2013). However, cortisol or other biomarkers should continue to be studied, as it still appears there is a correlation between cortisol concentration and perceived stress or burnout.

Finally, further research should be conducted on other assessment methods, as well as existing and proposed treatment methods. One method or a combination of several may be effective for assessing and/or treating burnout.

DECLARATIONS

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Author's Contributions

Hannah Oggerino was the graduate student who conceived the project and worked in all phases of the study and manuscript preparation. Ms. Oggerino defended her work and graduated and now is recognized as a Graduate Safety Professional (GSP) and practicing Industrial Hygienist. Hannah earned her bachelor's degree in Occupational Safety and Health and her master's in IH, both at Montana Tech University. Dr. Autenrieth is an Associate professor and Co-Major Advisor who provided statistical guidance and review for this manuscript. Dr. Autenrieth was involved in all phases of the study. Dr. Berrington is an Assistant Professor in the Chemistry Department who inspired Hannah to select the topic and provided a review for the manuscript. Dr. Gilkey was the Co-Major Advisor who worked with Hannah through all phases of the project.

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Manual Material Handling & Spinal Compression: A Pilot Study

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ABSTRACT

Manual materials handling (MMH) is a common cause of low back injury and low back pain (LBP). Low back injury is a major challenge in many industries and consumes the largest portion of the workers' compensation dollar. Low back pain is responsible for more lost workdays and disability than any other musculoskeletal disorder (MSD). Many industries require employees to engage in MMH that cause significant risk to their spinal health. This study investigated the application of two different lifting techniques. Spinal compression was estimated in four subjects lifting a 35 lbs load using two different lifting techniques. Finding revealed average compressive forces between 849 lbs/in2 and 1023 lbs/in2. Findings reveals a significant reduction (p-value < 0.05) in spinal compression using the Powerlift™ method compared to the traditional squat lift. Findings suggest that different lifting methods may reduce or increase stresses to the back. Investigators advocate for the adoption of Poweflift™ where possible to reduce risk for back injuries.

1. INTRODUCTION AND BACKGROUND

The workers engaged in manual materials handling (MMH) are at higher risk for low back injury and associated pain leading to more lost workdays due to injury more than any other occupational group (Ferguson et al., 2019). Material handlers come in all shapes and sizes and from a variety of different backgrounds and industries. The term "material handler" doesn't necessarily refer to laborers, stocking clerks, or freight handlers, but anyone who handles material by performing the following tasks: Lifting, lowering, pushing, pulling and carrying loads (Rajesh, 2016). Manual laborers perform a higher frequency of similar, and often, more strenuous MMH tasks managing in a wide range of loads (Ferguson et al., 2019). Many workers are at high risk of developing musculoskeletal disorders due to MMH stresses associated with lifting, lowering, pushing, pulling, and carrying loads. For example, manual laborers suffered 15.6% of all musculoskeletal injuries in 2016 (BLS, 2018). MMH-associated lower back pain (LBP) continues to be an immense challenge for employers and safety and health professionals (OSHA, 1994; Tang et al., 2020; Waters et al, 2007).

Each year more than 1 million people in the US suffer from back injuries. The annual incidence of low back pain has been estimated at 7% in the general population (Fatoye, Gebrye & Odeyemi, 2019). In fact, 1 out of every 5 or more workplace injuries is a back injury. Back injuries comprised 38.5% of all musculoskeletal injuries in 2016 (BLS, 2018). Eighty percent of these injuries occurred on the lower

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back and 75% of them happened during lifting activities (BLS, 2018). The most common type of injury workers encounter is strains and/or sprains, which can originate from several different MMH related factors (Marras, 2000; Tang et al., 2020; Water et al., 2007). Back pain is multifactorial may also be related to many other possible factors beyond MMH such as health status, poor posture, physical condition, lifestyle hobbies and activities, poor body mechanics, and psychosocial (Marras, 2000; Tang et al., 2020; Waters et al., 2007).

Low-back pain ranks number one among the most prevalent painful conditions experienced by individuals throughout their lives, it has been estimated that nearly 90% of all people will experience an incapacitating episode at some time in their lives (Gilkey et al., 2010). The Occupational Safety and Health Administration (OSHA, 1994) identified low back pain associated with lifting as the country's number one safety challenge. Occupational factors, particularly tasks involving heavy MMH, can contribute to the onset of LBP and result in persistent low back disorder (LBD)(Ferguson, et al, 2019; Marras, 2000; Water et al., 2005). Given the high occurrence of both LBDs and MMH in the adult working population, it is estimated that LBP is perhaps the most commonly encountered work-related ailment across the globe (Fatoye, Gebrye & Odeyemi, 2019).

The lifetime prevalence of low-back pain was estimated at 84%, depending on the specific criteria used for diagnosis, affecting individuals of all age groups, including children (Trompeter, Fett and Platen, 2017). While low-back pain is not a life-threatening condition, it was the third leading cause of disability-adjusted life-years in the USA in 2010 and ranked first in terms of years lived with disability. Globally, it held the 13th position in disability-adjusted life-years for the same year (Fatoye, Gebrye and Odeyemi, 2019).

The rise in musculoskeletal disorders in many industries may be attributed to workers' high MMH demands and not adhering to safe work practices and protocols for managing ergonomic hazards. Numerous resources are available from the internet, mobile applications and other multimedia electronic recordings with information that can help guide employers and MMH workers toward safer work practices. Workers encounter a range of health-related stressors in industrial settings, such as fatigue, poor blood circulation, discomfort, and back pain, often stemming from inadequate ergonomic designs of machinery, equipment, tools and entire work systems (Rajendran et al., 2021). Suboptimal working postures may lead to reduced productivity, exacerbating health problems, musculoskeletal disorders, and physical strain. Improper work postures, including bending, lifting, twisting, pushing, and pulling, are significant contributors to the development of ergonomic problems (Rajendran et al., 2021). Less than effective training for MMH also increase risk for low back injuries (Comeau, Gonella and Lauzier, 2020).

Despite extensive research and ongoing prevention efforts, MMH continues to pose a substantial risk of occupational injuries. Data indicates that in the period between 2003 and 2008, over $100 million annually was allocated for compensating workers in Quebec, Canada, who had suffered injuries related to manual handling (Allaire and Ricard, 2007). According to the U.S. BLS, in 2017, there were 113,620 cases of Musculoskeletal Disorders (MSDs) attributed to overexertion during lifting or lowering tasks in the course of work activities. The lumbar spine was the most commonly affected area, accounting for 60% of spinal injuries, with overexertion being the leading reported cause of injury, responsible for 40% of cases between 2007 and 2010 (Selvarajah et al., 2010).

1.1 Manual Material Handling Training

Raising objects from the ground is an essential task in many cases, and lifting is a recognized risk factor for experiencing LBP (Faber et al., 2009; Marras, 2000; von Arx et al., 2021; Washmut, McAfee and Bickel, 2022). Conventional lifting techniques encompass stoop (utilizing the back for lifting), squat (involving the legs in lifting), and semi-squat (a mid-way approach between stoop and squat) (Faber et al., 2009; Kahlil, 1993; von Arx et al., 2021; Washmut, McAfee and Bickel, 2022). While many healthcare professionals consider the squat technique as the most effective, training in squat lifting does not necessarily prevent lower back pain and has been found to have high compression values that exceeded the stoop lift (Faber et al., 2009). This disparity between clinical practice and evidence-based findings has given rise to ongoing debates.

A systematic review reached the consensus that a significant portion of MMH training methods prove ineffective in reducing lower back pain or back injuries (Davis and Jorgensen, 2005; Trompeter, Fett and Platen, 2017). This lack of efficacy may be attributed to one-dimensional interventions, the absence of transferability in training, and the failure to incorporate training based on the principles of modifying health behavior (Ricci et al., 2016). Furthermore, studies often assess training effectiveness in terms of long-term outcomes, such as the reduction of musculoskeletal disorders while intermediate variables have been overlooked (Ricci et al., 2016; Robson et al., 2009; Trompeter, Fett and Platen, 2017).

One of the current challenges lies in actively engaging employees in the training process, recognizing that greater participation leads to increased effectiveness (Ricci et al, 2016; Robson et al., 2009; Trompeter, Fett, and Platen, 2017). In this context, a training method that can accentuate the active involvement of employees is self-observation. Self-observation is a valuable technique for fostering behavioral change, as it impacts self-confidence and self-awareness (Anguera et al., 2020). This research project investigated lifting techniques to assess the difference in lumbar compression using 2D L5-S1 compression. Lumbar compression has been used widely to assess risk for low back injury (Genaidy, Waly, Khalil and Hidalgo, 1993). A review of 14 studies investigating spinal compression limits for different age groups revealed variability in compression values. Risk for injury appears present in nearly all recommended limits for those engaging in various MMH tasks (Genaidy, Waly, Khalil and Hidalgo, 1993).

1.2 Research Question

What are estimates of spinal compression when workers lift materials of the same weight from ground level using different lifting methods? Is there a lower risk method to lift materials that reduces lumbar L5-S1 compression? This research seeks to shed light on the significant lower-back stresses associated with MMH commonly seen while performing usual lifting duties in many working environments. This pilot study also aimes to demonstrate that amount of lumbar compression at L5-S1 is hazardous and that observed differences in L5-S1 compression is due to lifting techniques.

1.3 Old Lifting Method – Subject Background

Before performing any lifts, subjects were asked if they knew what the proper lifting technique was for picking something up off the ground. All participants stated the same or similar; approach the load with feet shoulder width apart, lift with your legs, keep your back straight and lift the load while keeping it in front of and close to their body. This is the most commonly taught technique, one which has been taught to myself at several different companies that I have worked for over the years. This method incorporates strategies like using your legs and keeping your back straight, but it leaves room for improvement.

Lifting objects in this manner keeps the weight of the load in front of the body which makes the person performing the lift put their weight on the balls of their feet, which can cause the person to lose their

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balance. Keeping the load close to your body while rising also becomes difficult due to the knees getting in the way, which also makes the lifter place the load forward, increasing the chance of losing balance even more and placing greater stress on the lower back. This position also requires greater knee flexion (around 65°), which affects the legs capabilities and makes it more challenging to stand upright.

1.4 Proposed New Lifting Technique

The new method called PowerLift™ was adapted from the athletic weight lifters and is being implemented across the world is known to reduce risk associated with MMH (Copeland, 2023; Powerlift, 2023). Powerlifting incorporates techniques used by weightlifters to reduce risks and enhance performance safely. Using a wider stance allows the lifter to straddle and get closer to the load and helps reduce torso inclination and keep the feet flat on the ground thus improving stability and reducing changes of losing one's balance. This allows us to lift with our legs vertically, which allows the back to stay in alignment and transfers the weight of the load to the legs and hips. Using this method lowers the angle of knee bend to around 100° (Copeland, 2023; Powerlift, 2023).

2. METHODS

2.1 Low Back Compression Measurement

To study the compressive forces at the L5-S1segment in the lower back, subjects of different heights and weights were recruited to perform two basic lifting tasks twice, a 35 lbs. crate from the floor using the two different techniques. Thirty-five pounds is often used and a threshold for many businesses and thought to be safer (Waters, 2007). One lift using the commonly taught method and then again, using a newer Powerlift™ technique that incorporates a wider base stance. Subjects were fitted with a 12-inch ruler for scaling dimensions and were video-recorded performing both lifts. A total of 4 subjects volunteered for a total of 8 lifts being video-recorded. Video recordings were then uploaded to a computer and still images were captured of the subjects at peak load. These photographs were then uploaded for analysis into the ErgoMaster™ software (Nexgen, 2023).

The specialized ergonomics software, ErgoMasterTM was used to predict 2D biomechanical compression at the L5-S1 spinal segment (Nexgen, 2023). Input data encompassed the location of the lifting operation, the nature of the task, the individual performing the lift, age, gender, height, weight, and the lifted load measured in English units. The subsequent set of actions involved marking specific anatomical landmarks. A dot was positioned at both ends of a 12-inch ruler for scale calibration. Following that, dots were placed on the lateral malleolus of the ankle, the lateral femoral condyle, the greater trochanter, the acromion process, the lateral epicondyle of the elbow, the second knuckle of the hand, and finally, the ear canal. The final step involves summarizing the results, which are printed and saved for later review and data extraction. Furthermore, additional force measurements were calculated, which include total compression and contributing forces at the L5-S1 segment that included shearing force, total joint reactive force, erector spinae force, and compression force in the erector spinae. These calculations are based on a 2-dimensional static model and will yield results regarding total compressive forces on the spine, shearing forces, and joint reactive force (Nexgen, 2023). To manage and organize the data, Microsoft Excel was used to create graphical presentations. (American Training Resources, 2023) Data were evaluated using Minitab™ Version 2.1. Descriptive statistics were estimated. Differences in mean scores were evaluated between old lift to new lift using the two-sample paired t-test.

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3. RESULTS

Compressive forces at the L5-S1 segment of the spine revealed estimates ranging from a low of 876.25 lbs/in2 to a high of 1212 lbs/in2 for the old method, and a low of 691.78 lbs/in2 to a high of 1046.98 lbs/in2 for the new method. The old method measured a mean score of 1023.1lbs/in2 (SD 76.09 lbs/in2) and the new lift was 849.09 lbs/in2 (SD 82 lbs.). The new lift method demonstrated an average of 173.97 lbs/in2. reduction in compression at the L5-S1. There was a significant difference found when comparing means of the old lift to new lift using the Minitab(TM) Version 21 paired t-test, p-value: < 0.00, see Figure 1.

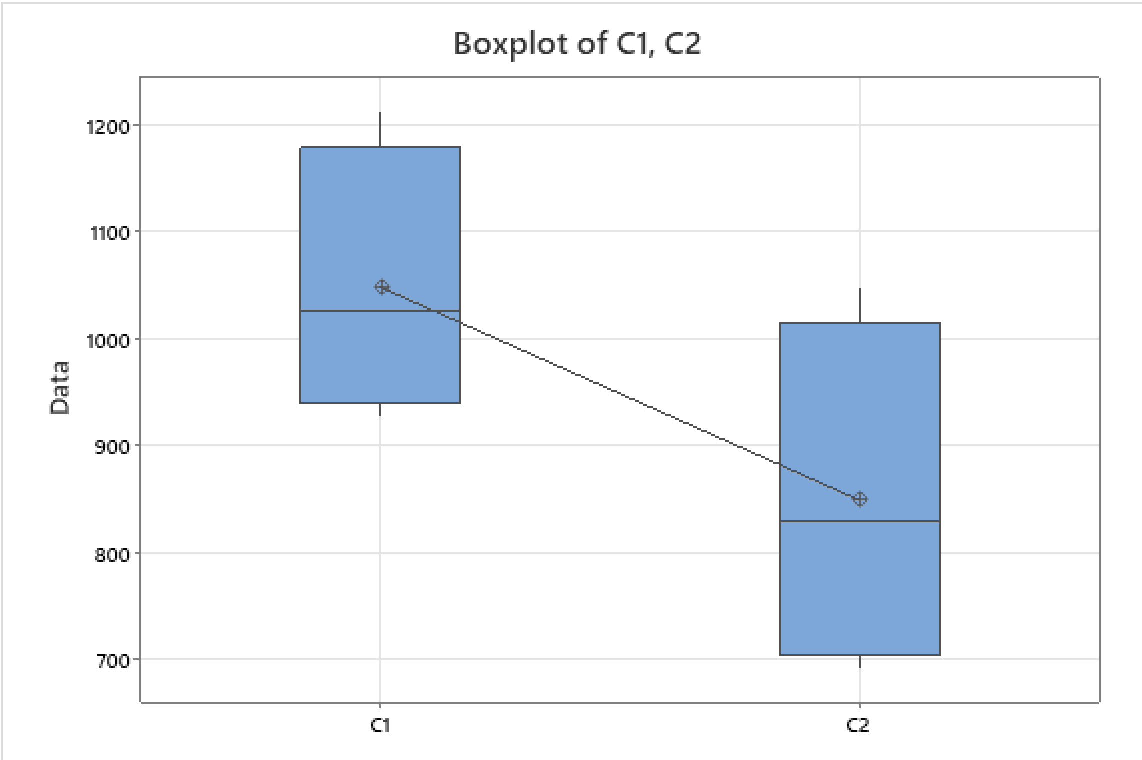

Figure 1. Box plot with significant differences in total compression mean scores and 95% CI for Lift 1 and Lift 2

All of the lifts performed using the old method were above the action limit of NIOSH AL of 750 lbs/in2, see Figure 2 whereas, the second method had two lifts below the AL, see Figure 3 and 4. Two of the subjects were still above the AL after incorporating the new method, 918.62 lbs/in2 and 1046.98 lbs/in2 respectively. No lifts were above the MPL. Shear forces were also evaluated using Minitab™ version 21 paired t-test for differences. Significant differences were found p-value 0.003, see Figure 6.

Compressive force due to load and compressive force due to upper body weight (UBW) increased on each subject with the new lifting method, however, every other measurement was improved with the new method. Total compressive force, total shearing force, total torque or bending moment, total joint reactive force, erector spinae force, compressive force – erector spinae, shearing force due to load, shearing force due to UBW, and shearing force – erector spinae were all reduced on all four subjects using the new lifting method, see Appendix.

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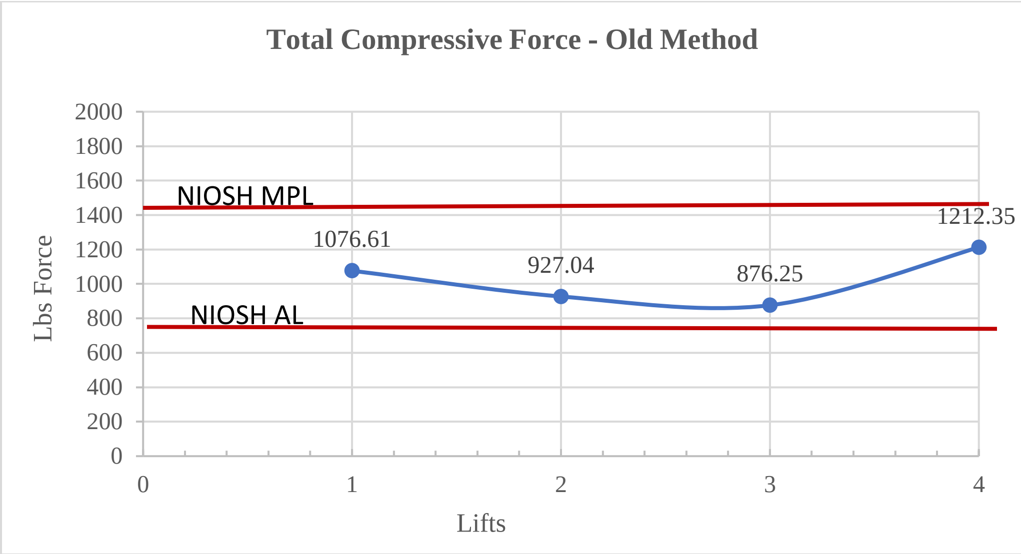

Figure 2. Total L5/S1 low back compressive forces compared to NIOSH AL & MPL

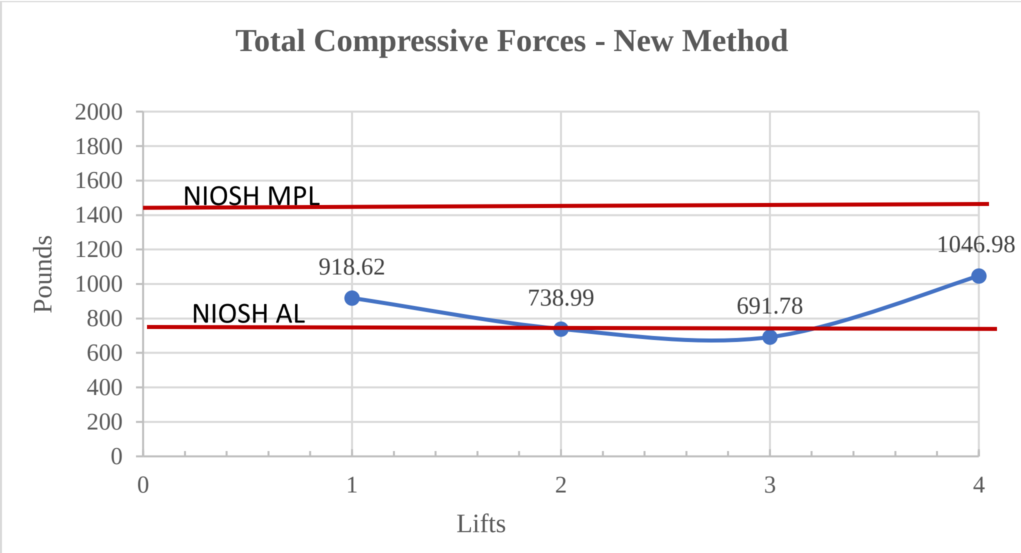

Figure 3. Total L5/S1 low back compressive forces compared to NIOSH AL & MPL

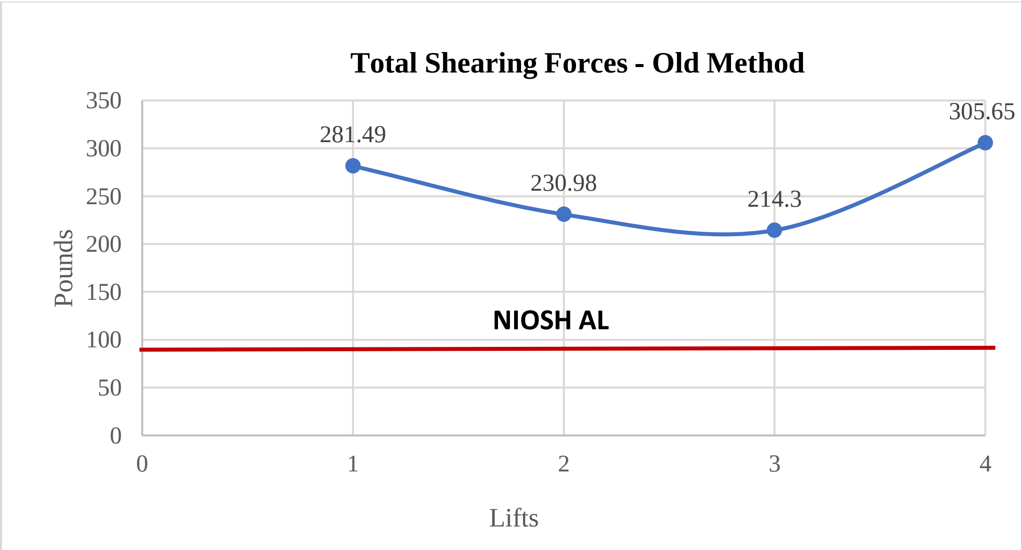

Figure 4. Total shearing forces of L5/S1 compared to AL & MPL

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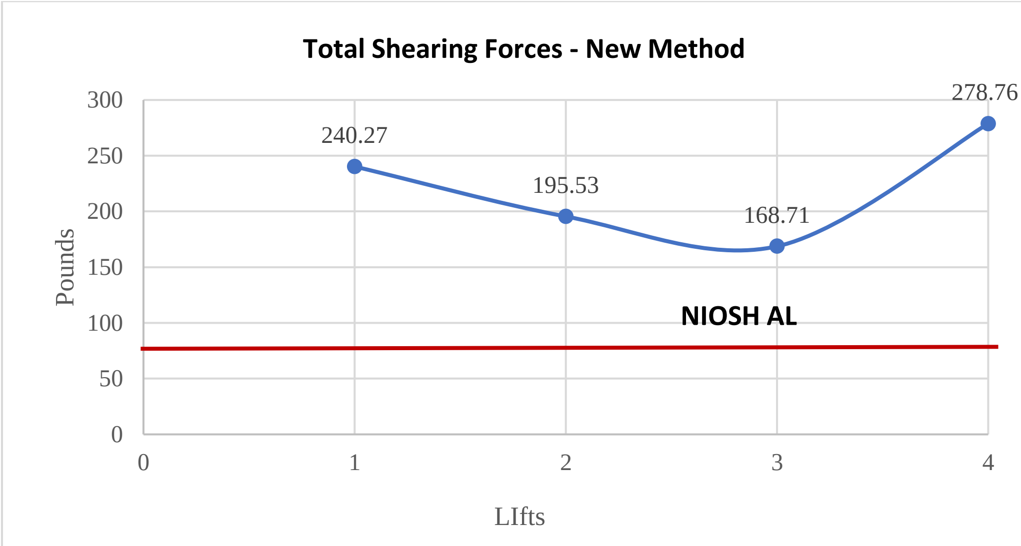

Figure 5. Total shearing forces of L5/S1 compared to AL & MPL

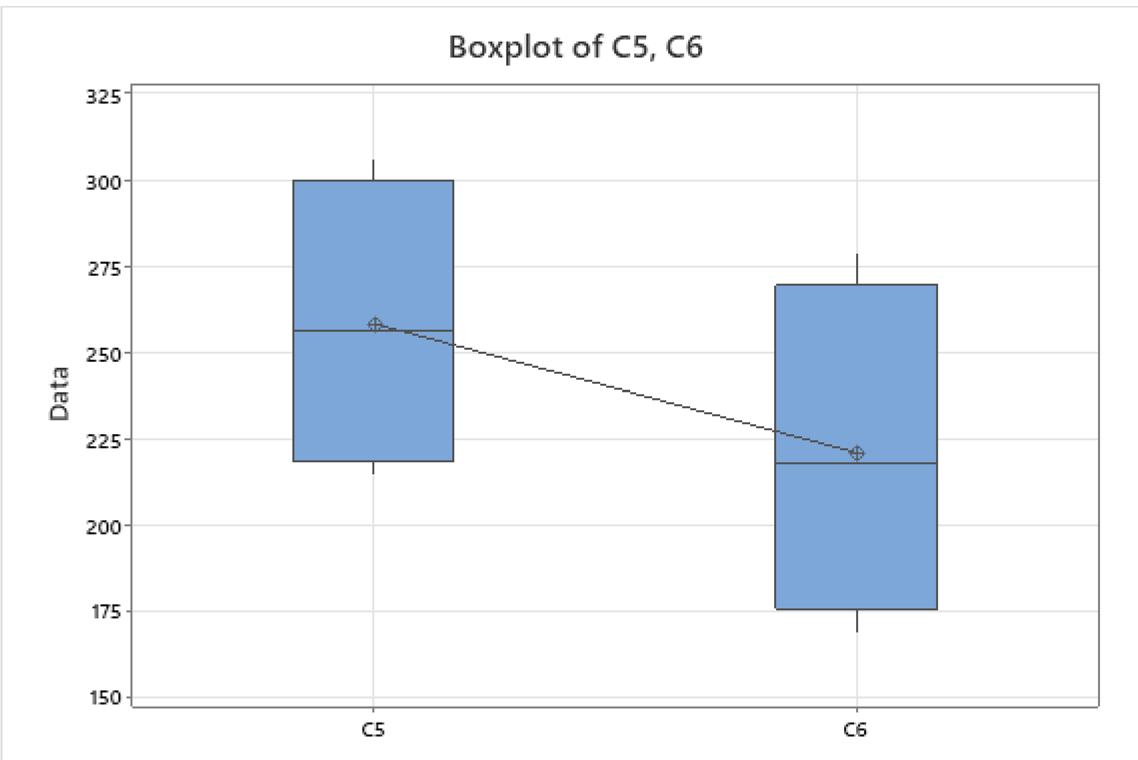

Figure 6. Box plot with significant differences in total shear mean scores and 95% CI for Lift 1 and Lift 2

4. DISCUSSION

The study aimed to investigate the degree of spinal compression experienced by workers while lifting materials of the same weights from ground level to measure and evaluate whether an alternative lifting method could reduce spinal strain. The findings suggest that the Powerlift™ technique does offer a significant reduction (p-value < 0.05) for total spinal compression and shear forces in the lower back compared to the traditional approach to lifting. Our pilot study offers valuable insights into the

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potential impact of lifting techniques on lower-back stresses. Prior research has found variations in compressive forces based on lifting techniques (Faber et al., 2009; von Arx et al, 2021; Washmut, McAfee and Bickel, 2022). Faber and colleagues (2021) found reduction in compressive forces using the straddle lift, which is similar to Powerlift™, compared to both stoop and squat lift methods.

The results of the current pilot study demonstrated substantial forces in the low back when lifting a 35 lbs crate. Total compressive forces associated with the commonly taught squat lift ranged from 876 lbs/in2 to 1212 lbs/in2, all above the NIOSH AL. Gilkey et al. (2010) examined several lifting tasks using Ergomaster™ seen on construction sites and found forces ranging from 649.0 lbs/in2 to 1,938.4 lbs/in2. The investigative team looked at 10 job tasks commonly performed on residential construction sites, five easy and 5 hard. The five low stress tasks were associated with bending forward without lifting to lifting small items only. Low back compression for easy tasks did not exceed 805.1 lbs/in2. The five hard tasks involved lifting objects ranging from a few lbs. to 150 lbs and generated maximum compression values exceeding the NIOSH MPL (Gilkey et al., 2010). Faber and colleagues (2021) evaluated four different lifting techniques with loads ranging from 10 to 20 kgs. Researchers found compressive loads below the NIOSH MPL with loads of 20 kgs regardless of lifting technique.

The old squat-style lift reveals compressive forces above the NIOSL AL which suggest risk is present even when lifting a weight thought to be safe (Waters, 2007). The new lift style decreases compressive forces by an average of 173.97 lbs/in2. Biomechanical advantages are associated with the newer lifting technique, commonly known as Powerlift™. Although the compressive forces at the L5-S1 segment still exceeded the recommended action limit in some cases, the new method showcased notable improvements in multiple measures of low back stress compared to the conventional lifting approach. The reduced total compressive force, shearing forces, joint reactive force, and erector spinae force suggest the potential benefits of adopting the Powerlift™ technique may help to mitigate the risk of back injuries among material handlers.

However, it is essential to note that while the new lifting method showed improvements in most biomechanical measures, some subjects still exceeded the NIOSH AL. We advocate for individualized training and the implementation of the Powerlift™ whenever possible. The variations among subjects emphasize the importance of personalized ergonomic interventions and training tailored to individual characteristics and capabilities.

The study’s findings align with existing literature that emphasizes the association between MMH and the prevalence of low-back injury and resulting LBP. The identified risk factors, including poor lifting techniques, inadequate ergonomic designs, and suboptimal working postures, corroborate previous research highlighting the multifactorial nature of musculoskeletal disorders in occupational settings. Moreover, the study's focus on assessing the effectiveness of alternative lifting methods contributes to the ongoing discourse on the inadequacy of conventional training approaches in preventing back injuries.

5. LIMITATIONS

This pilot study has several limitations. The sample size is small and a larger sample would yield more robust findings. Loads must be smaller to allow straddling and thus the technique may not work for larger containers and awkwardly shaped loads. The Ergomaster™ software requires the accurate identity of specific landmarks to determine biomechanical angles, vectors and load moments. It is possible that minor errors may have been made in the marking exact locations of each body part. Errors

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could have a differential effect that could push findings either toward or away from the null. Inferences associated with this pilot study should be made with caution.

6. CONCLUSION

In conclusion, the investigation sheds light on the significant impact of different lifting techniques on spinal compression during MMH tasks. The study supports the potential efficacy of the Poweflift™ technique in reducing biomechanical stress on the lower back compared to traditional lifting methods. However, while the newer technique displayed promising improvements, it did not universally reduce stresses below recommended safety limits (NIOSH AL) for spinal compression in all subjects. We recommend additional research will a large sample size.

None the less this team advocates for a new approach to MMH, ergonomic interventions that reduce and/or eliminate low back stresses coupled with effective training programs tailored to individual capacities and limitations (Comeau, Gonella and Lauzier, 2020). We also advocate incorporating the Powerlift™ methods for MMH. Incorporating advanced training methodologies that actively engage employees, such as behavioral-based techniques could enhance safe work practices, reduce stresses and prevent back injuries among material handlers.

Further research should explore engineering and personalized ergonomic solutions, considering factors like body morphology, strength, and work environment variability. Engineering is optimal but not universally available or applicable to all MMH tasks in all industries. Additionally, investigating the long-term effects and sustainability of implementing alternative lifting methods in diverse occupational settings will provide valuable insights into developing comprehensive strategies to safeguard MMH personnel from potential injuries and discomfort.

The findings underscore the need for continuous improvement in ergonomic practices, lifting techniques, and training protocols to address the persistent challenge of occupational LBP among manual material handlers. Ultimately, prioritizing worker safety and health through evidence-based interventions remains crucial in minimizing the burden of musculoskeletal disorders in the workplace.

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DECLARATIONS

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Author's Contributions

Nick Kruzich was the student who conceived the project and worked in all phases of the study and manuscript preparation. Presented his work and graduated and now is recognized as a Graduate Safety Professional (GSP) and practicing Occupational Safety and Health. Dr. Gilkey was the Major Advisor who worked with Mr. Kruzich through all phases of the project.

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APPENDIX

2-D Static Lift *Montana Technological University*

Subject: 1
Age: 44
Sex: Male
Height: 69”
Weight: 200 lbs.
Task: Lift 1
Load: 35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	8 in
Forearm:	14 in
Upper Arm:	10 in
Trunk:	15 in
Thigh:	15 in
Lower Leg:	14 in

Biomechanical Angles:

Neck:	58°
Forearm:	57°
Upper Arm:	82°
Trunk:	29°
Thigh:	40°
Leg:	63°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	21.8 in
Biomechanical Angle of Trunk:	29°
Total Compressive Forces:	**1076.61 lb > AL***
Total Shearing Forces:	281.49 lb
Total Torque or Bending Moment:	165.37 ft-lb
Total Joint Reactive Force:	1358.10 lb
Erector Spinae Force:	1008.16 lb
Compressive Force due to Load:	17.00 lb
Compressive Force due to UBW:	61.26 lb
Compressive Force - Erector Spinae:	998.35 lb
Shearing Force due to Load:	30.67 lb
Shearing Force due to UBW:	110.51 lb
Shearing Force - Erector Spinae:	140.31 lb

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2-D Static Lift *Montana Technological University*

Subject:	1
Age:	44
Sex:	Male
Height:	69”
Weight:	200 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	7 in
Forearm:	14 in
Upper Arm:	12 in
Trunk:	16 in
Thigh:	14 in
Lower Leg:	17 in

Biomechanical Angles:

Neck:	55°
Forearm:	71°
Upper Arm:	84°
Trunk:	39°
Thigh:	47°
Leg:	70°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	15.4 in
Biomechanical Angle of Trunk:	39°

Total Compressive Forces:	**918.62 lb > AL***
Total Shearing Forces:	240.27 lb
Total Torque or Bending Moment:	135.34 ft-lb
Total Joint Reactive Force:	1158.89 lb
Erector Spinae Force:	825.06 lb
Compressive Force due to Load:	22.07 lb
Compressive Force due to UBW:	79.51 lb
Compressive Force - Erector Spinae:	817.04 lb
Shearing Force due to Load:	27.26 lb
Shearing Force due to UBW:	98.19 lb
Shearing Force - Erector Spinae:	114.83 lb

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2-D Static Lift *Montana Technological University*

Subject:	2
Age:	18
Sex:	Male
Height:	72”
Weight:	135 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	8 in
Forearm:	16 in
Upper Arm:	15 in
Trunk:	18 in
Thigh:	19 in
Lower Leg:	17 in

Biomechanical Angles:

Neck:	67°
Forearm:	55°
Upper Arm:	86°
Trunk:	26°
Thigh:	40°
Leg:	70°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	24.4 in
Biomechanical Angle of Trunk:	26°

Total Compressive Forces:	**927.04 lb > AL***
Total Shearing Forces:	230.98 lb
Total Torque or Bending Moment:	144.83 ft-lb
Total Joint Reactive Force:	1158.02 lb
Erector Spinae Force:	882.90 lb
Compressive Force due to Load:	15.37 lb
Compressive Force due to UBW:	37.35 lb
Compressive Force - Erector Spinae:	874.31 lb
Shearing Force due to Load:	31.52 lb
Shearing Force due to UBW:	76.58 lb
Shearing Force - Erector Spinae:	122.88 lb

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2-D Static Lift *Montana Technological University*

Subject:	2	
Age:	18	
Sex:	Male	
Height:	72”	
Weight:	135 lbs.	
Task:	Lift 1	
Load:	35 lbs.	

Notes:

Anthropometry:		**Biomechanical Angles:**	
Shoulder-Ear:	6 in	Neck:	54°
Forearm:	13 in	Forearm:	76°
Upper Arm:	13 in	Upper Arm:	73°
Trunk:	18 in	Trunk:	33°
Thigh:	16 in	Thigh:	39°
Lower Leg:	18 in	Leg:	71°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	14.7 in
Biomechanical Angle of Trunk:	33°

Total Compressive Forces:	**738.99 lb**
Total Shearing Forces:	195.53 lb
Total Torque or Bending Moment:	111.56 ft-lb
Total Joint Reactive Force:	934.52 lb
Erector Spinae Force:	680.10 lb
Compressive Force due to Load:	19.10 lb
Compressive Force due to UBW:	46.41 lb
Compressive Force - Erector Spinae:	673.48 lb
Shearing Force due to Load:	29.41 lb
Shearing Force due to UBW:	71.46 lb
Shearing Force - Erector Spinae:	94.65 lb

2-D Static Lift *Montana Technological University*

Subject:	3
Age:	18
Sex:	Female
Height:	68”
Weight:	140 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	7 in
Forearm:	15 in
Upper Arm:	11 in
Trunk:	16 in
Thigh:	17 in
Lower Leg:	16 in

Biomechanical Angles:

Neck:	54°
Forearm:	58°
Upper Arm:	82°
Trunk:	35°
Thigh:	29°
Leg:	59°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	23.2 in
Biomechanical Angle of Trunk:	35°

Total Compressive Forces:	**876.25 lb > AL***
Total Shearing Forces:	214.30 lb
Total Torque or Bending Moment:	133.42 ft-lb
Total Joint Reactive Force:	1090.55 lb
Erector Spinae Force:	813.37 lb
Compressive Force due to Load:	20.12 lb
Compressive Force due to UBW:	50.68 lb
Compressive Force - Erector Spinae:	805.45 lb
Shearing Force due to Load:	28.73 lb
Shearing Force due to UBW:	72.38 lb
Shearing Force - Erector Spinae:	113.20 lb

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2-D Static Lift ***Montana Technological University***

Subject:	3
Age:	18
Sex:	Female
Height:	68”
Weight:	140 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	6 in
Forearm:	13 in
Upper Arm:	12 in
Trunk:	16 in
Thigh:	15 in
Lower Leg:	17 in

Biomechanical Angles:

Neck:	58°
Forearm:	74°
Upper Arm:	88°
Trunk:	47°
Thigh:	36°
Leg:	68°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	15.4 in
Biomechanical Angle of Trunk:	47°

Total Compressive Forces:	**691.78 lb**
Total Shearing Forces:	168.71 lb
Total Torque or Bending Moment:	99.64 ft-lb
Total Joint Reactive Force:	860.49 lb
Erector Spinae Force:	607.42 lb
Compressive Force due to Load:	25.65 lb
Compressive Force due to UBW:	64.62 lb
Compressive Force - Erector Spinae:	601.51 lb
Shearing Force due to Load:	23.92 lb
Shearing Force due to UBW:	60.26 lb
Shearing Force - Erector Spinae:	84.54 lb

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2-D Static Lift *Montana Technological University*

Subject:	4
Age:	18
Sex:	Male
Height:	72”
Weight:	210 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:

Shoulder-Ear:	11 in
Forearm:	15 in
Upper Arm:	14 in
Trunk:	21 in
Thigh:	18 in
Lower Leg:	17 in

Biomechanical Angles:

Neck:	79°
Forearm:	62°
Upper Arm:	88°
Trunk:	29°
Thigh:	35°
Leg:	72°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	26.0 in
Biomechanical Angle of Trunk:	29°

Total Compressive Forces:	**1212.35 lb > AL***
Total Shearing Forces:	305.65 lb
Total Torque or Bending Moment:	187.35 ft-lb
Total Joint Reactive Force:	1518.00 lb
Erector Spinae Force:	1142.16 lb
Compressive Force due to Load:	17.00 lb
Compressive Force due to UBW:	64.31 lb
Compressive Force - Erector Spinae:	1131.04 lb
Shearing Force due to Load:	30.67 lb
Shearing Force due to UBW:	116.01 lb
Shearing Force - Erector Spinae:	158.96 lb

2-D Static Lift ***Montana Technological University***

Subject:	4
Age:	18
Sex:	Male
Height:	72”
Weight:	210 lbs.
Task:	Lift 1
Load:	35 lbs.

Notes:

Anthropometry:		**Biomechanical Angles:**	
Shoulder-Ear:	11 in	Neck:	87°
Forearm:	14 in	Forearm:	79°
Upper Arm:	18 in	Upper Arm:	70°
Trunk:	24 in	Trunk:	31°
Thigh:	19 in	Thigh:	44°
Lower Leg:	20 in	Leg:	68°

Biomechanical Predictions about L5/S1:

Horizontal Distance of Load:	17.1 in
Biomechanical Angle of Trunk:	31°

Total Compressive Forces:	**1046.98 lb > AL***
Total Shearing Forces:	278.76 lb
Total Torque or Bending Moment:	159.12 ft-lb
Total Joint Reactive Force:	1325.75 lb
Erector Spinae Force:	970.04 lb
Compressive Force due to Load:	18.06 lb
Compressive Force due to UBW:	68.32 lb
Compressive Force - Erector Spinae:	960.60 lb
Shearing Force due to Load:	30.06 lb
Shearing Force due to UBW:	113.70 lb
Shearing Force - Erector Spinae:	135.00 lb

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GLOSSARY OF TERMS

ACTION LIMIT (AL):

A load weight above which musculoskeletal injury incidence and severity rates increase moderately. It is defined by the following criteria:

- Compressive forces acting on the L5/S1 spinal disc are 3425 N (770 lb) or greater.
- Twenty-five percent of the female workers and one percent of the male workers do not have the muscle strengths to be capable of performing the work.
- Metabolic rates would exceed 3.5 Kcal/minute (when integrated over an eight-hour day).
- Lumbosacral torque equal to or greater than 163 N-m (120 ft-lb) is considered hazardous to all but the healthiest of workers, as proposed by OSHA.

BIOMECHANICS:

The application of mechanics to the living human body.

COMPRESSION:

Occurs when equal and opposite loads are applied toward the surface of the vertebrae.

MAXIMUM PERMISSIBLE LIMIT (MPL):

A load weight at which musculoskeletal injury rates and severity rates have been shown to increase significantly. It is defined by the following criteria:

- Compressive forces acting on the L5/S1 spinal disc are 6361 N (1430 lb) or greater.
- Seventy-five percent of the men and ninety-percent of the women do not have the muscle strengths to be capable of performing the work.
- Metabolic rates in excess of 5.0 Kcal/minute (when integrated over an eight-hour day).

MUSCULOSKELETAL:

Refers to a system that consists of the peripheral parts of the motor system and comprises muscle and the connective tissue elements that form the skeleton.

SHEAR:

Occurs when a force is applied parallel to the surface of the vertebrae.

TORQUE:

or moment of a force, is the product of a force times the perpendicular distance from its line of action to the axis of motion (or potential motion). Force x Distance.

UPPER BODY WEIGHT (UBW):

Represents approximately 65% of the force exerted by the total body weight.

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Subject #1	1	Old Method	New Method	Difference
Male	**Total Compressive Forces (lbs):**	**1076.61**	**918.62**	157.99
69	Total Shearing Forces (lbs):	281.49	240.27	41.22
200	Total Torque or Bending Moment (ft-lb	165.37	135.34	30.03
	Total Joint Reactive Force (lbs):	1358.1	1158.89	199.21
	Erector Spinae Force (lbs):	1008.16	825.06	183.1
	Compressive Force due to Load (lbs)	17	22.07	-5.07
	Compressive Force due to UBW (lbs)	61.26	79.51	-18.25
	Compressive Force - Erector Spinae	998.35	817.04	181.31
	Shearing Force due to Load (lbs):	30.67	27.26	3.41
	Shearing Force due to UBW (lbs):	110.51	98.19	12.32
	Shearing Force - Erector Spinae (lbs)	140.31	114.83	25.48
Subject #2	2			
Male	**Total Compressive Forces (lbs):**	**927.04**	**738.99**	188.05
72	Total Shearing Forces (lbs):	230.98	195.53	35.45
135	Total Torque or Bending Moment (ft-lb	144.83	111.56	33.27
	Total Joint Reactive Force (lbs):	1158.02	934.52	223.5
	Erector Spinae Force (lbs):	882.9	680.1	202.8
	Compressive Force due to Load (lbs)	15.37	19.1	-3.73
	Compressive Force due to UBW (lbs)	37.35	46.41	-9.06
	Compressive Force - Erector Spinae	874.31	673.48	200.83
	Shearing Force due to Load (lbs):	31.52	29.41	2.11
	Shearing Force due to UBW (lbs):	76.58	71.46	5.12
	Shearing Force - Erector Spinae (lbs)	122.88	94.65	28.23
Subject #3	3			
Female	**Total Compressive Forces (lbs):**	**876.25**	**691.78**	184.47
68	Total Shearing Forces (lbs):	214.3	168.71	45.59
140	Total Torque or Bending Moment (ft-lb	133.42	99.64	33.78
	Total Joint Reactive Force (lbs):	1090.55	860.49	230.06
	Erector Spinae Force (lbs):	813.37	607.42	205.95
	Compressive Force due to Load (lbs)	20.12	25.65	-5.53
	Compressive Force due to UBW (lbs)	50.68	64.62	-13.94
	Compressive Force - Erector Spinae	805.45	601.51	203.94
	Shearing Force due to Load (lbs):	28.73	23.92	4.81
	Shearing Force due to UBW (lbs):	72.38	60.26	12.12
	Shearing Force - Erector Spinae (lbs)	113.2	84.54	28.66
Subject #4	4			
Male	**Total Compressive Forces (lbs):**	**1212.35**	**1046.98**	165.37
72	Total Shearing Forces (lbs):	305.65	278.76	26.89
210	Total Torque or Bending Moment (ft-lb	187.35	159.12	28.23
	Total Joint Reactive Force (lbs):	1518	1325.75	192.25
	Erector Spinae Force (lbs):	1142.16	970.04	172.12
	Compressive Force due to Load (lbs)	17	18.06	-1.06
	Compressive Force due to UBW (lbs)	64.31	68.32	-4.00999999999999
	Compressive Force - Erector Spinae	1131.04	960.6	170.44
	Shearing Force due to Load (lbs):	30.67	30.06	0.610000000000003
	Shearing Force due to UBW (lbs):	116.01	113.7	2.31
	Shearing Force - Erector Spinae (lbs)	158.96	135	23.96
Averages	Avg. Total Compressive Forces	**1023.0625**	**849.0925**	173.97
	Avg. Total Shearing Forces:	411.0965	346.4725	64.6239999999999
	Avg. Total Torque or Bending Moment	344.1881667	283.5375	60.6506666666667
	Avg. Total Joint Reactive Force:	986.1453095	1069.9125	-83.7671904761904
	Avg. Erector Spinae Force:	961.6475	703.954375	257.693125
	Avg. Compressive Force due to Load	17.3725	21.22	-3.8475
	Avg. Compressive Force due to UBW	53.4	64.715	-11.315
	Avg. Compressive Force - Erector Sp	952.2875	763.1575	189.13
	Avg. Shearing Force due to Load:	30.3975	27.6625	2.735
	Avg. Shearing Force due to UBW:	93.87	85.9025	7.96750000000002
	Avg. Shearing Force - Erector Spinae	386.3441054	107.255	279.089105442177

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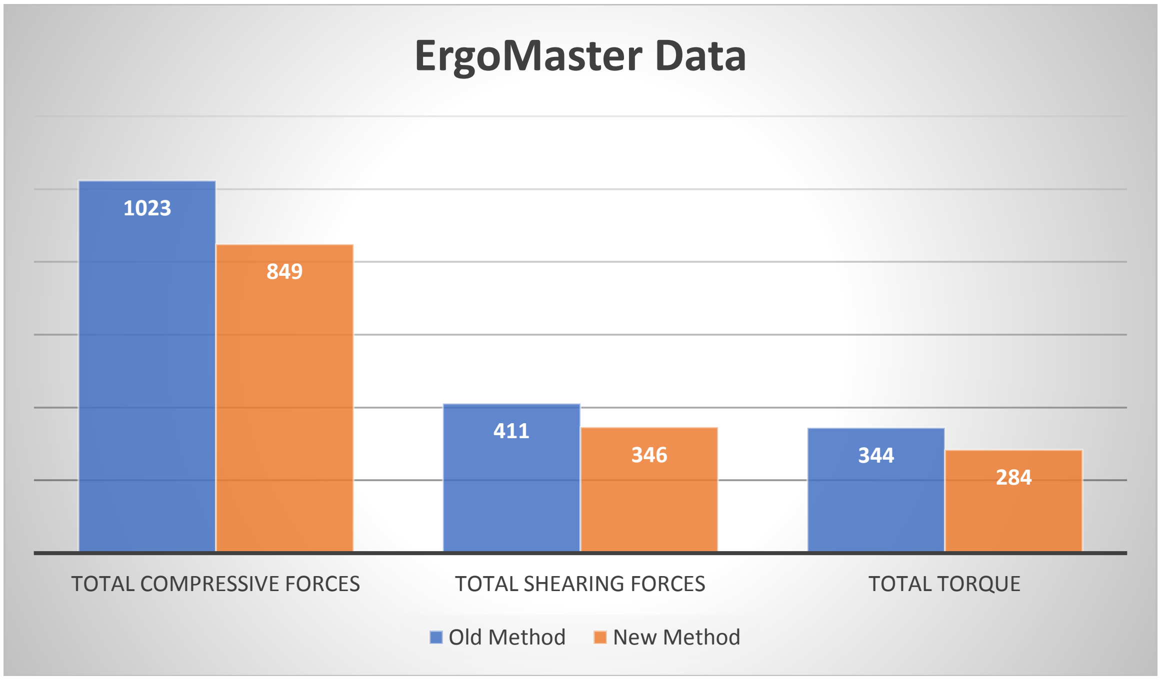
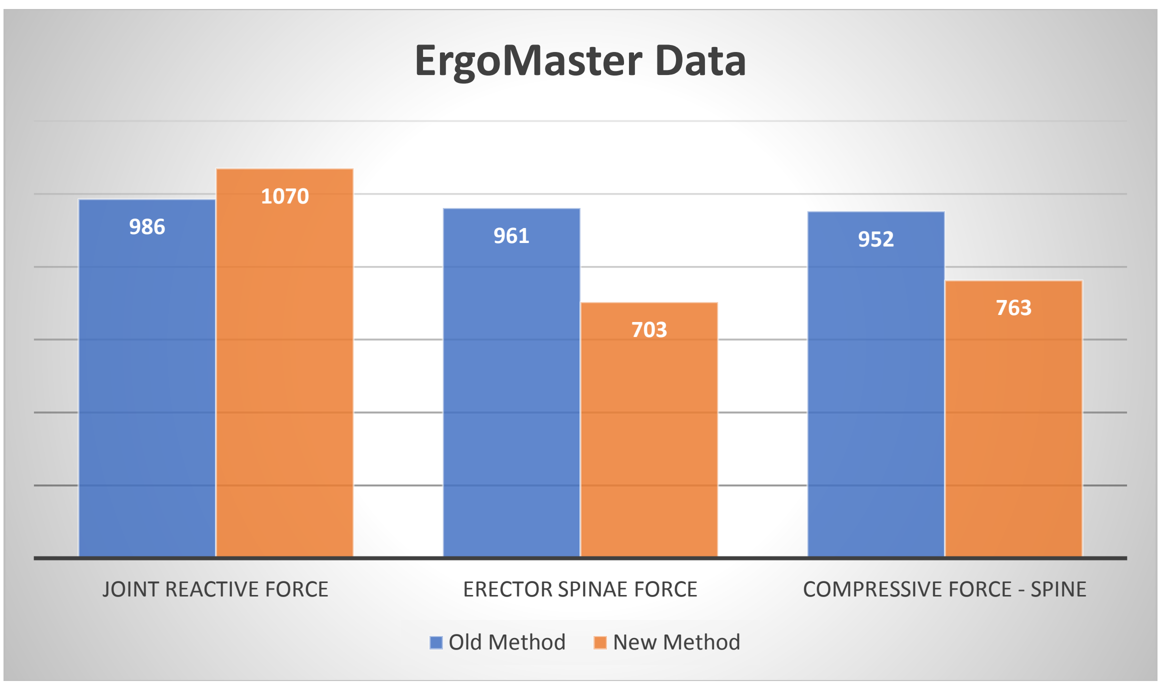
The data from the above table are displayed in the figures below.





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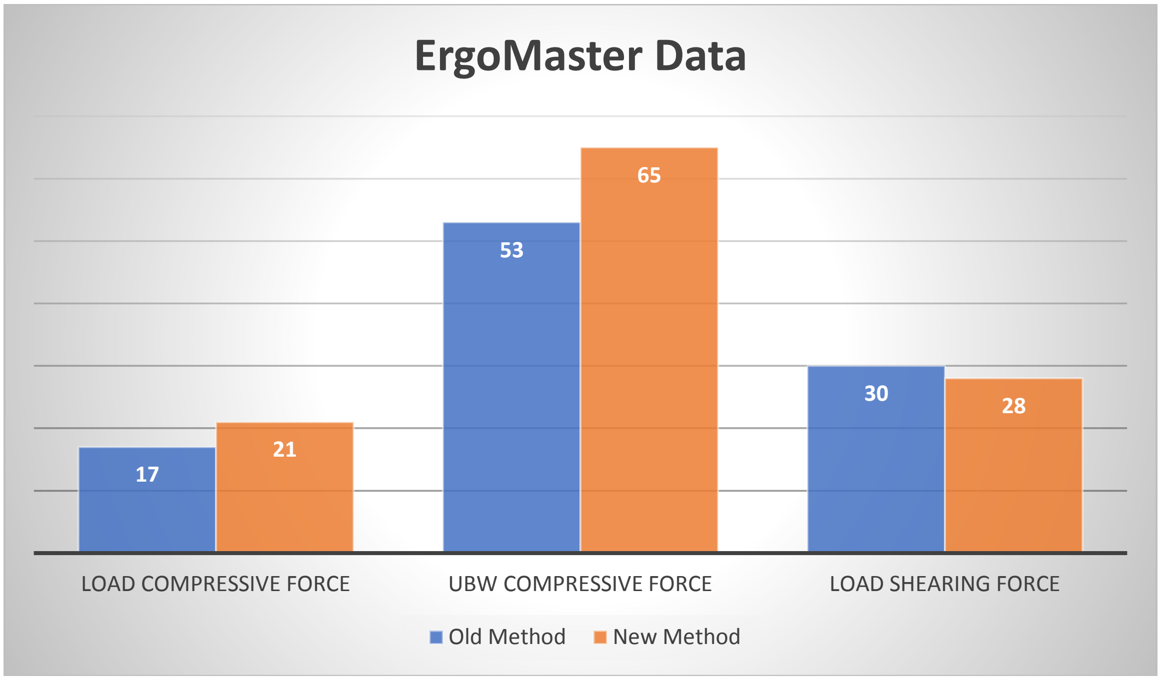

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Nick Kruzich is a driven professional who recently graduated with a Bachelor of Science in Occupational Safety and Health from Montana Technological University. Currently serving as an EHS Engineer for a large Construction Contracting Company, Nick applies his knowledge and expertise to oversee Environmental, Health, and Safety protocols within the company. With a strong foundation in occupational safety principles, Nick works diligently to implement and enforce comprehensive safety measures, contributing significantly to the well-being of employees and the success of ongoing projects. His dedication to promoting a culture of safety underscores his passion for creating workplaces where individuals can thrive without compromising their health and well-being.

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Driving Safely into the Future: Harnessing AI for Enhanced Road/Traffic Safety

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KEYWORDS

Artificial Intelligence (AI)
Road Safety
Intelligent Transportation Systems (ITS)
Advanced Driver Assistance Systems (ADAS)

ABSTRACT

Road safety is a serious concern around the world, with escalating accident and fatality rates. This paper examines the critical role of artificial intelligence (AI) in addressing and mitigating these issues. Beginning with an introduction to the importance of road safety, the paper progresses through current concerns and prevalent causes of accidents, laying the groundwork for the investigation of AI interventions. The paper digs into AI's multidimensional role in improving road safety, focusing on Intelligent Transportation Systems (ITS) for efficient traffic management and advanced driver assistance systems (ADAS) for collision prevention. It delves into AI technologies including computer vision for object and pedestrian recognition, as well as machine learning techniques for predictive analytics and driver behavior monitoring. Despite the exciting promises, the use of AI in road safety faces hurdles such as integration with current infrastructure and ethical concerns about privacy. The report emphasizes the importance of cautious thinking while using new technologies, while also recognizing their potential benefits. In conclusion, this paper provides a detailed assessment of the current state of road safety, the revolutionary role of AI, and the obstacles and potential connected with its application. It promotes ongoing research and development to spur innovation and contribute to a safer driving environment.

1. INTRODUCTION

The modern world is defined by rapid technological breakthroughs and an increasing emphasis on Road safety is a top priority in today's society, with an urgent need to address the rising rates of accidents and fatalities on our roadways. As we traverse an ever-changing transportation sector, the integration of cutting-edge technologies becomes critical to improving safety measures. This introduction lays the groundwork for a thorough examination of how artificial intelligence (AI) might revolutionize and strengthen our approach to road safety.

With grim statistics and a thorough grasp of the major causes of road accidents, it is clear that old tactics may no longer be sufficient. The arrival of AI ushers in a new era with unique solutions that go beyond the customary scope. This paper attempts to unravel the dense web of issues inherent in road

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safety, proposing AI as a critical tool for not just alleviating these challenges, but also fundamentally altering our understanding and management of road-related dangers.

In the following, we will look at the multifarious functions of AI in road safety, including Intelligent Transportation Systems (ITS) geared to optimize traffic flow and Advanced Driver Assistance Systems (ADAS) aimed at preventing collisions. The goal is to reveal the intricate tapestry of AI technologies such as computer vision and machine learning algorithms, which are poised to revolutionize how we detect, assess, and respond to possible roadside risks. As we explore these technical frontiers, it becomes clear that the combination of AI and road safety has the potential to usher in a new era of safer, smarter, and more efficient transportation systems.

2. OBJECTIVES

The major goal of this paper is to deconstruct the present issues facing road safety and identify the critical role that artificial intelligence (AI) plays in translating these challenges into opportunities for progress. This paper attempts to establish the groundwork for understanding the urgency and relevance of incorporating modern technologies to address the complexities of contemporary road safety challenges by conducting a deep examination of statistics and prevalent causes of accidents.

Building on this core understanding, the paper aims to highlight the specific ways in which AI might help improve road safety. Key aims include examining the use of Intelligent Transportation Systems (ITS) for traffic management optimization and Advanced Driver Assistance Systems (ADAS) for collision prevention. The emphasis will be on presenting a complete overview of how AI technologies, such as computer vision and machine learning algorithms, can be used to develop proactive and preventive methods for reducing road-related dangers.

Furthermore, the paper aims to identify and investigate the problems involved with applying AI solutions in the context of road safety. The objectives include a comprehensive evaluation of integration challenges with existing infrastructure, as well as a detailed investigation of privacy concerns and ethical factors. By addressing these issues, the paper hopes to provide useful insights into the appropriate and effective deployment of AI technology in the pursuit of safer road environments.

In addition to exploring obstacles, the paper aims to present real-world case studies of effective AI applications for increasing road safety. The paper intends to highlight the practical efficacy of AI interventions by providing concrete instances of positive outcomes and promoting trust in their ability to minimize accidents and save lives.

Finally, this paper attempts to present a forward-looking perspective by highlighting new AI technologies with the potential to further improve road safety. The goal is to support ongoing research and development, opening the way for a shift in our approach to road safety that incorporates intelligent and adaptive AI solutions.

3. CURRENT CHALLENGES IN ROAD SAFETY

The landscape of road safety is characterized by serious issues that necessitate concentrated attention and inventive solutions. One of the most pressing concerns is the frightening increase in traffic accidents and fatalities, particularly in developing countries. Statistics present a harsh picture, highlighting the scope of the problem and underscoring the need for effective remedies. The current

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trend highlights the crucial need for comprehensive policies to reduce the growing toll on human lives and infrastructure.

A closer look at the most common causes of traffic accidents reveals a complicated interaction of elements. Distracted driving, speeding, drunk driving, and noncompliance with traffic laws all contribute to the sad numbers. Understanding the underlying reasons is critical for developing focused treatments to address the root causes of road safety issues. As we go through these difficulties, it becomes clear that a holistic approach is required to effect meaningful change and promote a safer driving environment.

Furthermore, the dynamic character of transportation systems, along with the rapid increase in vehicle numbers, complicates road safety concerns. Urbanization, shifting demographics, and developments in vehicle technology all contribute to the complexity of managing and mitigating road dangers. Navigating these complexities necessitates a detailed grasp of the changing dynamics of modern traffic conditions, as well as a planned approach to implementing successful remedies.

In essence, the current issues in road safety necessitate a comprehensive and flexible solution. Recognizing the interwoven nature of variables contributing to accidents and fatalities allows stakeholders to pave the way for holistic solutions that emphasize safety, embrace technological breakthroughs, and align with the changing demands of modern transportation systems.

4. THE ROLE OF AI IN ROAD SAFETY

The importance of artificial intelligence (AI) in road safety is critical, representing a paradigm shift in how we approach and manage transportation issues. Intelligent Transportation Systems (ITS) use AI to optimize traffic management. These technologies allow for dynamic modifications to traffic flow, reducing congestion and the chance of accidents.

Advanced Driver Assistance Systems (ADAS) are another key component of AI's role in road safety. These systems use advanced sensors, cameras, and machine-learning algorithms to improve driver awareness and avoid collisions. Collision avoidance systems and lane departure warnings are proactive methods that provide drivers with real-time support while also limiting potential road concerns.

Computer vision, a key component of AI, plays an important role in improving road safety. Computer vision technologies help vehicles "see" and comprehend their surroundings, which leads to better object detection and recognition. This includes spotting pedestrians, other cars, and potential hazards, which gives vehicles a higher level of situational awareness and response.

Machine learning methods enhance AI's impact on road safety by enabling adaptive and predictive capabilities. These algorithms use massive amounts of information to find trends, predict potential threats, and make split-second judgments. Machine learning helps to create a more proactive and intelligent road safety ecosystem by predicting other drivers' behaviors and identifying high-risk regions.

In summary, the function of AI in road safety is more than just automation; it represents a paradigm in which technology becomes a vigilant ally in averting accidents and saving lives. The integration of these AI-powered technologies has the potential to reshape the dynamics of road safety, ushering in an era in which smart, responsive systems collaborate to create safer and more efficient transportation networks.

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5. AI TECHNOLOGIES FOR ROAD SAFETY

AI technologies play a critical role in redefining the landscape of road safety, providing new solutions to the multiple difficulties that modern transportation systems face. One of the key technological foundations is computer vision, which transforms how vehicles perceive their surroundings. Computer vision's object detection and recognition capabilities enable vehicles to identify pedestrians, obstructions, and other vehicles in real time, improving situational awareness and enabling quick responses to possible risks.

Machine learning algorithms, another key component of AI, are critical in predictive analytics for road safety. These systems can detect patterns, forecast driving behavior, and anticipate potential problems by analyzing large datasets. This proactive strategy enables advanced warning systems and adaptive measures to avoid accidents before they happen.

Within the field of AI technologies, computer vision and machine learning are used to detect pedestrians, which is an important part of road safety. These technologies help to design systems that can properly detect and monitor pedestrians, lowering the chance of collisions and improving overall safety for vehicles and pedestrians alike.

AI technology also makes it easier to implement Advanced Driver Assistance Systems (ADAS), which include features such as lane departure warning systems. These systems use AI algorithms to monitor a vehicle's position on the road, sending drivers timely alerts when unintended lane deviations are detected. Such actions help to reduce the risk of accidents caused by straying out of defined lanes.

In conclusion, AI technologies, such as computer vision and machine learning algorithms, are critical to transforming road safety. These technologies help vehicles see and understand their environment intelligently, resulting in a more responsive, adaptive, and ultimately safer transportation ecology. Their integration has the potential to drastically reduce accidents and improve overall road safety outcomes.

6. IMPLEMENTATION CHALLENGES

The application of artificial intelligence (AI) to road safety is not without its limitations, creating a complicated picture that necessitates careful study. One major problem is the smooth integration of AI technologies into current infrastructure. The integration of intelligent systems necessitates a harmonious collaboration with traditional traffic management and communication systems, which presents logistical and compatibility issues that must be overcome to enable a smooth transition and effective operation.

Privacy problems have emerged as a major aspect of the implementation challenges related to AI in road safety. The implementation of technology such as Intelligent Transportation Systems (ITS) and Advanced Driver Assistance Systems (ADAS) requires the collection and processing of massive amounts of data, creating concerns about individuals' privacy rights on the road. Striking a balance between using data to improve safety and protecting individual privacy necessitates strong legislation and ethical frameworks that guide responsible AI adoption.

Furthermore, the ethical problems surrounding AI in road safety go beyond privacy to include broader societal implications. Questions of accountability, decision-making algorithms, and potential biases in AI systems are critical. Addressing these ethical concerns requires a transparent and inclusive strategy that includes stakeholders from multiple domains to ensure that AI interventions promote fairness, equity, and safety for all road users.

The complexity of these implementation issues emphasizes the importance of collaboration among politicians, technological developers, and the public. Clear norms, standards, and laws can help negotiate the complex landscape of AI integration in road safety, creating a framework that combines technological progress with ethical issues. Finally, overcoming these problems is critical to fulfilling AI's full promise in improving road safety while upholding core principles of privacy, ethics, and social well-being.

7. CASE STUDIES

Examining real-world case studies gives tangible evidence of AI's impact on enhancing road safety, as well as insights into successful implementation and outcomes. One notable example is the city of Singapore, which has built an Intelligent Transportation System (ITS) powered by AI to efficiently control traffic flow. The system uses real-time data from numerous sources, such as cameras and sensors, to dynamically change traffic signals and optimize the entire transportation network. This has resulted in a significant reduction in traffic congestion, as well as a decreased likelihood of accidents.

Another compelling case study comes from the car industry, where Advanced Driver Assistance Systems (ADAS) have been extremely successful. Vehicles fitted with AI-driven collision avoidance systems and adaptive cruise control have demonstrated a significant reduction in accidents caused by human error. The incorporation of AI technology has proven useful in giving timely warnings and interventions, resulting in a safer driving experience.

In Pittsburgh, Pennsylvania, an AI-based experimental study aimed at pedestrian identification has yielded excellent results. Computer vision techniques are used to identify and monitor pedestrians in real time, especially at crosswalks. This system has improved pedestrian safety by warning vehicles of possible risks, resulting in fewer incidents involving walkers at designated crossings.

These case studies demonstrate AI's transformative impact in a variety of contexts, emphasizing its effectiveness in addressing road safety concerns. These examples, ranging from optimizing traffic management in urban settings to averting collisions with enhanced driver assistance and increasing pedestrian safety with computer vision, highlight the practical benefits that AI technology can bring to the forefront of road safety initiatives.

8. FUTURE OUTLOOK

The future of AI in road safety looks quite promising, as technological developments pave the door for even more imaginative solutions to solve the complexities of modern transportation networks. One prominent trajectory is the continuous advancement of Intelligent Transportation Systems (ITS), in which artificial intelligence will play a critical role in developing dynamic, self-adjusting traffic control systems. These systems will optimize traffic flow while also anticipating and responding to changing road conditions, reducing congestion, and improving overall safety.

As we look ahead, the integration of AI technology in vehicles is projected to become more widespread, with an emphasis on reaching increasing levels of autonomy. This includes creating autonomous vehicles that use AI for navigation, collision avoidance, and real-time decision-making.

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The future may see a gradual transition to a transportation ecosystem in which AI systems function together smoothly, resulting in safer and more efficient road networks.

Emerging technologies, like 5G connectivity, have the potential to significantly improve AI's skills in road safety. The effectiveness of AI-driven applications will increase thanks to the high-speed, low-latency connection that 5G networks provide for real-time data exchange between vehicles, infrastructure, and central systems. This link has the potential to result in a more coordinated and responsive transportation network.

Furthermore, the continuous improvement of computer vision and machine learning algorithms will lead to more advanced hazard identification and response methods. AI's ability to interpret complicated events, such as predicting and reacting to human behavior on the road, will continue to improve, providing a more complete approach to accident avoidance.

A promising trajectory toward a safer, more integrated, and technologically advanced transportation sector characterizes the future of AI in road safety. As these technologies mature and integrate into our daily lives, they have the potential to drastically reduce accidents, save lives, and fundamentally change how we approach road safety on a worldwide scale.

9. COSTS ASSOCIATED WITH AI IMPLEMENTATION

The incorporation of artificial intelligence (AI) into road safety programs raises not just transformative potential but also concerns about accompanying expenses. One major cost factor is the expenditure necessary for the development and implementation of advanced AI technologies such as Intelligent Transportation Systems (ITS) and Advanced Driver Assistance Systems (ADAS). Developing advanced algorithms, sensing technologies, and communication infrastructure requires large financial resources, especially in the early stages of implementation.

Ongoing maintenance and updates are another expense dimension. As AI technology advance, regular upgrades and maintenance are required to assure peak performance and resolve any vulnerabilities. This aspect of continual development introduces a recurring cost component, necessitating ongoing financial commitments from relevant stakeholders to keep AI-driven road safety systems current and effective.

Furthermore, the training and education of staff responsible for managing and controlling AI-integrated systems adds to the overall expenditures. Skilled personnel are required for the effective deployment and operation of these technologies. Training programs, knowledge transfer, and skill development activities are critical for ensuring that the human component of AI deployment is adequately prepared to handle the complexities of these advanced systems.

On the other hand, while there are large initial and recurring expenditures, supporters claim that the long-term advantages in terms of lives saved, reduced accident-related expenses, and overall increased road safety can offset the financial investments. Nonetheless, striking a balance between the initial costs of implementing AI in road safety and the potential long-term benefits necessitates careful consideration and strategic planning to ensure that these technologies are effectively and sustainably integrated into existing transportation infrastructures.

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10. CONCLUSION

Finally, incorporating artificial intelligence (AI) into road safety measures represents a watershed moment in the transition to a safer, more adaptable, and technologically empowered transportation sector. The examination of current issues highlighted the need for novel solutions, paving the way for AI to play a revolutionary role. AI technologies demonstrated their effectiveness in solving the numerous facets of road safety concerns, ranging from Intelligent Transportation Systems (ITS) that optimize traffic flow to Advanced Driver Assistance Systems (ADAS) that avoid collisions.

While the potential benefits are significant, the use of AI in road safety is not without challenges. Overcoming integration issues with current infrastructure, privacy concerns, and ethical considerations is critical for responsible deployment. Real-world case studies show that AI interventions are effective at reducing accidents and improving overall safety, providing tangible evidence of their effects.

Looking ahead, the future of AI in road safety has many interesting possibilities. The ongoing evolution of ITS, advancements in self-driving vehicles, and the incorporation of 5G connections promise a more synchronized, responsive, and efficient transportation system. As computer vision and machine learning algorithms progress, the possibility of more sophisticated hazard detection and prediction skills increases, raising the hope of lowering road accidents on a worldwide scale.

In summary, the combination of AI with road safety programs has the potential to save lives, reduce accidents, and radically change the way we approach transportation. As we move toward this future, it is critical that we continue to foster collaboration among policymakers, technologists, and the public to ensure that AI integration adheres to ethical principles, protects privacy, and ultimately contributes to a safer and more resilient road infrastructure for future generations.

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World Safety Organization
Code of Ethics

Members of the WSO,
by virtue of their acceptance of membership
into the WSO,
are bound to the following Code of Ethics
regarding their activities associated with the WSO:

Members must be responsible for ethical and professional conduct in relationships with clients, employers, associates, and the public.

Members must be responsible for professional competence in performance of all their professional activities.

Members must be responsible for the protection of professional interest, reputation, and good name of any deserving WSO member or member of other professional organization involved in safety or associate disciplines.

Members must be dedicated to professional development of new members in the safety profession and associated disciplines.

Members must be responsible for their complete sincerity in professional service to the world.

Members must be responsible for continuing improvement and development of professional competencies in safety and associated disciplines.

Members must be responsible for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

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