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WSJ Editor

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Slips, Trips, and Falls: A Call to Duty

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Abstract

Slips, trips, and falls are a problem globally. Safety and health professionals must work diligently to protect workers and the public from injury. Property owners and/or occupants have a duty to mitigate hazards and reduce or eliminate risks of injury to visitors, customers, or travelers. Older workers and citizens are at greatest risk. Many types of hazards and conditions have been identified that increase the chances of pedestrian slip, trip and fall injuries. Common indoor hazards include slippery floors due to wax, water, tracked in snow and/or ice, spills, loose carpets or mats, uneven flooring, transition areas, raised edges, worn flooring, or items left on the floor such a cords, tools, equipment, unused material or waste. In the outdoor environment, and in cold climates snow and ice, are the major hazards associated with slips, trips, and falls and should be addressed immediately. Additional outdoor hazards are uneven surfaces, objects, potholes, mud, water, and debris from natural sources or human activity. Preventing slips, trips, and falls can be as simple as evaluating the hazards, determining risks, identifying controls, implementing controls and prevention strategies, and evaluating effectiveness to reduce the burden of slip, trip, and fall injuries and fatalities.

Key Words: Slips. Falls. Injuries. Prevention. Duty to protect.

Introduction and Scope of Work

Slips, trips and falls are a ubiquitous problem throughout the world (Chang, Leclercq, Lockhart and Haslam, 2016; Gao, 2004; Kwan, Close, Wong and Lord, 2011) and a challenge to control for property owners, occupants, public agencies, and safety and health professionals. Fall related fatalities 2012 -2018 caused 32,000 deaths in the United States of America (US) and cost an estimated $50 billion (Moreland, Kakara and Henry, 2020). Fall related injuries may be mild, moderate or severe (Clarke, Yan, Keusch and Gallagher, 2015; Kwan, Close, Wong and Lord, 2011; Yoon and Lockhart, 2006) and/or be a major cause of fatalities for some industries such as in construction (OSHA, 2020). Brady (2015) reported that 54% of slips, trips and falls were due to human factors, 25% due to wet or slippery surfaces, and 16% due to housekeeping issues. Experts estimated that 55% of all slips, trips, and falls occurred on slippery walking surfaces and 25% associated with footwear (Troyer, 2012). Slip, trip and fall hazards are numerous and should be a priority to control when recognized in any environment where people visit, work, or travel across (Di Pilla, 2010; SAIF Corporation, 2016; Workplace Health and Safety Queensland, 2016).

Property owners, occupants, employers, visitors, public agencies, and safety and health professionals are all stakeholders in the health and well-being of workers and the public and thus have a duty to mitigate hazards when recognized (Maynard, Di Pilla, Natalizia and Vidal, 2012). In the US, the law requires that employers maintain a safe and healthy workplace free of recognized hazards (NIOSH, 2012; OSHA, 2020). Property owners and/or occupants have a duty to mitigate hazards that could cause injury to visitors, customers, or travelers (AmTrust, 2020; Eagle Mat, 2019; Minetz, 1981). The scope of this work places emphasis on slips, trips and falls at the same level and provides information from select sources that reflect opinions, practices and models from around the world. The goal of this paper was to inform the reader and increase awareness of the magnitude of the problem and available protection and prevention strategies.

Definitions

Slips occur when the individual loses traction with the travel surface due to many possible factors that cause the surface to become slippery (Safe Work Australia, 2012; Brady, 2015; Chang, Leclercq, Lockhart and Haslam, 2016; Gao, 2004; Gao and Abeysekera, 2004; Hanson, Redfern and Mazumdar, 2010; ISO Services, 2010). Friction is necessary between the shoe and floor to maintain walking stability. The amount of friction is important and measured as a coefficient of friction (COF) or slipperiness. A COF greater than 0.40 offers a safety factor (Kim, Hsiao and Simeonov, 2013; Maynard, Di Pilla, Natalizia and Vidal, 2012). Loss of traction usually occurs during the forward phase of walking, when the heel-strike contacts the surface and slips; whereas the toe-off phase of walking may also slip during the forward stride thrust and the rear foot slips causing a backward event (Abeysekera and Gao, 2001; Gard and Lundborg, 2000; Hanson, Redfern and Mazumdar, 2010). Many substances may alter friction between the person's feet and the walking surface causing increased slipperiness such as the highly polished floor, spilled grease, oil, water, tracked in snow, ice and/or many other possible substances (Safe Work Australia, 2012; Brady, 2015; Di Pilla, 2010; NIOSH, 2012). Common outdoor weather related hazards that increase slipperiness include water, snow, and ice as well as other possible agents (Di Pilla, 2010; Zurich Service Corporation, 2011).

Trips occur when a person unexpectedly catches their foot on an object or on the floor where they are standing, walking, turning, or running (Work Safe Australia, 2012; Brady, 2015; Workplace Health and Safety Queensland, 2016). A raised surface of 3/8" can cause a person to stumble and fall (CMT, 2009). Trip hazards are usually low to the ground and not easily recognized. Common indoor workplace trip hazards include uneven edges in flooring, loose mats, open drawers, untidy tools, equipment, and/or electrical cords (AF Group, 2020; Safe Work Australia, 2012; Workplace Health and Safety Queensland, 2016). Trip hazards outside of buildings can be numerous and include low-level obstacles such as uneven walking surfaces, natural substances including water, snow, ice, rocks, plants, etc. or human debris from poor housekeeping or other activities on or near the travel path (CMT, 2009; Workplace Health and Safety Queensland, 2016).

Falls may occur at the same level or from different heights. Falls at the same level may result from slips, trips or other factors that result in loss of gait or movement control, balance, and/or stability, that cause the person to descend rapidly to the floor or traveling surface (Brady 2015; Kurz, Oddsson and Melzer, 2013; Safe Work Australia, 2012) and are a major source of occupational injury globally (Chung, Leclercq, Lockhart and Haslam, 2016). External causal factors within the built environment include loose carpet, mats, spilled substances, or obstacles low and not seen (AF Group, 2020). Whereas, outdoor falls may come from naturally derived hazards such as rough terrain, debris, loose soil, mud, rain, snow, and/or ice. The use of equipment and tools out of doors including ladders, scaffolding, machinery, and utility poles may all increase the risk for slip and fall injury when used in adverse environments (AF Group, 2020).

Overview and Epidemiology

The National Safety Council (NSC) reported that estimated 34,673 people died in 2016 due to slips, trips, and falls at home and at work in the US (NSC, 2020). The NSC estimated that 25,000 events occur daily (ISO Services, 2010). Slips, trips and falls made-up an estimated 15% of all accidental deaths and 17% (3.8 million) of disabling occupational injuries (Brady, 2015; Accident Fund Insurance Company of America, 2018). A total of 217,392 slips, trips and falls were reported across eight industries with the highest prevalence in government employers followed by education, health services, and retail trades (NSC, 2020). Costs of medical care and compensation were estimated at $70 billion annually in the US (NFSI, n.d.).

Slips, trips, and falls rank second only to transportation accidents as a leading cause of injury among US workers and accounted for 27% of all non-fatal reported injuries (Bureau of Labor and Statistics (BLS), 2020; NIOSH, 2012). Slips and falls are a major cause of injury that result in medical care and account for an estimated one million emergency room visits per year. All types of falls result in an estimated 8.9 million emergency room visit each year in the US (Brady, 2015; NSFI, n.d.) and are a leading cause of injury in those over 55 years of age and a primary cause of fatality for those over 70 years of age (NSFI, n.d.).

The Centers for Disease Control and Prevention (CDC) estimates that fall related injuries result in three million emergency room visits for those > 65 years of age and 950,000 hospitalizations. Moreland, Kakara and Henry (2020) estimate that 5.5 million seniors > 65 years were injured by falls between 2012 through 2018. By 2050 one-fifth of the world's population will be > 60 years of age and 20% of them will be > 80 years of age (Kwan, Close, Wong and Lord, 2011). Authors investigated the literature on falls among Chinese older people and found the incidence of falls among those > 60 years ranged from 11% to 34% with 33% to 64% occurring in the home (Kwan, Close, Wong and Lord, 2011). The most common places to fall at home are in the dining areas and bedrooms. Falls outside the home are more common during the day and on the street or sidewalk. The most frequently reported causes for falls were slips, trips, legs giving way, and loss of balance (Kwan, Close, Wong and Lord, 2011).

The Zurich Service Corporation (2011) reported that most slip and fall claims associated with invitees involving snow and ice occurred in parking lots or parking areas. The company reported over $1 billion (US) in slips, trips, and fall claims occurred in North America with 25% due to snow and ice. The company further reported that the average liability claim is settled for $15,132 (US) and increased to $35,132 (US) per case if an employee was involved. The Accident Fund Insurance Company of America (n.d.) reported that employee claims cost an average of $40,000 each.

Falls from different heights are commonly due to a loss of footing, stability or other factors that results in a person falling from one level to another. Falls from one level to another tend to be more serious and result in many fatalities each year (CMT, 2009; OSHA, 2020).

Gevitz, Madera, Newbern, Lojo and Johnson (2017) investigated a surge in slips and fall injuries seeking emergency department (ED) care in Philadelphia, USA. The team used syndromic surveillance to identify and evaluate 4,988,985 injury reports collected from a five-year period 2006 through 2011. Their research revealed that 3.7% (185,385 cases) of all ED visits were due to slips and falls. Ages 18 to 64 years were more than two times likely to suffer fall-related injury. The most frequent fall months were December, January, February, and March. Snow was the most predictive of slips and fall with an adjusted odds ratio of 13.4 (95% CI 2.9-61.5). Study findings underscore the increased risk of snow and ice as a high-hazard and the need to be diligent in managing winter precipitation risks where people walk (Gevitz, Madera, Newbern, Lojo and Johnson, 2017).

The State of New Hampshire (NH) convened a taskforce in 2003 to address the slip, trip, and fall problem in their state and identify solutions that would lessen the adverse impacts to citizen health and the healthcare system (The NH Risk Reduction Task Force, 2003). The task force reported that an estimated 1/3 of all persons over the age of 65 years would experience a fall each year and that falls are a leading cause of death for this age group. Data showed that 60% of all falls are at home and prevention strategies are important and should be implemented (The NH Risk Reduction Task Force, 2003).

The European Union reported over 5,500 people die annually due to slips, trips, and falls and 75,000 suffer some permanent disability (Slip No More Canada, 2015). Preventable slips and falls caused more than four million lost workdays each year. The financial impact of slip and fall accidents was estimated to be more than $20 million Euros annually (Slip No More Canada, 2015). Factors associated with slip and fall accidents included inappropriate floor materials, slippery surfaces, poor lighting, and inadequate footwear for the surface traveled (Slip No More Canada, 2015). The most common locations reported in this study were shopping malls, supermarkets, hospitals, and hotels that had floor surfaces not meeting the European Union standards for non-skid surfaces (Slip No More Canada, 2015).

Netherland researchers investigated the frequency of snow and ice related fractures by comparing an unusual duration of heavy snow and ice during a 10-day period from January 2013 to the previous year (van den Brand, van der Linden, van der Linden, and Rhemrev, 2014). The heavy snow and ice resulted in twice the number of fractures compared to the previous year at approximately the same time. Researchers found that 68.3% of fractures were related to slip and fall events outside requiring 1,785 ED visits (van den Brand, van der Linden, van der Linden, and Rhemrev, 2014). Data analysis revealed the greatest number of fractures were in the forearm followed by the hand, ankle and foot, upper arm, chest and spine, and hip. Few fractures were seen in the knee, leg, and head. More females suffered fractures than males, 75.5% compared to 42.9% respectively (van den Brand, van der Linden, van der Linden, and Rhemrev, 2014). Age was not a good indicator of risk: those between 31 years to 60 years had the greatest number of fractures.

Finnish experts estimated that approximately 70,000 citizens are injured in slip and fall events each year that require medical attention with a significant cost estimated at $2.4 billion Euro (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). Researchers also found that typical injuries include bruises, sprains, and fractures. They found that distal radius fractures were 2.5 times more frequent in winter months compared to other times in the year (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). Individuals between 35 years and 65 years of age were most often injured. Investigators found that sidewalks, outdoor paths, courtyards and parking lots are the most frequent sites for slip and fall events. The slip and fall problem was so significant they expanded their Road-Surf Warning system designed for automobile travel to include pedestrian traffic with slippery walking surfaces information and warnings (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020).

The United Kingdom reported that slips, trips, and falls comprised approximately 1/3 of all major injuries costing Great Britain an estimated 750 million £ (Pounds) per year (Slip No More Canada, 2015). Slip and fall events were estimated to occur every three seconds throughout the country. The Health and Safety Executive (HSE) evaluated 62 slip and fall injuries and learned that 24% of cases were due to an individual losing their footing and/or balance, 22% due to inadequate floor maintenance, 11% were due to poor housekeeping, 11% due to customer spills, and 9% due to water (Peebles, Wearing and Heasman, 2005).

Swedish researchers reported that slips, trips, and falls were a significant occupational safety hazard (Kemmlert and Lundholm, 2001) and public health problem (Abeysekera and Gao, 2001). Slip, trip, and fall injuries comprised 21.9% of 37,000 occupational injury claims examined (Kemmlert and Lundholm, 2001). Snow and ice were to blame for 70% of all injury claims involving postal workers (Gao, Holmer and Abeysekera, 2008) and accounted for 37% of all costs for injuries among elderly in traffic related environments (Gao and Abeysekera, 2004). Claims associated with those > 45 years of age and engaged in transfer of materials, equipment, or tools comprised up to 36% of accidents (Kemmlert and Lundholm, 2001). Men and women > 45 years had the longest total temporary disability and most lost workdays, 43 and 38 days respectively. The majority of men (87.5%) and women (57%) reported that slip, trip, and fall mechanisms were associated with three conditions:

1) slip due to miss-step, loss of footing on floor or ground,
2) slip on snow or ice, and
3) slip due to lack of housekeeping, spills and/or secure flooring (Kemmlert and Lundholm, 2001).

The most common reported causes for slips, trips, and falls were miss-step or loss of footing, at 28% for men < 45 years and 27% for men > 45 years and 21% for women in both age groups. Snow and ice were also significant risk factors for men compared to women, 25% for men < 45 years compared to 13% for woman and 30% for men > 45 years with 18% for women (Kemmlert and Lundholm, 2001). Gao and Abeysekera (2004) evaluated slip and fall injuries from a systems perspective and found that contributing factors include type of footwear, underfoot surface characteristics, footwear-surface interface, gait biomechanics, human physiological and psychological aspects, and environmental factors. Their research found that gaps remained in fully understanding the risks of snow and ice and their role in slip and fall injuries (Gao and Abeysekera, 2004).

Spain estimated that 27 slip and fall events occur domestically every hour and that such events make up nearly a third of all workplace accidents (Slip No More Canada, 2015). In addition, slips and falls are the second most frequent cause of paraplegia (Slip No More Canada, 2015).

New Zealanders report that slips, trips and falls are the greatest cause of domestic related injury with an estimated $135 million impact (Slip No More Canada, 2015). More than 70,000 New Zealanders between the ages of 25 years to 55 years suffered a serious injury due to slip and fall events at home each year. Work related slips, trips, and falls commonly occurred in milking sheds, yards, and paddocks (Slip No More Canada, 2015). A number of falls were also related to individuals mounting and dismounting vehicles or other equipment (Bentley, Tappin, Moore, Legg, Ashby, and Parker, 2005).

The Safe Work Australia (2020) reported that slips, trips, and falls were the second most common injury mechanism associated with work-related accidents. In 2019, there were 24,890 injury incidences reported comprising 23% of all work related traumatic events. The top three body areas injured in slips, trips, and falls were knee, ankle, and back (Safe Work Australia, 2020). The Safe Work Australia (2020) also reported that 16 workers died in agriculture and 21 in construction due to falls between 2015 and 2019. Fatal falls were associated with ladders, roof, horses, donkeys, mules, trucks, semitrailers, and lorries.

Workplace Health and Safety Queensland (2016) reported an estimated 13,000 Queensland workers suffered slip, trip, and fall injuries resulting in more than 256,000 lost workdays with economic costs exceeding $60 million in workers' compensation payments each year. Steinberg, Cartwright, Peel and Williams (2000) reported that slips, trips, and falls were common among Australian seniors. Risk factors for fall related events included the decline in physical conditioning, medication use, impairments of nervous system, chronic disease, disorders of the musculoskeletal system, history of previous fall, and being between 60 to 74 years of age. Senior slips and falls create a public health burden and more research is needed to identify effective controls (Steinberg, Cartwright, Peel and Williams, 2000). The investigators developed four interventions aimed at fall prevention among seniors:
1) education,
2) exercise,
3) safety instruction to modify home environments, and
4) health assessment to optimize health.
They recruited 250 seniors from Brisbane Senior Center to participate in their study. One year follow up revealed significant benefit from the interventions with an estimated probability for reductions in slip and fall injury for the intervention groups compared to controls (Steinberg, Cartwright, Peel and Williams, 2000).

Contributing Hazardous Conditions

The National Floor Safety Institute (NFSI) reported certain types of floor materials may pose risk for slips, trips, and falls (NSFI, n.d.). A COF of greater than 0.40 offers a safety factor to reduce chance of slip and fall (Maynard, Di Pilla, Natalizia and Vidal, 2012). A variety of devices (tribometers) are used to measure COF (Maynard, Di Pilla, Natalizia and Vidal, 2012). Finnish researchers defined slipperiness by classifying conditions based on the COF (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). Very slip-resistant flooring was >/= to 0.30, slip-resistant 0.20 – 0.29, unsure was 0.15 – 0.19, slippery was 0.05 – 0.14, and very slippery had a COF < 0.05 (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). Floor design is important and should minimize changes in floor levels and avoid slopes greater than 1:12 rise over the run (Safe Work Australia, 2012).

Common slip hazards that alter traction in the built environment include liquid spills, cleaners, solid materials in footpaths, sudden changes in floor level, unstable or loose flooring, change from wet to dry surfaces, dusty, or sandy surfaces (Safe Work Australia, 2012; Brady, 2015).

The American National Standards Institute (ANSI) and National Floor Safety Institute (NFSI) standards list low traction as static COF < 0.40, moderate static traction COF 0.40 – 0.60 and high static traction > 0.60 (Thom, 2013). Common trip and fall hazards include ridges in carpets, worn floor materials and broken tiles, potholes and cracks in surfaces, changes in floor levels, thresholds and transition areas, floor mounted sockets, extensions, and other obstacles in a travel path (Safe Work Australia, 2012). Transition areas from smooth floors to carpet may also pose risk for stumbles and falls.

Stairs pose a trip hazards as well (The NH Falls Prevention Task Force, 2003). Stairs have been identified as potential slip, trip and fall hazards (Safe Work Australia, 2012). Risers should be uniform over the flight, any variation in riser height presents a hazard and should be minimized (Safe Work Australia, 2012). The proper design of stairs is important to minimize slip, trip, and fall hazards. The overall elevation of the stairway should not be too steep and the rise of the stairway should be between 15 and 55 degrees (Safe Work Australia, 2012). Landings should be installed no less than every 16 steps. Handrails on both sides of the stairway adds user stability (Safe Work Australia, 2012).

Snow and Ice Hazards

Snow, ice, water and freezing temperatures create reduced COF conditions that significantly increase the risk for slips and falls (Bongrade, 2017; Gao, Holmer and Abeysekera, 2008). Snow management has many possible considerations such as moisture content in the atmosphere, temperature and temperature ranges, wind speed, depth of snow, and rate of snowfall all influence control strategies and effectiveness of removal (Di Pilla, 2010). The Snow and Ice Management Association (SIMA) estimated that North America invests $22.7 billion for snow and ice management. The retail industry spends and estimated $6 billion annually to manage snow and ice on their property (SIMA, 2016). An estimated 90% of all pedestrian slip and fall injuries are on less than one inch of snow (Konst, 2017). The SIMA reported that one in four falls in the US is due to snow and ice, totaling and estimated 2,250,000 incidences per year with 35% occurring in parking lots (SIMA, 2016). In 2014, an estimated 42,480 snow and ice work related injuries resulted in at least one lost workday each in the US (Bongrade, 2017). Snow and ice are the top two weather factors that negatively impact mobility of older adults (Clarke, Yan, Keusch and Gallagher, 2015). Researchers surveyed 502 citizens in Michigan and found that ice was the major deterrent to daily activity 46.51% of the time compared to 21.71% due to snow. For those >65 years, avoidance rises to 51.14% (Clarke, Yan, Keusch and Gallagher, 2015).

The outdoor environment is susceptible to a number of unique hazards that include: sleet, freezing rain, black ice, snow and ice (Accident Fund Insurance Company of America, n.d.). Sleet formation begins as snow that melts in a warm band of atmosphere air and then refreezes in colder lower atmosphere air forming pellets that bounce when hitting the ground (Accident Fund Insurance Company of America, n.d.). Freezing rain begins as snow that melts in warm atmospheric air but then refreezes when it hits the ground due to colder temperatures. Freezing rain is extremely dangerous for walking or driving (Accident Fund Insurance Company of America, n.d.). Black ice is a thin layer of ice that blends into ground surfaces. Black ice forms from water, dew, or fog often in the early morning and then melts with sunshine but may reform on wet surfaces with freezing temperatures (Accident Fund Insurance Company of America, n.d.). Snow is precipitation that freezes in cold atmospheric temperatures and maintains its freezing form to accumulate on the ground or other surfaces. Ice forms when water from many possible sources freezes due to freezing lower atmospheric temperatures (Accident Fund Insurance Company of America, n.d.).

Additional Outdoor Hazards

The ISO Services (2010) identify same level slip, trip, and fall hazards to include uneven or slippery walkway surfaces, contaminants on walkways, inadequate lighting, poor housekeeping, inadequate maintenance, poorly designed or worn-out or degraded walkway surfaces, and adverse weather conditions.

Walkways include parking lots, fields, playing fields, paths, walks, footpaths or a combination thereof. Additional walkway hazards include broken pavement, depressed, raised, undermined, uneven, or cracked surfaces to the extent that pieces may be easily removed (ISO Service, 2010). Parking lots are frequent locations for slip, trip, and fall hazards (State Automobile Insurance Company, 2020). A one-inch hole is enough to cause someone to stumble and fall. Parking lots should be designed and maintained free of uneven pavement, cracks, bumps, or holes that might cause someone to stumble and fall. Adequate lighting is essential for employees, customers and/or visitors. Poor lighting can be a factor in slips, trips, and falls as well as criminal activity, and vehicle collisions (State Automobile Insurance Company, 2020).

Personal Factors

Numerous personal risk factors have been associated with slips, trips, and falls (Chang, Leclercq, Lockhart and Haslam, 2016; Kurz, Oddsson and Melzer, 2013; Mersey Care NHS, 2016). Factors that may predispose individuals to slips, trips, and falls include age (Moreland, Kakara and Henry, 2020), balance and gait problems (Kurz, Oddsson and Melzer, 2013; Lockart, Smith and Woldstad, 2005; Mersey Care NHS, 2016), decreased strength and flexibility (Lockart, Smith and Woldstad, 2005), impaired hearing, dizziness, altered mental status, use of multiple medications, alcohol use, impaired vision, chronic or acute illness and having had a recent fall (Kurz, Oddsson and Melzer, 2013; The NH Falls Risk Reduction Task Force, 2003). Improper footwear has also been identified as a personal risk factor (Gao, Holmer and Abeysekera, 2008).

Prevention and Management Strategies

Prevention of slips, trips, and falls are best accomplished with a systematic approach (Maynard, Di Pilla, Natalizia and Vital, 2012; Safe Work Australia, 2012). The primary steps involve:

1) identifying the hazards,
2) evaluating the risks,
3) implementing, and maintaining controls, and
4) reviewing effectiveness of controls.

Basic prevention strategies target risk reduction through optimizing factors associated with the person, place, environment, or activity performed. The hierarchy of controls provides an excellent framework for improving the safety of individuals at work, in public, or at home (Safe Work Australia, 2012; Workplace Health and Safety Queensland, 2016.)

The **first** and preferred strategy is to eliminate the hazard through removing the slip, trip and fall hazards such as clearing snow, ice, natural debris, low-lying hazards including tools, equipment, cords, and/or waste from walkways (Safe Work Australia, 2012). The **second** control strategy is substitution such as replacing a slippery surface with a slip-resistant coating or new material (Safe Work Australia, 2012). The **third** strategy is to isolate the higher–hazard area and keep people away using signage and/or barriers to restrict access (Safe Work Australia, 2012). The **fourth** strategy is to use engineering to address hazards and reduce or eliminate risks. Examples of engineering controls might include applying floor treatments to increase friction, improved lighting, stop leaks, provide effective drainage, and clearly mark edges for changes in surface heights (Safe Work Australia, 2012). The **fifth** strategy is to use administrative controls such as high standards for housekeeping, cleanliness, and spill clean-up. Using signage is prudent to warn others that hazards are present such as a freshly mopped floor, snow, ice, water, or other substances that reduce the COF. Training is an administrative responsibility and fundamentally should enhance knowledge, skills and competencies of those trained in all aspects of slip, trip and fall prevention (Safe Work Australia, 2012). The **final** strategy is the use of personal protective equipment such as slip resistant shoes and stabilization-assist devices such as canes or walking sticks (Safe Work Australia, 2012).

Brady (2015) recommends a 10 step process for minimizing slips, trips, and falls in the workplace: 1) assess the workplace, 2) mark isles and passageways, 3) provide traction on slippery surfaces, 4) improve stair safety, 5) mark emergency exits, 6) post safety signs and labels, 7) warn of temporary hazards, 8) inspect scaffolds and ladders, 9) control and clean oil and spills, and 10) train employees.

Chang, Leclercq, Lockhart and Haslam (2016) recommend a simple three-step systematic approach that included

1) primary prevention such as good slip resistant flooring, well designed walkways, effective spill mitigation procedures, robust storage capabilities to keep walkways clear of trip hazards, good lighting, and strong maintenance programs,

2) risk reduction through education and training, audits, controls, housekeeping, signage, discourage carrying loads while walking, manage risks associated with inclement weather, and manage risks associated with vulnerable persons,

3) maximize capability of individuals to navigate the workplace environment through recommended footwear, suitable clothing and PPE, vision testing, vision correction if needed, fitness, and management of risks secondary to medications and shiftwork (Chang, Leclercq, Lockhart and Haslam, 2016).

Workplace Health and Safety Queensland (2016) recommends a risk management matrices that include the following risk factor groups: internal floor surfaces and conditions, external ground surface and condition (including access/egress), contaminants, cleaning procedures, cleanliness, housekeeping and obstacles, environmental and lighting, stairs and ramps, activities (tasks), footwear and others. The property owner, operator or responsible person should identify the detailed risk factors within each group and rank them based on probability of injury: hazard is **Low** (least likely), **Moderate** (some risk of injury), or **High** (very likely to cause injury) (Workplace Health and Safety Queensland, 2016). Once the matrices are complete, rank hazards, create an action plan, develop, and implement controls (Workplace Health and Safety Queensland, 2016).

Maynard, Di Pilla, Natalizia and Vidal (2012) underscored the reality that everyone in an organization is a stakeholder in the prevention of slips, trips, and falls. The recommended process for managing risks and hazards follows a systematic approach using a continuous cycle of improvement. Their model includes eleven actions or parts to achieve success:

1) management responsibility, 2) education and training, 3) incident and injury surveillance, 4) hazard surveillance, 5) floor surface selection, 6) floor surface treatments, 7) housekeeping and maintenance, 8) slip-resistant footwear, 9) mats, 10) floor slipperiness assessment and 11) warning signs and instructions (Maynard, Di Pilla, Natalizia and Vidal, 2012). Coordination of organizational components is essential. Priority stakeholders include facilities management, operations management, risk management, safety, purchasing, occupational health, engineering, maintenance, and housekeeping (Maynard, Di Pilla, Natalizia and Vidal, 2012).

The New Hampshire Falls Risk Reduction Task Force (2003) focused on slips, trips, and fall prevention related to senior citizens. The task force concluded that basic elements of a slip, trip, and fall prevention program were the **4 'E's**: **E**ducation, **E**nvironmental modification, **E**xercise and **E**mergency planning. Education materials should be developed that could be taken home by participants, environmental conditions need to be changed to reduce risks, exercise to strengthen core muscles, lower extremities and balance, and emergency planning to minimize severity and improve outcomes. Environmental conditions could be guided by a Safe House Tour checklist that includes assessment of kitchen, hallways and stairways, bathrooms, bedrooms, living room, and general living areas, entrances, and outdoor walkways. The completed checklist culminates in an action plan that residents can use to make their environments safer. The taskforce continues to be active and provide community education with the most recent virtual class held November 3, 2020 to introduce the new Executive Director of the New Hampshire Commission on Ageing and also focused on fall prevention in seniors (The NH Falls Reduction Task Force, 2020).

Troyer (2012) presented a slip, trip, and fall prevention program based on established standards from the American National Standards Institute (ANSI) and National Floor Safety Institute (NFSI). Using the framework of ANSI/NFSI floor safety standards, Troyer

(2012) outlined a Plan, Do, Check, Act (PDCA) continuous process approach.

Step 1 is planning, this invites a risk assessment that includes common risk estimation tools such as the Failure Modes and Effects Analysis (FMEA) for evaluation and identification of hazards and estimation of probability and magnitude of an event (Troyer, 2012).

Step 2 outlines the action plan for interventions to be taken based on step 1.

Step 3 requires checking or evaluating control strategies for effectiveness.

Step 4 is checking and evaluation for dangerous levels of COF needing proactive interventions to return safety to walking surfaces (Troyer, 2012). The author asserts that monitoring walkways is easy using modern tribometers and comparing results to standards. Using the PDCA cycle of continuous monitoring with appropriate action results in a safer environment for pedestrians and is more likely to prevent and/or reduce slip, trip, and fall incidences (Troyer, 2012).

The Accident Fund Insurance Company of America (n.d.) developed the SAFE Campaign: Slip And Fall Elimination (SAFE). Elements of the SAFE campaign include use of weather advisory systems, snow blower and snow removal equipment, hire a contractor for snow removal, a plan for when off-premises work is necessary, maintain a good supply of ice melt products, obtain appropriate slip resistant footwear, post slip, trip and fall advisories around the premises, ensure entryways are clear with mats. The SAFE program reminds businesses to service parking lots and frequently traveled areas and to keep ice melt product well supplied because it is far cheaper than an insurance claim (Accident Fund Insurance Company of America, n.d.).

The Mersey Care NHS Foundation Trust (2016) offers a policy for the management and reduction of work related slips and falls based on established consensus standards for safety, practice, prevention and care of slips, trips, and falls in the healthcare industry. The 47 page policy includes 12 sections: purpose and rationale, outcomes focused aims and objectives, scope, definitions, duties, process, consultation, training and support, monitoring, equality and human rights analysis, implementation plan, and appendices. The aim of the policy is to ensure efficient and effective prevention and management of slips, trips, and falls of patients in healthcare settings. Key to the success of the program is compliance with the United Kingdom's Management of Health and Safety at Work regulations with accountability of those in charge of safety, facilities, staff, and remaining stakeholders (Mersey Care NHS Foundation Trust, 2016). Systematic hazard identification is paramount to risk estimation and abatement. Risk management strategies include a selection of appropriate and effective controls to mitigate or eliminate hazards with documentation. Knowing who is at risk for falling and taking action to protect the vulnerable is equally important. Training stakeholders, monitoring compliance, and evaluation of outcomes leads to successful prevention and/or care of slip, trip, and fall events (Mersey Care NHS Foundation Trust, 2016). The Mersey Care NHS Foundation Trust (2016) policy for slip, trip, and fall prevention is an open-source model for others to use, it includes tools and resources accessible to all parties for use and enhancement of their injury prevention effectiveness.

NIOSH (2010) published a slip, trip, and fall prevention guidelines for the healthcare industry with the express purpose of explaining how hazards contribute to slips, trips, and falls. The NIOSH (2010) guidance document provides information on where hazards may be found with recommendations on how to abate hazards. The document lists ten major classes of hazards and recommends controls. Hazard classes include 1) contaminants on the floor, 2) poor drainage, 3) indoor walking surface irregularities, 4) outdoor walking surface irregularities, 5) weather conditions: ice and snow, 6) inadequate lighting, 7) stairs and handrails, 8) stepstools and ladders, 9) tripping hazards, clutter, including loose cords, hoses, wires, medical tubing, and 10) improper use of floor mats and runners. Each hazard group has recommendations that reduce or eliminate the risk of injury (NIOSH, 2010).

W.W. Granger Incorporated (n.d.) outlined a simple slip, trip and fall prevention plan for employers that includes: 1) create good housekeeping practices – plan ahead, assign responsibilities, and maintain the program, 2) reduce wet or slippery surfaces – check parking lots, sidewalks, food preparation areas, shower stalls in dorms and floors in general, 3) avoid creating obstacles in aisles and walkways – keep all work areas, passageways, storerooms, and service areas clean and orderly, 4) create and maintain proper lighting – use illumination in walkways, staircases, ramps, hallways, basements, construction and dock areas, 5) wear proper shoes – require or provide footwear that provides good traction and safety for the job, and 6) control of individual behaviors – provide training to teach employees to enhance awareness of slips, trips and falls, stay alert, avoid distractions such as cell phones or carrying objects that might obscure vision, don't wear sun glasses indoors, avoid taking shortcuts, don't hurry, maintain control of motions and activities (W.W. Granger, n.d.).

Snow and Ice Management

Snow and ice on pedestrian walkways, traveled surfaces, and routes should be considered emergency work and managed with the utmost urgency (Di Pilla, 2010). Removal of snow from walkways and parking lots is essential for the safety of employees and visitors (Di Pilla, 2010; Hofmann, 2020; Hossain and Fu, 2015). Snow and ice control can be accomplished using mechanical, thermal, and chemical means (Hossain and Fu, 2015). Optimal snow and ice removal should be determined through field tests (Hossain and Fu, 2015). Application of preferred methods should be focused on entrances, exits, ramps, slopes, stairs and shaded areas (Hofmann, 2020). Business operators and landowners have a 24/7/365 responsibility to manage their snow and ice risks (Hofmann, 2020; Konst, 2017). Don't think that slip and fall risks are not present just because it didn't snow. Dangerous ice can form with moisture and low temperatures. Snow bias is the potential to disregard risks associated with ice formation without snow (Melchior, 2016).

Gao (2004) investigated snow and ice related injury events in his doctoral dissertation and concluded that snow and ice risks are multifactorial and required multiple measures to successfully reduce fall risks. Best Management Practices (BMPs) are effective interventions to reduce and/or eliminate snow and ice hazards and risks and should include monitoring property with emphasis on walkways, posting warning signs of possible slip conditions, and snow and ice removal (Gao, 2004; Konst, 2017).

NIOSH (2010) outlines several safety measures to reduce employees' and customers' injuries associated with ice and snow through the development and implementation of an aggressive program to promptly remove ice and snow from parking lots, garages, sidewalks, entrances and outside stairs. Their recommendations included distribution of weather information to employees, placing freezing monitors in parking areas and entrances, locating ice melt products in a bin near entrances of parking lots and garages with scoops so anyone can apply the product to ice as needed, displaying phone number for maintenance service, encourage employees to report dangerous conditions, posting signage, using mats at entrances and recommending or provide anti-slip footwear (NIOSH, 2010).

Zion Market Research (2018) estimates that snow melting systems will reach $6 billion (US) in sales by 2022. Such systems monitor the environmental conditions, detect precipitation, and freezing temperatures then automatically activate systems to prevent snow and ice build-up on surfaces such as walkways, patios and roadways.

The Minnesota Pollution Control Agency (MPCA) (2015) recommended sand for parking lots to enhance traction for pedestrians and autos. Special attention was recommended for handicap parking. Mixed sand and salt is recommended for freezing rain (MPCA, 2015). The agency outlined BMPs and winter maintenance basics for snow and ice. The BMPs include removal first, remove snow as quickly as possible, protect the environment, apply deicers per manufacturer's recommendations, record quantity used, record effectiveness and outcomes, cover salt and sand piles, use magnesium or calcium chloride as effective alternatives, use wet snow-melt materials for improved efficiency and reduce total quantities used (MPCA, 2015).

Swedish investigators studied slips and falls due to snow and ice using a systematic perspective with an emphasis to identify preventive factors (Gao and Abeysekera, 2004). The researchers recommended the following steps for effective prevention: 1) proper footwear that had anti-skid and anti-slip features, 2) effective snow clearing with anti-slip materials spread on walking and driving surfaces, 3) walking aid, gait and balance exercise, 4) good environmental lighting, 5) prioritizing management of winter weather risks and hazards, 6) signage to warn pedestrians of risks and hazards and 7) training for the general populations on safer walking techniques and behaviors in snow and ice (Gao and Abeysekera, 2004)

Gao, Holmer and Abeysekera (2008) investigated the opinions and recommendations for slip safety among Swedish workers in newspaper delivery, military, mining and construction industries. Respondents ranked controls from most effective to least effective, results were as follows: 1) spreading anti-slip materials on surfaces, 2) use of slip resistant footwear, 3) walking carefully, 4) snow removal, 5) use of anti-slip devices on shoes, 6) walking slowly, 7) taking small steps and 8) not using ordinary shoes.

The Finnish Meteorological Institute (FMI) developed a public broadcast warning system to inform citizens of times of increased risk when walking (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). The country began using a road condition warning system in 2000 that was expanded in 2004 to include walking surfaces. The developers classified walking surfaces into five categories based on the COF. Class 1 conditions were very slip-resistant COF >/= to 0.30, class 2 was slip-resistant COF 0.20 – 0.29, class 3 were described as unsure COF 0.15 – 0.19, class 4 conditions were slippery COF 0.05 – 0.14, and class 5 conditions were highest risk with COF < 0.05 (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). Their research found that the most slippery conditions were near zero degrees centigrade (32^{0}F) where freezing and thawing cycles occur forming ice. Public health messages included a colored warning scheme to communicate conditions and encourage adaptions including slip resistant devices worn on shoes/footwear, alternative travel routes or cancellation of planned walk/travel (Hippi, Kangas, Ruuhela, Routsalainen and Hartonen, 2020). The pilot program started in 2004 remains active today. The system runs 24/7/365 providing a 10 day, 5 day, and 3 hour forecasts. The most recent innovation includes the FMI weather app for citizens to use on their mobile phones that collects data from the accelerometer in the phone.

Swedish investigators, Gard and Lundborg (2000), investigated 25 anti-skid devices that attach to footwear using subject trials where participants ranked devices. Study participants were required to don the anti-skid devices and perform basic walking maneuvers on five different ice surfaces: gravel applied, sand applied, snow over ice, salted surface and ice with no coverage. The participants travelled and maneuvered a 10 meter path. Participants were observed, analyzed, and asked to walk normally, turn around, walk rapidly 4-5 steps, stop, walk backwards 4-5 steps, and walk rapidly across the designated area. Study subjects reported their perceived advantages and disadvantages of the different devices. Evaluation revealed two devices that were ranked as good on all types of iced surfaces and one that was good or fairly good on all surfaces (Gard and Lundborg, 2000). The products that received superior ratings for iced surfaces were named 'Studs' and 'Sensi Galoch' and a third 'Beaver' was ranked highest by test subjects for all surfaces. These types of devices are intended to increase the grip between the wearer's shoes and the underfoot walking surface (Gunvor and Lundborg, 2000).

Parkin, Williams, and Priest (2009) conducted a novel investigation of pedestrians wearing socks on the outside of their shoes to evaluate the slip resistance. The researchers randomized 30 pedestrians to two different group: those wearing socks on the outside of their shoes and those not wearing socks on the outside of their shoes. Pedestrians wearing socks on the outside of their shoes reported significantly improved traction (Parkin, Williams, and Priest, 2009).

The OSH Healthcare System (2020) recommends walking like a penguin. The unique gait advocated that individuals assume a slightly bent posture, walk flat-footed and move carefully over ice like a penguin. Walking on slippery surfaces such as snow and ice should be deliberate, planned and carefully executed (OSH Healthcare System, 2020). Learning to fall safely may also be a tenable strategy for reducing injury and adverse outcomes from slip and fall events (OSH Healthcare System, 2020). The martial arts offers fall landing techniques that may reduce injury by landing more safely (Black Belt Wikki, n.d.).

Snow and ice removal can prevent costly liability insurance claims due to injury (Melchoir, 2016; Schaefer Enterprises, 2020). If a contractor is hired for snow removal, verify that they are insured by obtaining a certificate of insurance before signing the contract. Documentation of snow and ice management will lessen the chances of slips, falls, injuries, and lawsuits (Perkoski, 2018).

Safety Standards

A significant number of safety standards exist to reduce and eliminate slip, trip, and fall hazards (Maynard, Di Pilla, Natalizia and Vidal, 2012; Troyer, 2012). In the US the occupational safety and health standards are enforced by OSHA (OSHA, n.d.; USDOL, 1970; Thom, 2013), The Occupational Safety Standards for general industry 29 CFR 1910 and construction 1926 outline specific standards to protect workers from slip, trip and fall hazards (OSHA, n.d.; Thom, 2913). Emphasis on fall prevention in construction is paramount to saving lives. The OSHA recommends a static COF of 0.50 or higher to reduce chances to slips, trips, and falls (Fairfax, 2005; Thom, 2013).

The American National Standards Institute (ANSI) and the American Society of Safety Engineers (ASSE) collaborated on a number of standards. For example: ANSI/ASSE A 1264.2-2006 Standard of Slip Resistance on Walking-Working Surfaces. This is a voluntary consensus standard that establishes COF at 0.50 for safety on dry surfaces and specifies four slip evaluation devices. The ANSI/ASSE TR-A 1264.3-2007 Using Variable Angle Tribometers (VATs) for Measurement of Walkway Surfaces details the validity of VATs. The ANSI/ASSE B101.1-2009 test Method for Measuring Wet SCOF of Common Hard Surface Floor Materials provide values of traction ranging from a high of > 0.60 COF to a low < 0.40.

The American Society for Testing and Materials (ASTM) C1028 Test Method for Determining the Static Coefficient of Friction on Ceramic Title and Other Like Surfaces by the Horizontal Dynamometer Pull Meter outline test method. The ASTM D 2047 Test Method for Static Coefficient of Friction of Polish-Coated Surfaces as Measure by the James Machine outlines testing methods. The ASTM F609 Standard Test Method for Using a Horizontal Pull Meter (HPS) details methods for using the Liberty Mutual HPS. The ASTM F1679 Standard Test Method for Using Variable Incidence Tribometers (VIT) details methods for using the English XL VIT. The ASTM F1677 Standard Test Method for Using A Portable Inclinable Articulated Strut Slip Tester (PIAST) details test methods for using the Bungraber MK II Slipmeter. The ASTM F2508 Standard Practice for Validation and Calibration of Walkway Tribometers Using Reference Surfaces is an evidence-based standard that established parameters for validation and calibration of walkway tribometers using reference surfaces.

The ANSI and NFSI sponsored additional standards that include ANSI/NFSI B101.0 specifies the process by which walking surfaces are audited for slip resistance using the NFSI approved tribometers. The ANSI/NFSI B101.3 specifies the process for measuring the dynamic COF. The ANSI/NFSI B101.1 specifies the process for measuring static COF.

Communities often have county or city codes and/or ordinances that require property owners, tenets or agents of the premises to maintain pedestrian safety by removing snow and ice from sidewalks and driveways. For example, in Butte, MT, the county ordinance 12.12.020 – Snow and Ice Removal – Generally (2014), requires snow removal from sidewalks within 24 hours of accumulation or the party faces a $50 fine for the first offense, $100 for the second and $150 for the third (Butte-Silver Bow, 2014; McClendon, 2019).

A Duty to Protect and Prevent Slips, Trips, and Falls

Property owners and occupants have an obligation to protect visitors and/or the public that may enter their property (AmTrust Financial, 2020; Barker and Parry, 1995; Beckman, 2017; Cassisi Law Firm, 2020; Eagle Mat, 2019; Goguen, 2020; Grigg, 2016; Hofmann, 2020; Melchior, 2016; Miller, 2020; Minetz, 1981; Philadelphia Insurance Companies, 2017; Prior and Thompson, 2017; State Automobile Association, 2020). Employers have an obligation to protect employees, contractors (USDOL, 1970; OSHA, 2020), customers and/or visitors who enter their business (Beckman, 2017; Chang, Leclercq, Lockhart and Haslam, 2016; Eagle Mat, 2019; Minetz, 1981; Prior and Thompson, 2017; State Automobile Association, 2020). While this author is not offering legal advice, it is recommended to assume that current laws and precedent exist that compel and/or suggest property owners and/or businesses to take responsibility for their property and exercise diligence to eliminate or mitigate hazards that might cause injury to employees, contractors, customers and/or visitors. Regardless of natural or unnatural accumulation (Schutte and Waldman, 2015) a fundamental ethical and/or legal obligation exists for property owners and/or occupants to ensure reasonable safety.

Step one of the risk reduction process is to identify hazards that could cause injury to employees, customers, or visitors (State Automobile Association, 2020). *Step two* is to act on the presence of recognized hazards by reducing or eliminating the hazard and related risk of injury through self-directed hazard abatement or through contract services. The lack of action to do so is negligent and likely to expose property owners and occupants to claims and liability (Beckman, 2017; Goguen, 2020; Minetz, 1981; State Automobile Association, 2020). An aggressive program to eliminate and/or mitigate slip, trip, and fall hazards is highly recommended to reduce risks (Chang, Leclercq, Lockhart and Haslam, 2016; Philadelphia Insurance Companies, 2017; Troyer, 2012; Zurich Service Corporation, 2011). Property owners or occupants must decide if they wish to manage snow and ice removal or contract the service (State Automobile Association, 2020). A snow management plan begins before it snows and ends with safe and effective snow removal, anti-icing treatment (Limban, 2020) and posting of danger warnings (Hofmann, 2020). There is a duty of care to anticipate dangers caused by snow and ice and to take action to mitigate and/or eliminate hazards (Goguen, 2020). Ignorance is not an excuse (Hofmann, 2020), so people should not be negligent, should take proactive measures to avoid potential injury claims (Schaefer Enterprises, 2020) and manage slip, trip and fall hazards at their business and/or property using a documented, systematic, and effective risk management processes (ISO, 2010).

Conclusion

Slips, trips, and falls are a significant problem worldwide. Stakeholders have considered multiple risk factors, conditions and alternatives leading to sound prevention strategies for employers and property owners/occupants. Taking action to manage and mitigate slip, trip, and fall hazards is prudent, ethical, and a legal obligation in many circumstances.

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The Effects and Management of Heat on Surface and Underground Mine Sites in Australia

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Abstract

Within a working mine there is an importance to constantly maintain and control the heat that comes from many different natural and man-made heat sources. The importance for maintaining the temperature within a mine is primarily for the health and safety of the workers that are at risk of heat related illness but also for the efficiency of the mine site. Heat related illnesses are best described on a spectrum and can range from very mild symptoms to very extreme symptoms and even have the potential to kill. The mild symptoms when not identified quickly can rapidly turn into the severe symptoms. It is for this reason the heat in mines is such a risk to workers and must be controlled. Temperature can be controlled by the use of engineering controls, administrative controls and correct personal protective equipment (PPE).

Key Words: Underground mining. Working conditions. Heat stress. Heat management.

Introduction

The mining industry is very important to the Australian economy. The mining sector in Australia contributes to 8.5% of Australia's gross domestic product (Garnett, 2015). The mining sector makes up about 2% of Australia's workforce which is about 220,000 workers and this does not include the stimulating effects that the mining sector has on countless other industries (Garnett, 2015). With the importance that the mining industry has to the stability of the Australian economy and the job opportunities that the industry brings to Australia it is important that miners are provided with a safe workplace.

A study in 2013 conducted with 97 miners on three South Australian mine sites found that 87% of surface mine workers and 79% of underground mine workers experienced symptoms of heat illness, with 81% of the reported cases occurring more than one time (Hunt et al., 2013). These statistics were then further broken down with 56% of symptoms being classes as minor and 31% as moderate (Hunt et al., 2013). Heat from underground mines sites can be challenging to control as it is unavoidable and cannot be eliminated. There are however many risk control measures for heat that are implemented on mine sites currently, and also some innovations that can be implemented on mine sites to increase the effectiveness of heat control and decrease the risk to the workers.

Methodology

The method for conducting the literature review on the effects and management of heat in underground mine sites in Western Australia was by searching multiple databases in the Curtin University catalogue. This identified reports and peer reviewed articles from multiple databases including ProQuest, Science Direct and Wiley Online Library. Key words used for this search included *heat stress*, *underground mining* and *working conditions*. Predominantly sources that were between 2010 to current were chosen to keep the information as current as possible, with the exception of a few articles that were chosen because they were relevant and the industry practices have not changed since the time they were written. Included in this review are 8 journal articles, one web page, one Master thesis and one PhD thesis.

Discussion

In mining there are many source of heat which contribute to the danger to the workers on the mine site these include:

Geothermal which is the increase in temperature in relation to depth (Maurya et al., 2015b). The geothermal gradient is the rate at which temperature increases in relation to distance from the earth's core (Maurya et al., 2015b). Temperature tends to start increasing at between the 50 metre mark and almost always has an increase after the depth is greater than 100 metres (Maurya et al., 2015b). The geothermal gradient in existing underground mines can also be used as a renewable energy source (Hall et al., 2011). The contribution of heat from the thermal gradient comes from the rock wall, because the temperature of rocks increases with depth. It is usually hotter than the air in the mine and therefore the heat is transferred from the rock wall to air (Fenton, 1972). The efficiency of heat transferred from the rock wall to the air depends on a "the air temperature, a great amount of heat is given up by the wall rock. The effects of thermal conductivity, coefficient of heat transfer, emissivity, air temperature and velocity, wetness, and many other variables have to be taken into account" (Fenton, 1972, p. 20).

Auto compression is the result of air that flows down the mine shafts and as more air flows down the shaft, either naturally or via unnatural ventilation (Maurya et al., 2015b). The pressure increases as more air enters the shaft and therefore has an increased ability to take on heat (Fenton, 1972). If contributing factors such as water vapour and the transfer of heat from the rock wall in the mine shaft are removed, the temperature of the shaft would still increase the temperature linearly by 3.0 degrees Celsius every 1000 feet due to auto compression. The deeper the mine the higher the temperature (Maurya et al., 2015b).

Electrical equipment. There is heat production from electrical equipment used in the mine site. Most of the energy created by these machines is released as heat (Maurya et al., 2015b).

Diesel equipment. Diesel engines are used very commonly in mines for four-wheel drives, trucks, loaders and explosive transport vehicles as diesel fuel is less likely to start a fire than petrol (Maurya et al., 2015b). The efficiency of these diesel engines used on mine sites is only around 33% with the other 66% of the energy produced by the engine being released as heat into the surrounding environment (Maurya et al., 2015b). When diesel engines are compared to electrical equipment they are roughly 1/3 the efficiency, meaning they will produce about 3 times the amount of heat as electrical equipment with the same output (Maurya et al., 2015b).

Explosives and blasting. Studies have shown that around 90-95% of energy that is released during the process of blasting using explosives in some way ends up being heat in the underground environment (Maurya et al., 2015b). Some ways that the heat can be released, other than directly from the blast, is stored in rocks and released when rocks are removed, and in blast fumes (Maurya et al., 2015b).

Underground water. There are two types of underground water that can contribute to being a heat source for underground mine sites (Maurya et al., 2015b). Ground water is the first type of heat source. Ground water, when found in natural rock reservoirs and hot fissures, is an inexhaustible source of heat that the mine will have to control in order for work to be carried out in locations where this is present (Maurya et al., 2015b). The water will usually be the same heat as the surrounding rock, if not sometimes it will have higher temperatures (Maurya et al., 2015b). The heat transferred from the water to the air in the mine site is mainly through evaporation, which increases the temperature in the air. The second source of heat from water comes from the evaporation of service water that is water supplied to the mine by man for things such as wetting down, drilling and drainage water. Mine water gets it heat from the heated rocks (Maurya et al., 2015b).

Heat Transfer Mechanisms

<u>Conduction.</u> In the context of heat conduction is the process where heat is directly transferred from one median at a higher temperature to another at a lower temperature without movement of either medium (Hall et al., 2011).

<u>Convention</u> is the movement within liquid and gasses caused by temperature. Liquid has the tendency for hot and less dense liquid to rise and cool and more dense liquids to move downwards due to gravity. This results in heat being transferred (Maurya et al., 2015b).

<u>Radiation</u> is the emission energy in the form of electromagnetic waves or moving subatomic particles from one medium to another (Maurya et al., 2015b).

Risks and hazards of heat.

When working underground improper reduction of heat in above or underground mines can lead to an increase of multiple risks of heat related illness to the workers on the mines. Heat related illnesses can be put on a spectrum that include:

Heat stroke is one of the more deadly illnesses that can be caused by heat. Heat stroke occurs when the person's body temperature reaches over 40 degrees Celsius (Peiris et al., 2017). When heat stroke occurs the body's core temperature gets too high and the body is no longer able to cool itself. This results in a hot and dry skin (failure of cooling mechanisms), high pulse rate and low blood pressure. Heat stroke is a life threatening condition. The mortality rate is around 80% for people who have heat stroke as the body gets to a temperature that causes tissue damage to the brain, liver & kidneys. It requires immediate medical attention and is most likely to occur in miners who are highly motivated to keep working or who are working in paced labour in the heat. Symptoms of heat stroke usually include hot, blemished dry skin, sweating, confusion and loss of consciousness (Maurya et al., 2015a).

Heat exhaustion can affect any individual exposed to heat, although more common in young children and the elderly. Heat exhaustion is the inability of the circulation to meet metabolic and thermoregulatory demands. The body becomes unable to simultaneously meet the demands of sending blood to the skin to reduce body temperature and the demands for blood flow to the vital organs. Heat exhaustion is more likely to occur in miners who are not acclimatised, are unfit, obese or dehydrated. The temperatures that miners can experience increases the prevalence of heat exhaustion among miners (Hunt et al., 2013). Symptoms of heat exhaustion include weakness, difficulty continuing work, frontal headache, anorexia, nausea, breathlessness, feeling faint or actually fainting, clammy moist pale skin, body temperature is normal or slightly elevated, heart rate is often very high and blood pressure low (Maurya et al., 2015a).

Heat syncope is a variant of heat exhaustion where the person is standing and passes out due to a decrease in blood volume from dehydration (Maurya et al., 2015a). Symptoms include fainting and symptoms of heat exhaustion (Maurya et al., 2015a).

Heat cramps occur due to dehydration after prolonged exposure to a heated working environment and are due to a loss of salts because of sweat (Kenny et al., 2018). Heat cramps occur in the muscles used for work such as the muscles of the legs, arms and abdomen as sharp and painful spasms of muscles. This cramp results from simple salt depletion even though the person may have replenished fluids lost from sweating. Reduced blood flow may be involved. It can be avoided by consumption of fluids containing the correct balance of potassium, sodium and calcium. This condition usually precedes heat exhaustion (Maurya et al., 2015a).

Heat rash occurs when the sweat glands in the skin become blocked after profuse and prolonged sweating and where evaporation cannot easily take place. The condition causes a red rash on the skin. Blocked sweat glands forced the sweat out across the wall of the sweat duct into the tissue under the skin. Infection of the skin can result. Heat rash reduces the body's ability to sweat and, therefore, to lose heat. Symptoms of the heat rash range from blisters under the skin to red lumps on skin and some rashes can be extremely itchy (Maurya et al., 2015a).

Transient heat fatigue is a state of physiological or mental strain that occurs after exposure to prolonged heat. Symptoms of transient heat fatigue include the loss of performance in skilled physical activity and intensive mental work. This fatigue can effect coordination, performance and alertness (Maurya et al., 2015a).

Risk Control Measures

The management of heat on mine sites is important and must be constantly maintained in order to achieve maximum productivity of machinery and workers. The most important factor of heat management is the health and safety of the workers on and in the mine. With mine sites forever expanding and making mines deeper the management of the risk of heat is becoming more complex. Heat can be controlled by the proper application of engineering, administrative controls and wearing personal protective gear. These are the controls which current literature show to be effective in managing heat on mine sites (Maurya et al., 2015a).

Engineering controls:
Ventilation controls are the most important and effective way of controlling heat in underground mines (Nie et al., 2018). Ventilation can be found in all sizes of underground mines, usually in the form of an electric fan that delivers cool air to all ends of the shaft whilst forcing the hot air up and out of the mine shaft. Ventilation also has an important roles in removing gasses and dust that are in the mines (Nie et al., 2018).

A study conducted in 2015 by Shi, et al. used the engineering control of *injection of liquid nitrogen* to control the temperature and humidity of 2 underground mines. The project had positive results with both mines showing cooling. One decreased underground temperature by 10.8% and the other by 21.9%. This injection of liquid nitrogen is an adaptational addition to the mine's control of heat because it is economical, saves energy and has low emissions (Shi et al., 2015).

A peer reviewed journal article by Ryan & Euler (2017) states that temperature monitoring stations in strategic locations is an effective way to monitor the temperature of a mine site. By incorporating the use of monitoring systems the health safety officers on the site can observe and keep data which can be used for research and finding the temperature that promotes optimal efficiency of workers at the mine (Ryan & Euler, 2017).

Administrative controls:
Screening tests can be used to screen the employees before they are hired to ensure that they are fit for work. This can be done by using their body mass index (BMI), partnered with aerobic capacity tests (Maurya et al., 2015b). These tests are designed to exclude people with pre-existing conditions that are effected by heat (Maurya et al., 2015b).

Work cycles that coincide with compulsory water breaks can be useful as these rest cycles have shown that they effectively decrease the heat stress of the worker as well as improving productivity as a side benefit (Maurya et al., 2015b). The work-rest cycles are even more effective when partnered with compulsory water and salt replenishment breaks as this replaces the salts and water that is lost through sweating and counteracts dehydration (Maurya et al., 2015b). This can be made further productive by providing the workers with water bottles (Maurya et al., 2015b).

The workforce can also be *educated* on the risks and hazards of heat and what processes are occurring in their bodies to maintain a healthy physical state (Maurya et al., 2015b).

Properly implemented *health and safety medical protocols* are necessary in controlling the risk of heat illness (Maurya et al., 2015b). Protocols should be regularly implemented as a way of early detection of heat illnesses. They can be as simple as a healthy urine colour chart on the toilets for workers to monitor themselves and as intense as checking the temperature of workers regularly (Maurya et al., 2015b).

Personal Protective Equipment:
Personal protective equipment (PPE) can also be used as a last resort against heat. The PPE that is compulsory to be worn on mine sites, such as clothing and gloves, must be designed in such a way so that it does not impact on the body's natural cooling system. When the PPE is not correct for hot climates, such as mine a sites, this can lead to a barrier where the body cannot cool (Maurya et al., 2015b).

Conclusions

There are many risks on mine sites that endanger the workers, affect their ability to perform at an optimal rate and, more importantly, can affect the health and safety of the workers. One of the major risks to the health and safety of miners is heat, particularly in the Australian desert known for its hot weather. When not controlled effectively heat can have adverse consequences on the body that can initially result in minor illness that are easily treatable. When these illnesses are not monitored, they can often go unreported, and lead to more serious consequences such as permanent injury or even death. Heat can be controlled by engineering controls such as reducing temperatures and using a liquid nitrogen injection systems that cools down the mine. There are also administrative controls such as education and properly implemented health and safety protocols. When correct temperature controls are in place on a mine site it makes the site a lot safer and work more effective.

Limitations

The limitations of this literature review that were found in the process of researching the topic was the limited amount of recent and relevant research conducted in Australia on this topic in recent years. This is also a limitation for the industry in two ways. Australia has a very unique and hot environment which may need different controls to that of counties like America and Canada. An industry limitation was that research brings to light new information that could impact the way in which companies operate mines sites. This highlights the need for more research to be conducted and published on this topic.

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Railway Network Controllers Grind to a Halt: A Preliminary Investigation into Sedentary Work Risks and Practical Solutions

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Abstract

This paper examines the development of sedentary work practices for railway network control room workers. The railway control room is used to illustrate how subtle changes to this unique work environment have covertly led to health risks more commonly found in traditional office settings. Advancements in railway technology have been introduced to primarily increase safety, however, they have gradually led to higher levels of sedentary work in the control room and have unwittingly introduced new health risks. The complicating factor for the railways is that network controllers are faced with the added burden of extended shifts and working with safety-critical systems. To date, Human Factors / Ergonomic (HF/E) research within network control rooms has traditionally focussed on the cognitive issues that arise at the human-automation interface; therefore, few studies have focused on the new, less obvious sedentary physical risks and their emerging resultant health issues. In looking for workplace solutions, interventions are needed to reduce, or interrupt, bouts of sedentary time, rather than to focus on increasing physical activity alone. This paper discusses the increased risks associated with sedentary work and sedentary time and a number of practical solutions have been offered to support risk reduction in the railway control room.

Key words: Human factor. Ergonomics. Sedentary work. Railways. Control rooms.

Introduction

Throughout history, new technology has led to changes in job demands. As technological advancement allows, this process continues, and many jobs become sociotechnical in nature. That is, systems that require humans to interact with technology to reach work goals. The human-machine interface is often in the form of a console, visual display unit, or computer screen and frequently positioned in a fixed location often remote to operations. As the prevalence of these technologies rise and cluster together, more traditionally field-based roles are now office based and worker interactions with technology becomes increasingly stationary to accommodate technology constraints. As a result, advancements in technology are changing the way people physically move (or don't move) at work in unanticipated ways and introduce new risks that warrant investigation.

In recent years, network controllers have gradually become centralised into office based working environments. In the railways, the rise in computer-based railway control systems has encouraged greater levels of sedentary work for network controllers.

The computer-based systems that have been introduced draw the network controller's attention to visual display units to set the train routes, signals, and electrical points from a typically seated position. While it is well recognised that technology has increased the cognitive complexities of the system itself, less obvious is that this technology has increased the sedentary nature of work and decreased the physical demands of the network controller role.

Of concern to HF/E practitioners are the health-related risks associated with physical inactivity that are emerging due to the increasing use of technology. Sedentary work, and its associated increased screen time, leading to poor health outcomes have been identified as one of the six megatrends for workplace safety in the future (Horton et al., 2018). Significantly, the Sedentary Behaviour Research Network estimated that between 25% and 50% of adults in Europe and the United States of America are exposed to the health risks relating to sedentary work (Commissaris et al., 2014; Katzmarzyk, 2013; Staker et al., 2016).

These trends raise HF/E concerns, particularly for industries with safety-critical systems, such as the railways. This paper traces the evolution of train control to show how new technology has transformed what were once physical tasks into modern day sociotechnical tasks, and how these changes have led to the emergence of office-based working environments. Further, health risks associated with office-based sedentary work are highlighted, and practical solutions are offered.

The Evolution of Railway Control Work

To provide some insight into the changing nature of work for network controllers, changes in train control due to advancements in technology are briefly outlined. Initial train controllers were called railway policemen because they stood trackside and were responsible for giving trains permission to travel on the section of track under their authority. The railway policeman provided hand signals and later waved different coloured flags to relay instructions to train drivers on how to proceed (Clarke, 2014). This work was outside and physically demanding.

This system was followed by a disc and crossbar signal that removed the policemen off the track but kept them trackside. However, working near the tracks made the railway policeman vulnerable to being hit by trains (The Railway Technical Website, 2017). To improve safety, the mechanical or electric semaphore stop signals were introduced. Gradually signals became automated. Automation led to the redundancy of human trackside orders and the role of policeman was replaced by a 'signalman' who operated the new signals (Landscape Change Program, 2011).

Signal boxes were strategically placed at track junctions and spaced throughout the railway network. This allowed the signalmen to set routes, by operating points levers, and to set signals for train drivers from within the signal box (The Railway Technical Website, 2017). This new role required signalmen to walk between various pieces of equipment within the signal box to set the train path and to signal track authority by manipulating the many levers, handles and buttons within the signal box (Cunliff, 1968). Even when the first automated signals were introduced, the points operations remained a manual task. The points were connected directly by a rod that travelled hundreds of metres through to the signal box and was operated by signalmen pushing and pulling a lever from inside the signal box (Clarke, 2014). While the job title and tasks changed, the nature of work within the signal box remained physically demanding. While many signal boxes remain operational today, they are gradually being phased out. In the United Kingdom, 800 signal boxes are being replaced with a dozen centralised control centres, a project soon to be complete within the next few years (Network Rail, 2015). Centralised control entails thousands of kilometres of signalling cabling to be installed along the network. Advancements in signalling and communications have improved many of the inefficiencies within the rail system as well as the safety of the operator and passengers (Clarke, 2014). Consequently, greater levels of automation are highly sought after, due to their contribution towards a safer railway; hence, centralised control centres continue to emerge.

Essentially, the modern control system allows the network controller to maintain safety by authorising train movement, maintaining train separation, and the safety of track workers. Tasks are achieved using the technologies within the control room that remotely provide an interface to the railway system. Therefore, a large part of a controller's working day involves monitoring screens, managing track activity, communicating with train drivers, and responding to alarms and emergency events (Grozdanovic, Janackovic & Stojiljkovic, 2016). Due to the safety-critical nature of their work, the quick and effective response to unwanted events is therefore imperative. Presently, train control requires human intervention to react to visual cues for the authorisation and protection of these various workgroups (Charalambous, Fletcher & Webb, 2015; Roth et al., 1999). Therefore, to maintain a safe railway, the network controller must remain actively attentive and present at the workstation throughout the entirety of their shift (Balfe et al., 2012). The nature of this work revolves around the interface technology, which tethers the network controller to the workstation.

While no longer physically demanding, the outcome from these technological advancements is that workers are spending more time at their workstations in a sedentary state (Healy et al., 2012). These changes are notable, and researchers recognise that automation has introduced new HF/E issues within the network controller's role (Farrington-Darby et al. 2006). The changes in technology and human error issues arising from the technology demands soon led HF/E researchers and practitioners to shift their focus away from the signalmen manual musculoskeletal risks to primarily focus on the cognitive influences from the introduction of technology (Bainbridge, 1983; Balfe, Sharples & Wilson, 2015; Endsley & Kiris, 1995; Hollnagel, 1998; Jones, 1995; Reason, 1997; Yang et al., 2012). While it will never be prudent to revert to the older systems, it is also not yet practical for the railway system to become fully automated, and at present someone must monitor and manage the system when necessary (Lenior et al., 2006). Of concern here is that automation has increased the sedentary work of the network controller, with around seven hours per day screen time not unusual. To date, the HF/E issues associated with a reduction in physical activity and the resulting sedentary screen time in control rooms has received relatively little attention (Grozdanovic, Janackovic & Stojiljkovic, 2016). Nevertheless, since the modern railway control has become sociotechnical by nature, it is pertinent to draw information from research that has focused on sedentary risks associated with typical office workers to detail the extent of the problem.

Methodology

A systematic review of English articles was performed using Google Scholar and University library databases including MEDLINE, Cochrane, PsychINFO, SPORTDscuss, and EMBASE. Additional studies were identified through back-searching, bibliographies. The articles found discussed current theories of human factors. Several were qualitative research. Group fuzzy analytic hierarchy process, naturalistic and simulated studies were identified. There was a considerable amount of research that had been aimed at cognitive issues, automation and design human factor related issues. More generally in the past five years the research has been coming out of the United Kingdom, Serbian Rail and Australia that related to the physical ergonomic and environmental human factors, although only limited studies are specifically targeted at control room ergonomics within railways. Overall, there were 140 publications and one PhD thesis obtained and examined with publications ranging from 1968 to 2017. Publications that were not peer reviewed or appropriate were excluded, leaving 77 relevant publications included in this study. A Code of Practice 64 articles, 6 reports, 3 professional web pages and 3 books are included as references in this article.

The Extent of the Problem

Researchers report that the more time that a person remains sedentary, the more they are exposing themselves to the sedentary time associated risks. This includes the time that a person sits at work, drives a vehicle, at home and during leisure time (Dunstan et al., 2010, 2012; Thorp et al., 2014). Sedentary time is a combination of the activities that a person would conduct throughout their daily life, excluding the time spent sleeping. As it is, a large percentage of a 24-hour period is spent displaying sedentary behaviours, with adults having been found to spend between eight to nine hours during the day sedentary (Straker et al., 2013). By 2008, the moderate intensity of daily physical activities had reduced from 48% to 20% (Grunseit et al., 2013). These changes were related to the introduction of computers, automation, and mechanisation that reduces physical work (Choi et al., 2010).

In an office environment, sitting for prolonged periods is a regular task that is undertaken by most workers. In a study conducted on 4500 office workers, 81% reported some sort of sitting at work, and 23% reporting sitting all the time when they worked (Straker et al., 2016). Research from Denmark confirms that workers spend three-quarters of their work time sitting, with other developed countries reporting over 70% of workers are spending one-third of their waking hours at work, working within sedentary tasks (Grunseit et al., 2013). Research which examined over 200,000 Australian adults showed that prolonged sitting was significantly associated with higher all-cause mortality risk and suggested that sitting was responsible for 6.9% of the deaths studied (van der Ploeg et al., 2012). In the United States during the 1960s, 15% of employees worked in sedentary jobs, and by 2010, this figure increased to approximately 25% (Straker, 2016). These studies show that sedentary time at work is on the rise and a concerning global trend.

The Human Cost

Physical inactivity and prolonged sitting have been linked to the onset of chronic disease. The World Health Organisation (2013) estimate that 3.2 million people die prematurely because of an inactive lifestyle, exacerbated by sedentary behaviours at work. In Australia, the ill health effects that are caused by a lack of physical activity have been ranked second only to tobacco smoking (Straker & Mathiassen, 2010). Researchers are concluding that sitting for prolonged periods of 4 hours put the person at an increased risk of cardiovascular disease, type 2 diabetes, premature mortality, and other chronic illnesses (Chau et al., 2015; Callaghan, 2015; Commissaris at al., 2014; Dunstan, 2010; Dunstan et al., 2012; Healy et al., 2012; Jiwakanon & Mehrotra, 2013; Katzmarzyk, 2010, 2013; Straker et al., 2013, 2016; Thorp et al., 2009). Globally, the human cost of the lifestyle related illnesses is high and increasing. Therefore, since the rising levels of sedentary work are contributing to these costs, there is good evidence for taking this trend seriously and worthy of further investigation.

Sedentary work has also been found to contribute to musculoskeletal disorders (MSD), with a worker sitting for prolonged periods without changing their posture having a 50% increased risk of musculoskeletal injury (Gerr et al., 2002; Westgaard & Winkle, 1996). In Victoria, this has been estimated to cost on average AUD $7400 per case (Worksafe Victoria, 2006) and across Australia, the expected cost of musculoskeletal disorders is estimated to be more than AUD $11 billion (Australian Institute of Health and Welfare, 2005). When seated at a desk, the centre of mass is directly above the ischial tuberosity, and these sitting bones provide an unstable posture as they act as a pivot to allow the individual to lean forward (anterior posture) to complete desk work. When the worker leans forward, their centre of mass is in front of the ischial tuberosity. This affects the person when they sit for a prolonged period, as the body's load is moved to supportive locations by the ischial tuberosity and the surrounding soft tissues (Pope, Goh & Magnusson, 2002). However, with no lumbar support the intradiscal pressure increases by 35% compared to standing. Other office-based studies identified low trapezius activities occurred for up to 20% of the working day (Straker & Mathiassen, 2010) and that lower back pain is also caused by fixed postures, prolonged sitting, and awkward postures (Pope, Goh & Magnusson, 2002).

Sitting and Ill-Health Indicators

Extensive research has shown that the longer people sit, the more they are at risk of acquiring a chronic illness and/or premature mortality. Epidemiological researchers have measured the effects of sedentary behaviour by examining biomarkers in the blood, such as glucose and serum triglycerides (Dunstan et al., 2012; Hamilton et al., 2008). The elevated presence of these biomarkers indicated cardiometabolic risk factors that rose with sedentary time, and elevated readings indicated increased susceptibility to chronic diseases such as cardiovascular disease and type 2 diabetes (Chau, 2015; Chau et al., 2015; Commissaris et al., 2014; Dunstan et al., 2010, 2013; Healy et al., 2008; Healy et al., 2012; Jiwakanon & Mehrotra, 2013; Katzmarzyk et al., 2009, 2013; Matthews et al., 2012; Straker, 2013; Straker et al., 2016; Thorp et al., 2014). However, a reduction in these blood markers is seen if prolonged sitting time is reduced throughout the day (Champion et al., 2018).

Sedentary behaviour is usually displayed during sitting or reclining (Dunstan et al., 2010; Katzmarzyk, 2013; Straker et al., 2016) and characterised by an energy expenditure of 1.0 - 1.5 multiples of the basal metabolic rate (METS) (Commissaris, 2014; Katzmarzyk, 2013). Moderate-to-vigorous physical activity involves an energy expenditure of at least 3 METS, while higher energy expenditure from increased physical activity has been found to reduce the risk of cardiovascular disease and type 2 diabetes. Researchers commonly use accelerometers and heart rate monitors to measure energy expenditure as an indicator of risk of developing lifestyle related chronic illnesses (Dunstan et al., 2012). To date, none of this research has been conducted on the sedentary nature of the network controller's job and is therefore yet to be reported.

The current tasks that are conducted by a network controller is unlikely to require energy expenditure exceeding 1.5 METS, as the network controller predominately conducts office-based duties placing them into the sedentary worker category. However, the exact expenditure warrants further research. If the energy expenditure does not exceed 1.5 METS, the network controller's role needs to be understood to ensure rail providers are aware of the associated risks of sedentary work to maintain the workforce's health. In general, the ability to achieve adequate levels of physical activity is increasingly difficult for most people who work in a society that encourages prolonged sitting. Particular if the job requirements tether the worker to their workstation, as is the case for network controllers. Currently, it appears that the onus to reduce sedentary behaviour at work is on the worker, who may need to find other activities throughout the day and outside of work to increase energy expenditure to maintain optimal health.

Assessing the Risk

There are no dedicated standards that might assist workplaces with the assessment of sedentary work for the purpose of health and safety risk reduction (Callaghan, 2015). Due to this, there is a significant difference in the approaches used in workplaces to manage health risks. The issue with non-prescribed rules is that workplaces with little knowledge of the problem will not identify the risks. Further complicating the matter is that risk perception is inconsistent between individual beliefs, attitudes, behaviours, and knowledge (Johnson, 1993). Many organisations and people perceive sedentary tasks as the absence of hazardous manual work. Tasks like lifting a heavy object or repetitive movement on a production line are recognised as hazardous due to the energy expenditure needs. However, the health risks associated with sitting for prolonged periods where there is no exertion and no force exerted goes unattended. This results in the absence of sedentary tasks being assessed and reduces the likelihood of the sedentary risk being consistently managed in relation to a person's health, including the musculoskeletal system (Vladimir 2016). In cases where national or international guidance for ergonomic issues do not yet exist, HF/E experts offer that a railway-specific standard should be developed (Crawford, Toft & Kift, 2013). In light of these findings, consideration of ways to reduce sedentary work should be included when designing work systems and the work environment.

In relation to Australian legislation, the model laws set the standard for state legislation. Regulations 60 and 61 of the model *Work Health and Safety Regulation* (2011) specify how to manage the work-related risks associated with hazardous manual tasks. These provisions include sustained postures, and further elaborated as prolonged sitting, standing or otherwise prolonged static postures in the associated Code of Practice (Safe Work Australia, 2016). Even though legislated provision is made for the risk management of hazardous manual tasks, tasks that involve sitting for extended periods continue to be engineered into the working lives through social norms (Dunstan et al., 2012). This is a cultural problem, and therefore, requires a cultural shift to change the behaviours of those involved in task design. To achieve a consistent risk management approach to be used within Australia, Safe Work Australia, recommends using the risk management framework identified within the AS ISO 31000:2018 Risk Management Guidelines, and to apply the hierarchy of control measures when reducing the risk (model *Work Health and Safety Regulation* (2011), r. 36).

Practical solutions

Public health authorities have recommended 30 minutes of moderate to vigorous physical activity five days a week to maintain good health (Dunstan et al., 2012). However, the efficacy of this guidance is coming into question (Helmerhorst et al., 2009; Weed, 2016). Rather, researchers recommend that if the health effects of sedentary work are to be combatted workplace interventions should aim to not only increase physical activity, but more importantly aim to break up and reduce sedentary time (Chau et al., 2010; Kirk & Rhodes, 2011; Tremblay et al., 2010). Therefore, the following solutions will focus on these three aims, with an emphasis on reducing sedentary time.

Aside from the aims of the intervention, researchers put forward that workplace interventions are more effective when workers participate in planning, risk assessment and risk intervention decision making (Driessen et al., 2012**;** Healy et al., 2012; Parry et al., 2013). This approach is called participatory ergonomics (PE). A useful tool developed in Australia is the Participatory Ergonomics for Manual Tasks (PErforM) program (Burgess-Limerick et al., 2007). The program follows a simple participatory approach whereby workers are involved in the overall risk management process from discomfort identification through to intervention decision making. However, it should be noted that while many researchers have reported positive health outcomes and productivity gains from applying the PE approach (Vink, Koningsveld & Molenbroek, 2006), others have found PE to offer poor cost-effectiveness (Driessen et al., 2012). If there is little guidance provided on the approach, this may influence its success (Haines, Wilson & Vink, 2002).

Work Breaks

One way to interrupt sedentary time is to implement a break routine with short breaks every 20-30 minutes being recommended (Worksafe Victoria, 2006). Positive findings have been reported when breaks are taken in a consistent manner (Dunstan et al., 2012) and micro-breaks consisting of 30 seconds to 3 minutes taken throughout the day produces positive results (Atlas & Deyo, 2001; Dunstan et al., 2013; Hamilton et al., 2008; Worksafe Victoria, 2006). Another way to interrupt sedentary time is to design short bursts of physical activity into the working day. These programs promoted healthier workers and workers developed changed views on what constitutes healthy exercise (Mainsbridge et al., 2014). Another sedentary time breaker is to alternate postures through job rotation. This has been found particularly useful when the worker performs the same repeated task, with researchers finding that exposure to musculoskeletal risks were reduced (Callaghan et al., 2015). The implementation of break regimes or changes that break up bouts of sedentary time provides practical solutions that can be implemented immediately at minimal cost.

Sit/Stand Desk Working

While technology has been flagged as a culprit for increasing sedentary time, the next set of interventions utilise technology to reduce sedentary time with greater physical activity. A highly popular solution is the sit to stand desk. Some have identified sit to stand desks as the currently preferred method by many workplaces for reducing sedentary time at work (Hadgraft et al., 2016; Healy et al., 2012; Husemann et al., 2009; Straker et al., 2013; Thorp et al., 2014). Researchers have investigated the effects of sit-stand alteration regimes with sit to stand desks. Regimes found useful included 60-minute (Callaghan et al., 2015), and 30-minute change over routines (Roelofs & Straker, 2002). In support of alternating sit-stand regimes, Krause et al., (2000) argues that too much standing can lead to Carotid atherosclerosis (narrowing of the carotid arteries). If planning to implement sit to stand desk, researchers recommend a balanced approach be taken when alternating sit-stand postures and advises to stop standing if any pain is experienced (Callaghan et al., 2015). While highly popular, the establishment of a timed sit-stand regimes offers relatively low-risk control reliability.

To combat discontinuance, one study examined the effectiveness of a timed lighting system that was mounted on the computer screen. The light would illuminate to indicate when to start and finish break sessions. Breaks ran every 15-minutes, with an alternating micro-break regime. Three micro-breaks were 30 seconds in length while stretching exercises were conducted during the three-minute micro-breaks. Results showed a positive response by participants with the workers reporting a reduction in discomfort in problematic musculoskeletal areas (Healy et al., 2012). The study also showed that these lighting devices helped to manage the behaviour and motivation of the workers and therefore warrants consideration and further investigation in network controller settings.

While not a primary concern for workers, researchers also examined the effects of sit to stand desks on worker productivity. However, the evidence was mixed. Chau et al., (2015) found no impact on productivity compared to those who sat at normal desks (Chau et al., 2015); while other researchers reported ambiguity regarding productivity gains or losses (Neuhaus et al., 2014; Torbeyns et al., 2014). Therefore, more research is needed in this area before conclusions can be drawn about their impact on productivity.

Slow Walk and Work Treadmills

Another intervention to reduce sedentary time while increasing physical activity, takes the sit to stand concept one step further with the incorporation of slow walking treadmills at workstations. While this trend is yet to be extensively tested and is probably unheard of in a railway control room, it is worthy of mention and further consideration in the future. The slow walk and work treadmills operate at reduced speed, as low as 1.2 to 3.5 $km.h^{-1}$ (Champion at al., 2018; Rogers et al., 2017) and researchers examined whether increased exercise at work promoted cognition, however, results were inconclusive. Studies showed no effect was found on cognitive ability (Rogers et al., 2017) or executive function (Larson et al., 2015) however, Labonte-LeMoyne and colleagues (2015) found that workstation treadmills had a delayed, yet positive effect on recall and attention. As walking treadmills do not appear to have any negative effects on cognitive function or decision making, they may have a place in a network control room. Workstation treadmills also showed positive results for reducing the risk of chronic illness, evidenced by a sudden drop in blood glucose and triglyceride readings when workers accumulated two hours of walking in 10 to 20-minute bouts throughout the working day (Champion et al., 2018; Charalambous et al., 2017). While these findings show promise more research is needed to validate these early findings.

Mobile Applications and Wearable Technology

Some technological solutions that could allow for greater work mobility include emerging advancements in voice and motion mobile applications and emerging wearable technologies (Stephenson et al., 2017). These technologies are worth exploring since they may allow network controllers basic control of the network while moving around the control room and returning to their workstation if more in-depth interaction with the network is required. While an emerging area, these solutions may provide an answer to being tethered to the workstation and poses an interesting area of future research and development.

Conclusions

Sedentary behaviour has been traditionally linked to office workers however, over time, the continual technological advancements to improve the health and safety of railway workers, and the wider public, has seen the introduction of highly automated systems. This emergence has resulted in an once field-based activity and role, now also becoming office-based within a network control centre. Prompts to improve railways over time and train movements has embedded the role into a complex railway sociotechnical system, whereby the network controller now works intimately with an automated system to control train traffic. For the most part, safety has been improved, however, and somewhat ironically, is that these changes have introduced new and unexpected health risks to network controllers. The rise in automation that reduced physical workload has led to a rise in sedentary work, as the network controller conforms to technology constraints. Advancements in technology have gradually reformed train control which is now more reflective of a traditional office-based environment.

Several practical solutions were highlighted to provide organisations and network controllers themselves with a way forward to reduce the risk associated with sedentary work practices. The success of these interventions would include a participatory HF/E focus and interventions should aim at reducing or interrupting sedentary time including the incorporation of schedule breaks, sit-stand routines that disrupt sedentary time and change the working posture, and perhaps in the not so farfetched future, workstation treadmills to break bouts of sedentary time and encourage movement.

Finally, it was recommended that technology should be embraced that allows for greater freedom of movement while controlling the network. This may include wearable technology, or voice and motion activated mobile applications. This paper has shown that office-based concerns about sedentary work now extend beyond traditional office environments and into the railway control room environment. It is just one example of the growing emergence of office environment work due to technology advances throughout the world. Therefore, similar concerns about sedentary work are likely to extend to other working situations across many industries that are also embracing the rise in information communications technologies.

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Effective Health and Safety Measures in Reducing Work-Related Musculoskeletal Disorders in Australian Industries

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Abstract

This literature review provides an overview of effective health and safety controls and ergonomic principles with a focus on manual handling related injuries, specifically Work-related Musculoskeletal Disorders (WMSDs) in Australian industries which are a significant problem in Australia, affecting a wide range of Australian industries. Drawing from credible, newly peer-reviewed publications and government agency reports, this review aimed to examine and elaborate from comparative perspectives on existing effective health and safety and ergonomic interventions in order to minimise Work-related Musculoskeletal Disorders in Australian industries. The findings of this review suggest that strictly adhering to effective health and safety controls and ergonomic principles can decrease the chance of WMSDs. Effective strategies include the implementation of task-specific mechanical aids and control measures such as job rotation, rest breaks and team handling. Adopting these measures has the potential to prevent a worker from developing WMSDs while performing physically demanding tasks. Findings also indicate that minimising exposure to risk factors that contribute to the development of WMSDs should be taken into account in Australian industries. Existing publications indicate that risk factors such as force, repetition, duration, awkward posture, vibration, compression and temperature are leading contributors to the development of WMSD injuries.

Key words: Manual handling. Work-related Musculoskeletal Disorders. Health and safety.

Introduction

Manual handling is attributed to activities, which requires users to impose force to lift, carry, pull, push, move, lower, or restrain items (McDermott et al., 2012; Safe Work Australia, 2018b; Stack et al., 2016). Manual handling related injuries, such as musculoskeletal disorders (MSDs) are recognised as the most common form of injuries in industries (Safe Work Australia, 2018a). Work-related musculoskeletal disorders (WMSDs) refers to a broad range of degenerative illnesses or non-traumatic inflammation of the musculoskeletal system (Stack et al., 2016; Stock et al., 2018). These conditions include impairment to bones, joints, cartilage, muscles, tendons, ligaments, nerves, blood vessels and spinal discs (Hogan et al., 2014; Stack et al., 2016).

A broad range of industries, such as health care, social assistance, manufacturing, construction, transport, retail, mining, food and accommodation services, administrative and support services, agriculture, forestry, fishing, education and training are widely affected by WMSDs injuries (Safe Work Australia, 2020; Safe Work Australia, 2018a).

WMSD injuries are not just an industrial problem but also influences the quality of life, health, can cause serious economic losses, lost work time and absenteeism (Dormohammadi et al., 2012; Yao et al., 2019). In Australia there were 360,180 severe WMSD injury and illness cases between 2009 to 2014, equalling 60% of the total number of workers compensation cases during these five years (Safe Work Australia, 2016). In 2017-2018 there were 93,890 severe WMSD injuries claims in Australia accounting for 40% of the serious WMSD injuries (Safe Work Australia, 2020). The median lost time from work increased by 35% due to serious MSD injuries between 2000 to 2013, from 4.3 working weeks to 5.8 working weeks (Safe Work Australia, 2016). Whereas, the median lost time for MSDs claims increased by 29% (Safe Work Australia, 2016). The median cost of compensation for severe MSD cases increased 59%, from $5,600 in 2000 to $8,900 in 2013; while, the median compensation for all MSDs cases increased by 71% (Safe Work Australia, 2016). In Australia WMSD injuries account for the majority of the employee's compensation costs (Safe Work Australia, 2019).

Researchers have identified key risk factors leading to the development of WMSDs. These are force, repetition, duration, awkward posture, vibration, compression and temperature (Stack et al., 2016). In addition, organisational or psychosocial risk factors, such as poor work deigns, lack of autonomy, poor job satisfaction, quotas, distress, alongside personal risk factors, including, age, gender, physical fitness and structure, existing medical conditions and work techniques contribute to the development of WMSDs (Stack et al., 2016). According to Stack et al. (2016) the risk factors mentioned above can result in strains or tears to muscle, tendons, ligaments, decrease in blood flow, cause compression, elongation, as well as damage to nerves, discs and joints. Applying effective health and safety controls using ergonomic principles decreases the chance of WMSDs occurring and reduces exposure to WMSD risk factors (Stack et al., 2016; Sultan-Taïeb et al., 2017).

This review's purpose was to examine and elaborate from comparative perspectives on existing effective health and safety and ergonomic interventions in order to minimise work-related musculoskeletal disorders in Australian industries.

Methodology

In this literature review, the selection process of sources was principally via the databases of Curtin University Library. The inclusion criteria of this paper were all study designs, credible source types, such as *Articles*, *Government Documentation*, *Books*, *Book chapter* and *Reviews* while mainly focusing on newly published peer-reviewed journal articles, such as publications between 2010 to 2020 and systematic reviews addressing WMSD. The exclusion criteria were source types, such as *Conference Proceedings*, *Text Resources*, *Newspaper Articles* and *non-English papers*. The inclusion and exclusion criteria were to ensure the credibility of this review and to ensure the information was recently published and relevant to this review's aim.

The primary resource used to conduct research was the Curtin Library catalogue using the keyword terms *Work-related Musculoskeletal Disorders*. Approximately 75,000 publications were generated. The generated publications were filtered down to display publications eligible to meet the inclusion criteria. The results declined to about 28,000. Almost 65 abstracts were read; however, only 15 publications were read completely as these were the most relevant to the researched topic.

Further academic services including Google Scholar, ProQuest, PubMed, ScienceDirect, Ebook Central, Taylor & Francis Web and Wiley Online Library were accessed through the webpage of the Curtin University Library. The various keyword terms *Work-related Musculoskeletal Disorders*, *Risk factors*, *Australian industries*, *Workplace design*, *Mechanical aids*, *Training*, *Team Handing*, *Posture*, *Rest breaks*, *Job rotation* and combinations of these keyword terms were utilised to have a more refined and relevant research. The various keywords were used to help in identifying comparative perspectives on existing effective health and safety and ergonomic interventions preventing or reducing WMSDs. This study also examined the reference lists of key publications via scanning the title, published date, and abstract to identify additional beneficial academic references to review for this paper.

Much of the research was focused on publications of the Australian Government agencies related to WMSDs. Specifically, WMSDs policies and procedures, effective health and safety practices as well as ergonomic principles. Hence, searches were conducted on Commerce Western Australia (Department of Mines, Industry Regulations and Safety), Safe Work Australia, Australian Government Comcare and National Institute for Occupational Safety and Health. Here keyword terms were *Work-related Musculoskeletal Disorders.* Numerous Australian Government publications were selected and used for this review.

The selection process of sources, inclusion and exclusion criteria of this paper remained the same for any online resources that were employed in this literature review.

Manual handling industries and WMSD injuries are commonplace in developing countries, however, this review was restricted to Australian industries only. Hence, the review was limited in examining the extent of WMSDs injuries and the impact of these injuries in industries on a global scale, especially as the occurrence of WMSDs is a result of performing improper manual handling. In Australia, recent publications of industrial WMSDs are nearly non-existent with government agency reports being the primary reference of WMSDs. There was a substantial amount of WMSDs publications focussing on other countries such as Canada, America, France and numerous developing countries, but very limited Australian based peer-reviewed journal articles were available. A total of 18 articles, 5 government publications and one book (24 publications) are cited in this article.

Discussion

Introduction

There are multiple study gaps which existing academic studies have not adequately explored and addressed. The examination and elaborations of health and safety controls and ergonomic principles are not industry-specific, while the studies and government legislations have investigated and applied controls and principles under a generalised lens. The practices and principles should be addressed under a more refined scope, with interventions being tailored to the respectable industry based on the aspects unique to the workplace.

Mechanical aids

Mechanical aids are a task-specific intervention mainly focussing on the provision of various equipment which has the potential to eliminate or minimise a worker from improper manual handling while performing physically demanding tasks (Safe work Australia, 2019). Mechanical aids reduce the demand to carry, lift or support objects (Safe work Australia, 2019; Safe Work Australia, 2018b). The reductions of physical force and loads are highly likely to eliminate or minimise the risk of WMSD injuries (Safe work Australia, 2019).

A task specific intervention aims to minimise loads on workers' muscles through adjustments to workstations (Safe work Australia, 2019). An example of a task specific intervention is moving work from floor to seating positions (Afshari et al., 2015; Ferguson et al., 2012), devices which enhance visual acuity (Aghilinejad et al., 2016; Hayes et al., 2014), mechanical lifting devices that minimise load carrying (Armstrong et al., 2017; Dormohammadi et al., 2012), redesigning agricultural equipment to adjust to workers' body shapes (Singh et al., 2012), ergonomic keyboards and work stations that can be adjusted to fit various body sizes (Smith et al., 2015), changing the bench design for woodwork so that the height and space is suitable for the work performed (Sudiajeng et al., 2012), and tripods with an overhead elevation to aid drilling (Rempel et al., 2010).

Wide-ranging mechanical types of equipment are accessible and implementable to reduce WMSD injuries in various industries. These include vacuum lifting devices, mechanical and hand stackers, conveyors, cranes, turntables, lift tables, lift trolley, lifting hoists, loading dock levellers, forklifts, tractor-trailer trains, platforms trucks, pallet trucks, duct, plaster lifters, glass panel and more (Safe Work Australia, 2018b). According to the recommendations of the Australian Model Code of Practice mechanical aids in industries need to be designed to suit:

1. A range of diverse users, the work type, the environment the tasks are utilised in, and the task loads (Safe Work Australia, 2018b).
2. The mechanical equipment should be easy to utilise, light, adjustable and safe (Safe Work Australia, 2018b).
3. Most importantly workers must be given, as far as reasonable, adequate information, instruction, training and supervision to avoid risks associated with new equipment arrangements (Safe Work Australia, 2018b).

Job Rotation

This administrative intervention aims to prevent WMSDs at an organisational level, specifically addressing team handling, rest breaks and work rotation performing tasks that use different muscles. According to the Australian 2018 Model Code of Practice, job rotation allows workers to perform different tasks which increases task variation and can also decrease the risk of developing WMSD (Safe Work Australia, 2018). This statement is supported by numerous studies which have suggested job rotations as an effective intervention for preventing WMSDs (Comper et al., 2017).

Effective job rotation prevents WMSDs by reducing the duration of workers exposure to risk factors of WMSDs such as awkward or static postures, load-lifting and repetitive movements (Asensio-Cuesta et al., 2012). Moreover, a well-designed rotation plan requires tasks to be adequately different to ensure recovery of muscles as well as allowing different muscles to be used in a different way (Safe Work Australia, 2018b). Practices that increase task variation include change of workstations, items used, and breaks from repetitive tasks via carrying out a different type of task (Safe Work Australia, 2018b). Job rotation has been reported to reduce monotony and boredom (Azisi et al. 2010), as well as work stress and absenteeism while increases job stratification (Asensio-Cuesta et al., 2012). Despite some reported benefits of job rotation in reducing the occurrence of WMSD in industrial environments, several studies that previously evaluated job rotation have indicated that it can be an ineffective intervention in preventing WMSDs (Comper et al., 2017) so this strategy is not as successful as eliminating the need for performing repetitive muscle work.

Rest Breaks

Frequent rest breaks provide rest opportunities for workers to prevent the build-up of lactic acid in muscles and to recover from fatigue in the muscle groups used for performing hazardous manual tasks, such as involving awkward postures, repetitive-long duration movement, static movement, execution of high force, vibration, rigorous mental demands or monotonous manual tasks (Safe Work Australia, 2018b).

The time of muscular fatigue depends on the human energy system being used. For aerobic muscle activity fatigue is cause by the depletion of muscle energy sources or inadequate oxygen in the muscles. Aerobic muscle activity is a long duration energy system that uses energy sources in food such as fats and carbohydrates (glycogen) in combination with oxygen to produce Adenosine triphosphate (ATP). ATP transports chemical energy with in cells for metabolism.

ATP-CP is a very short duration energy system. Adenosine Triphosphate stores in the muscle last for approximately 2 seconds and the resynthesis of ATP from Creatine Phosphate (CP) will continue until CP stores are depleted which is in approximately 4 to 6 seconds. This provides around 5 to 8 seconds of ATP production. To develop this energy system sessions of 4 to 8 seconds of high intensity work at near peak velocity are required. For anaerobic muscle activity fatigue is caused by the depletion of stored glycogen in the muscles and depletion of available ATP and CP. Anaerobic muscle activity is a short duration energy system generally used for less than 2 minutes. It uses stored glucose to produce ATP with the unwanted by products of lactic acid and hydrogen ions.

The rest break duration and frequency depend on the particular type of industry and the nature of tasks (Safe Work Australia, 2018b). Generally, recovery depends on how much force, static movement or awkward posture is required, thereby the longer the exposure to this risk factors the greater duration required for recovery (Safe Work Australia, 2018b). More frequent and smaller breaks, such as micro-pauses, are extremely effective for recovering and resting in comparison to a few longer breaks (Safe Work Australia, 2018b).

Team handling

'Team handling is a team of two or more workers handling tasks together (Safe Work Australia, 2018b). Working as a team has its risks and requires effective coordination to be safe while working together (Safe Work Australia, 2018b). Australian legislation suggests team handling should only be utilised until a more efficient control measure, such as eliminating the requirement to lift or move by redesigning manual tasks and allowing the use of mechanical aids is being applied, if there is a regular requirement for team handling (Safe Work Australia, 2018b).

Team handling has the potential to increase the risk of developing WMSDs in situations, such as when the load is unequally shared, simultaneously unequal amount of force exerted or when workers are readjusting their hand or foot which leads to an unequal share of loads while supporting team members (Safe Work Australia, 2018b). Lastly, while performing a manual handling task on a slope or steps or when workers suddenly lose their grip, leaving most of the weight on other team members (Safe Work Australia, 2018b).

The weight and difficulty of the load should be reasonable for the number of workers present (Safe Work Australia, 2018b). Each team member should be appointed a task and be aware of their responsibility for the lift; capability and height should be taken into consideration (Safe Work Australia, 2018b). A member must also be nominated to direct the operation (Safe Work Australia, 2018b). Training must be provided prior to the operation, including rehearsals for the circumstance in which the plan is not taking place accordingly to Safe Work Australia, (2018b). The appropriate aids should be utilised to support handling and in training, for example, a stretcher, slings, straps, lifting bars, lifting tongs, trolleys and hoists (Safe Work Australia, 2018b).

Conclusions

This review's purpose was to investigate comparative perspectives of different publications on existing health and safety and ergonomics concerning WMSDs in Australian industries. The interventions employed, such as task-specific mechanical aids and control measures such as job rotation, rest breaks and team handling can reduce and the burden of WMSD severe economic loss across Australian industries and can be implemented to reduce the number of severe WMSD injuries. The best way to reduce the number of manual handling related injuries is to use the hierarchy of risk control measures that begins with the need to eliminate the need for people to perform manual handing tasks. Numerous studies have supported the findings of the interventions used in this paper. It is recommended that future research should be conducted on industry-based interventions which can prevent WMSDs for workers across Australia.

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Noise Hazards Assessment in Effurun Sawmills, Delta State, Nigeria

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Abstract

The study assessed the level of noise hazards at sawmill factories in Effurun and its environs. A digital sound level meter was used to obtain the noise level reading from the field. The highest value obtained was 114.8dBA at a distance of 1.0 meters from the noise source while the lowest value was 73.5dBA at a distance of 15.0 meters from the noise source. The noise pollution level on the sawmill workers could cause hearing impairment. Therefore, the workers who carry out their daily routine work in these sawmill factories are at the risk of noise induced hearing loss which would definitely occur overtime (cumulative effect). Risk control recommendations are made.

Key words: Noise. Hazards. Assessment. Pollution. Impact.

1. Introduction

A sawmill, or lumber mill, is a facility where logs are cut into lumber. Before the invention of the sawmill, boards were made in various manual ways, either rived (split) and planed, hewn, or more often hand sawn by two men with a whipsaw, one above and another in a saw pit below. The circular motion of the wheel was converted to a reciprocating motion at the saw blade. Generally, only the saw was powered, and the logs had to be loaded and moved by hand. An early improvement was the development of a movable carriage, also water powered, to move the log steadily through the saw blade.

By the time of the Industrial Revolution in the 18th century, the circular saw blade had been invented, and with the development of steam power in the 19th century, a much greater degree of mechanization was possible. The arrival of railroads meant that logs could be transported to mills rather than mills being built besides navigable waterways. In the 20th century, the introduction of electricity and high technology furthered this process and now most sawmills are massive and expensive facilities in which most aspects of the work are computerized. Besides the sawn timber, use is made of all the by-products including sawdust, bark, woodchips and wood pellets, creating a diverse offering of forest products.

The need for noise investigation in sawmill factories was shown in previous studies (Aremu *et al, 2015)*. The results obtained from those studies showed that the noise levels in the sawmill factories were far beyond the United States of America Occupational Safety and Health Administration (OSHA)'s permissible exposure limit (PEL) which is 90 dBA. Thus, the noise pollution level can cause hearing impairment in the sawmill workers.

Previous studies (Aremu *et al, 2015)* have shown that the level of noise induced hearing loss and other adverse effects acquired from noise related occupations are high in sawmill workers. Noise can also cause physical and psychological stress, reduce productivity, interfere with communication and concentration, and contribute to workplace accidents and injuries. Unwanted or high noise levels can make it difficult to hear warning sounds, make employees susceptibility to mistake as they are unable to concentrate, cause irritation, and sleeping and social discomfort. OSHA sets a legal limit on noise exposure level in the workplace that is 90 decibels per 8-hour workday (Agbalagba *et al*., 2013; OSHA, 2013). From the foregoing, it is important that noise levels in sawmill factories be studied hence the choice of the topic, “Noise Investigation in Sawmill Factories”.

Noise and vibration are both fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term 'noise' to indicate unwanted sound. Noise and vibration can harm workers when they occur at high levels and continue for a long time (OSHA, 2013).

Noise can be broadly classified into occupational and domestic type. Occupational noise is derived from the workplace environment where industrial equipment/machines, such as heavy duty machines, generators, aircrafts, sawmill machines, pumps and fans blades that emit noise, whereas examples of domestic noise are those derived from municipal and domestic sources such as road traffic, grinders, vehicular sirens and musical system (Agbalagba *et al*., 2013; Owate et al., 2005).

Industrial noise pollution herein may be any undesired sound originating from industrial machines or equipment that poses a threat to man and his environment. Noise can startle, annoy and interrupt concentration, sleep, and speech communication and consequently interfere with job performance and safety as well as the physiological effect such as noise-induced hearing loss or aural pains (Avwiri & Nte, 2003).

Noise is measured in units of sound pressure levels called decibels, using A-weighted sound levels (dBA). The A-weighted sound levels closely match the perception of loudness by the human ear. OSHA also sets legal limits on noise exposure in the workplace. These limits are based on a worker's time weighted average over an 8-hour day. With noise, OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8 hour day (OSHA, 2013).

Exposure to high levels of noise can cause permanent hearing loss. Neither surgery nor a hearing aid can help correct this type of hearing loss. Short-term exposure to loud noise can also cause a temporary change in hearing (ears may feel stuffed up) or a ringing in ears (tinnitus). These short-term problems may go away within a few minutes or hours after leaving the noise. Long-term exposure to environmental noise may result in cardiovascular diseases such as high blood pressure, heart disease and stroke, annoyance; sleep disturbance, decreased school performance, besides hearing problems (Basner et al., 2014).

Sound is inevitable for effective communication among humans in the workplace, for instructions and for warning signals when there is an emergency but it becomes noise when disrupts or interferes with one's of normal activities such as working, sleeping and during conversations. When there is a lot of noise in the environment beyond certain limit, it is termed as noise pollution. It is an underrated environmental problem because of the fact that it cannot be seen, smelt, or tasted. Most machinery and manufacturing processes generate noise as an unwanted by-product of their output. Typical examples of noise and vibration sources in the industrial environs include; impact noise associated with punch processes, sewing machines, motors, generators and other electro-mechanical devices, unbalanced rotating shafts, gears, steam or gas flows in piping systems, pumps, compressors, washing machines and vibrating panel (Anjorin et al., 2015; Dasarathy, 2015)

Occupations at highest risk for noise induced hearing loss (NIHL) include those in manufacturing, construction, transportation, mining, agriculture, and military. The mechanism of noise generation depends on the particular noise operations and equipment including crushing, riveting, punch presses, drilling, pneumatic equipment, tumbling barrels, dividing and metal cutting such as punching, pressing, lathes, milling machines and grinders as well as pumps and in-plant conveying systems. Equipment induced vibration is widely recognized as a health hazard (Bibhuti and Anup, 2006).

Noise is a physical stressor to which many people are exposed to at work place (Uzorh, 2014). Variation in the Nosie levels occur at different times of the day is as a result of the business flow of such area Farouq (2016). High level noise exposure in women during the development period of a foetus is a stressor that may increase the risk of implantation failure, dysregulation of placentation or decrease of blood flow into the uterine (Farouq, 2018; Ristovska *et al*., 2014).

2. Methodology

Study Area/ Method of Data Collection

The study was carried out in sawmill factories in Effurun and its environs in Delta State of Nigeria. The data needed for this research work was collected using measuring instrument, the instrument used was a digital sound level meter to get the noise levels of the sawmill factories.

Figure 1

Digital Sound Level Meter

Note. From Extech 407730 Instruments, 2014.
Note. From Evidence-Based Critical Care (p. 108), by P. E. Marik, 2015, Springer (https://doi.org/10.1007/978-3-319-11020-2). Copyright 2015 Springer International Publishing.

Table 1

Noise Dose using Reference duration for noise, T table.

A-weighted sound level, L (decibel)	Reference duration, T (Hour)	A-weighted sound level, L (decibel)	Reference duration, T (Hour)	A-weighted sound level, L (decibel)	Reference duration, T (Hour)
80	32	97	3.00	114	0.290
81	27.9	98	2.60	115	0.250
82	24.3	99	2.30	116	0.220
83	21.1	100	2.00	117	0.190
84	18.4	101	1.70	118	0.160
85	16	102	1.50	119	0.140
86	13.9	103	1.30	120	0.125
87	12.1	104	1.10	121	0.110
88	10.6	105	1.00	122	0.095

89	9.2	106	0.87	123	0.082
90	8.0	107	0.76	124	0.072
91	7.0	108	0.66	125	0.063
92	6.1	109	0.57	126	0.054
93	5.3	110	0.50	127	0.047
94	4.6	111	0.44	128	0.041
95	4.0	112	0.38	129	0.036
96	3.5	113	0.33	130	0.031

Note. From "Climate Change Impact on Rainfall and Temperature in Muda Irrigation Area Using Multicorrelation Matrix and Downscaling Method," by N. Tukimat and S. Harun, 2015, Journal of Water and Climate Change, 6(3), p. 654. (https://doi.org/10.2166/wcc.2015.015). Copyright 2015 by IWA Publishing.

When the sound level, L, is constant over the entire work shift, the noise dose, D, in percent, is given by:

$$D=100\ C/T$$

where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L, as given in Table 1 above or by the formula:

$$T=8/2(L-90)/5$$

where L is the measured A-weighted sound level.

When the work shift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the workday is given by:

$$D = 100\ (C_1/T_1 + C_2/T_2 + ... + C_n/T_n)$$

where C_n: indicates the total time of exposure at a specific noise level, and T_n shows the reference duration for the level as given in Table 1.

For an eight-hour work shift with the noise level constant over the entire shift, the time-weighted average (TWA) is equal to the measured sound level.

$$TWA = 16.61\ \log_{10}(D/100) + 90.$$

3. Results

The results of the study are given in Table 2. Table 2 shows time weighted average of the noise level (in decibels) for all four locations at different distances from the nose source (1.0m, 2.0m, 7.0m and 15.0m) for four weeks in four different locations where the average work period was eight hours daily. The daily average was used to get the weekly average and the weekly average was then used to get location average, Dose (%) and the Time Weighted Average (TWA) for each of the sampled locations (Table 1 and Table 2).

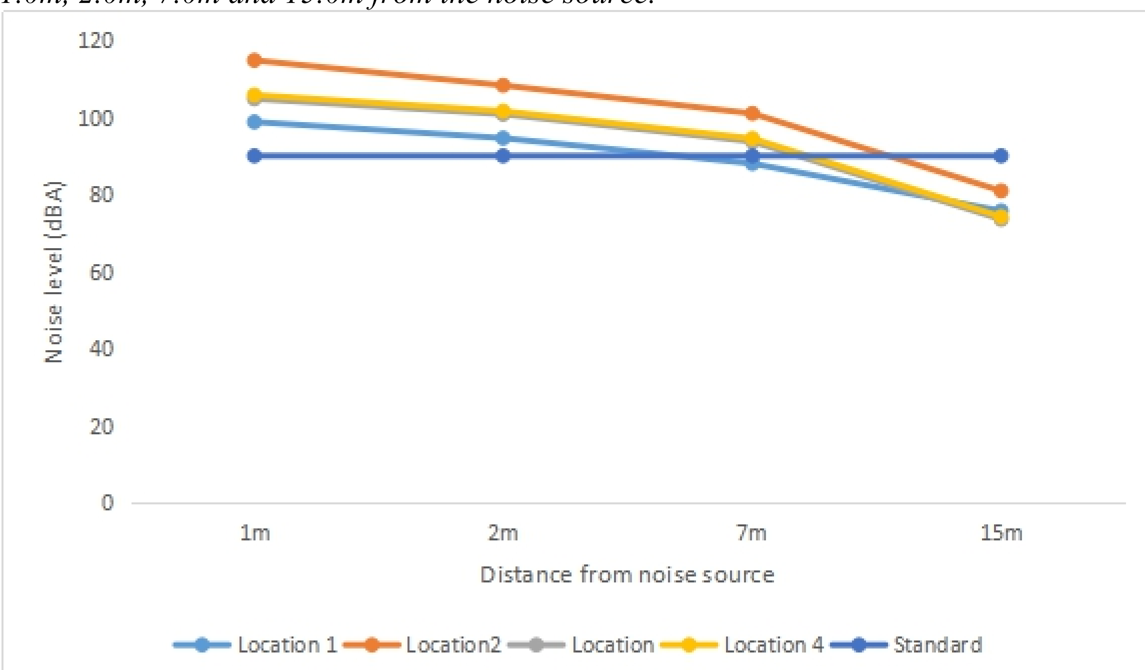
Table 2

Time Weighted Average of the Noise Level (in decibels) for all four Locations at 1.0m, 2.0m, 7.0m and 15.0m from the noise source.

Location	1.0m	2.0m	7.0m	15.0m
LOCATION 1 dBA	98.8	94.6	88.0	75.7
LOCATION 2 dBA	114.8	108.3	101.0	80.9
LOCATION 3 dBA	104.8	100.8	93.7	73.5
LOCATION 4 dBA	105.8	101.6	94.5	74.2

Figure 1

Line graph showing the time-weighted average of the noise level (in decibels) for all four locations at 1.0m, 2.0m, 7.0m and 15.0m from the noise source.



4. Discussion of Results

From the Table 2 results it was observed that the lowest values (73.5dBA – 80.9dBA) of the noise were obtained at 15.0m from the noise source which falls within the acceptable limit of OSHA and the number of workers at this point are usually about 2-3 on an average. The highest values (98.8dBA – 114.8dBA) of the noise were obtained at 1.0m from the noise source which falls beyond the acceptable limit of OSHA. The number of workers here are usually 4-5 on an average.

This proves that the further away from the noise source a person is, the lesser the effect of the noise on the person and the closer a person is to the noise source the more the effect of the noise on such person. In comparison to a similar work done by Agbalagba et al., (2013), all the locations that were sampled in this study, some complied with the standard acceptable limit

5. Conclusions and Recommendations

The needs for noise hazards assessment in sawmill factories environment in Effurun and its environs has been demonstrated in this research work. The measurement reveals that the noise level status in the four studied Sawmills are far above the OSHA recommended permissible limit for an industrial environment. The highest value obtained was 114.8dBA at a distance of 1.0m from the noise source while the lowest value measured was 73.5dBA at a distance of 15.0m from the noise source. The noise pollution level having impact on the sawmill workers could cause hearing impairment.

Therefore, the workers who carry out their daily routine in these sawmill factories are at the risk of noise induced hearing loss which would definitely occur overtime (cumulative effect). They also exposed to other effects of noise such as physical and psychological stress, lack of sleep, reduce productivity, impaired communication and concentration, it also contributes to workplace accidents and injuries by making it difficult to hear warning signals.

RECOMMENDATION

- At source, adequate maintenance and replacement of machine parts should be undertaken because faulty equipment also contributes to the noise being emitted.
- Equipment without guards should be guarded so as to reduce the noise exposure.
- Work stations can also be compartmentalized so that the number of exposed workers are reduced.
- At the path of the noise proper land use should be employed to ensure that sawmill factories are not situated near residential areas.
- Regular monitoring of the noise levels must be carried out to ensure the noise hazards have not increased.
- Regular noise assessment of the factories should be conducted to ascertain their compliance to the acceptable standard and at the receiver of the noise (workers and visitors).
- Training and enlightenment should be done regularly for the workers to be inform about the harm that can be caused by the high noise level exposure and regular auditory checkup should be done for those who work in the sawmill factory so as to know their hearing status.

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A Review of Contemporary Literature on Cognitive Ergonomics

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Abstract

Cognitive ergonomics looks at how people understand and interpret information and is user centred.. Societal and technological advancements have led to increasingly sophisticated systems of work, and with that an increase in cognitive based demands. In a modern workplace in which many workers have become operators, considerations must be made toward maximising worker cognitive capacity, reducing cognitive overload and the design of appropriate person-machine interfaces.

Key words. Cognitive ergonomics. Health. Safety. Workplace. Cognitive processes. Person machine interface. Workload.

Introduction

Cognitive ergonomics is the discipline concerned with the interactions between mental processes such as memory, reasoning, motor responses and perception, and the workplace in which they occur (Sanil, Nair & Ramanathan, 2013). The aim is to ensure the cognitive demands of work do not exceed the mental capabilities or limitations of workers (Kim, 2016). With rapid technological advancements and an ever-changing work environment, contemporary work demands are particularly cognitively straining. Cognitive strain related to work demands can impair cognitive function, task performance and can, ultimately lead to cognitive failure (Kalakoski et al., 2020). A cognitive failure is described as any cognitively-based error that occurs while completing a simple task, that a worker is expected to be able to complete without error (Kim, 2016). Cognitive failures play a significant role in human error in the workplace, which is of significant risk to workplace health and safety (Kalakoski et al., 2020). Cognition is an extremely complicated field of study. A significantly simplified model of cognitive processes includes;

1. Perception

How people see, or perceive a situation or object, directly influenced by sensory capabilities such as sight, sound, taste and touch. Enhanced understanding, as a result of education and experiences, influence the way in which incoming sensory information is perceived (Kim, 2016).

2. Attention

The focus of certain aspects of perceived information which can impact the capacity to focus on or perceive certain incoming information. It is a limited resource, and therefore must be adaptive to different situations. It may be selective, focussed, divided or vigilant (sustained alertness) (Kim, 2016).

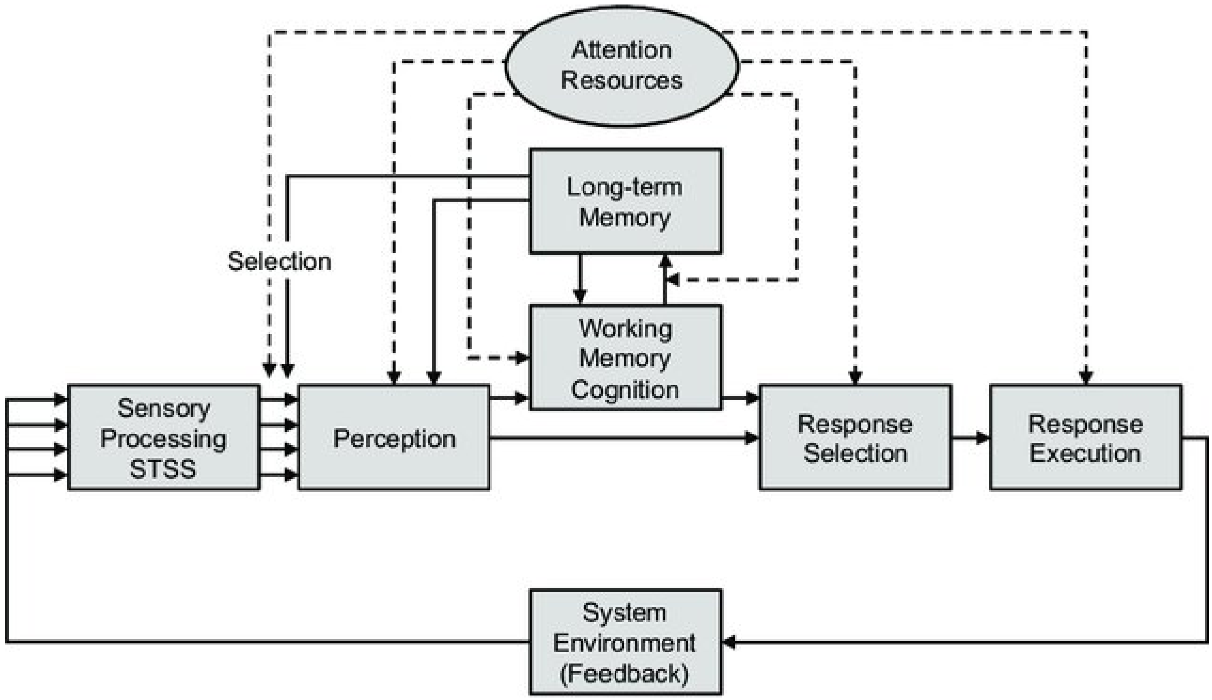
3. Short term memory

The short-term storage of information which is actively rehearsed or manipulated in the mind. It is extremely limited in capacity. All incoming sensory information is stored in the sensory storage automatically for an extremely short period of time. Sensory information that is attended to makes up the working memory. It is here where sensory information is manipulated into codes (Branaghan & Lafko, 2020).

4. Long-term memory

With long-term storage of information. information is transferred from the working memory via semantic coding (supplying meaning to information and relating to already held knowledge). Long-term memories can be either semantic (knowledge) or episodic (events) (Branaghan & Lafko, 2020).

Figure 1
A model of human information processing



Note: From *Engineering Psychology & Human Performance* (p.4), by C. Wickens, J. Hollands, S. Banbury, R. Parasuraman, 2015, Psychology Press.

These factors directly impact the way in which humans receive, process and make decisions about information or 'inputs' they are presented with (Kim, 2016). The extent to which people are able to correctly receive and interpret this information is dependent on alertness, knowledge, experiences and ability to problem solve and form new ideas.

Though some processes become automatic, humans are limited in cognitive capacity and as such, can only process a limited number of inputs at a time (Kim, 2016). In order to maximise cognitive capacity, and in doing so, increase productivity and decrease risks to health and safety, workplaces must implement a user-centred design.

Such considerations include; design and allocation of work tasks, design and placement of equipment which is to be used by people and design and correct placement of signs, which have information printed for people (Sanil, Nair & Ramanathan, 2013).

Methodology

Databases sourced from the Curtin University Library resources were used to search for relevant literature. The ProQuest data base was searched for the key words 'cognitive ergonomics' and 'workplace' and 'health and safety'. The search was limited to only include peer reviewed articles published within the last 10 years and resulted in 18 publications, 4 of which were included in the final review. The data bases *researchgate* and *Science Direct* were then searched with the same key words and restrictions, from which one further relevant publication was identified for inclusion in this article. The final 3 articles were sourced using *Google Scholar*. Eight books from the Curtin University library were also reviewed and are cited in this article.

When searching for relevant literature, the parameters could have been widened to include articles outside the window of the last 10 years. Though the field of study is relatively contemporary, many cognitive models written in the early 2000's are still widely used and accepted and provide the basis for modern theories. Many of the contemporary articles only briefly mentioned cognitive ergonomic models without going into detail and so, it was difficult to find sources for older, accepted models of thought.

Discussion

A changing workplace

The 'workplace' has evolved exponentially over recent years, and there are no signs of that change will not continue in the near future. Technological advancements, societal changes and competitive pressures have given rise to new, often complex work environments and processes. Many contemporary workplaces, as a result of machine automation, have seen a reduction in physical demands for workers, which has coincided with an increase in cognitive demands (Young, Brookhuis, Wickens & Hancock, 2014). Automation, in most cases, is implemented to improve safety and performance, however, in doing so has created drastic change in work place practices (Boy, 2011). With the implementation of new technologies, inevitably comes a period of adaption, which may be marred with an increase in work related accidents (Boy, 2011). The contemporary workplace is filled with new technologies, so it is therefore vital to ensure workers are well equipped to deal with, and adapt, to any issues which may as a result come about.

Decisions

Decision making is a cognitive process which involves selecting and executing a response to presented information (Wickens et al., 2015). There are many models and theories which try to explain decision making. One way is to categorise them as either programmed or non-programmed. Programmed decisions are those made under the guidance of established rules and procedures. Workers will rely on existing organisational structure to make the decision (Lee & Stinson, 2014). A significantly large proportion of workplace decisions will be programmed. In order to maximise workers capacity to make correct programmed decisions, workplaces should have a strong organisational structure or framework in which workers are given up-to-date, well informed information regarding rules and procedures. Alternately, non-programmed decisions are those made without the guidance of rules or procedures, relying on personal cognitive characteristics such as judgement, intuition, creativity and risk aversion (Lee & Stinson, 2014).

Generally, non-programmed decisions make up a smaller proportion of day-to-day workplace decisions. When an individual is required to make a non-programmed decision with insufficient information, is when errors are most likely to occur (Lee & Stinson, 2014). This can be controlled by ensuring workers are well trained and informed on all relevant information and placing individuals in positions which are suited to their personal cognitive skills.

In the book Managing major hazards. The lessons of the Moura Mine disaster by Hopkins (1999), there is a very good chapter on decision making. The under manager in charge of the Moura Mine had the information that the methane gas would enter the explosive range sometime after 11.30pm that day. A new shift started underground at 10.30pm. This information about the expected time of explosive range of methane gas was not communicated to the Deputy in charge of this shift. The information on the expected time that the methane gas would be in the explosive range was not easily available for the Deputy to have access to it, although the registered mine manager, the shift under manager and the under manager in charge had this information. The decision to send the miners underground when the mine Methane gas was in an explosive range was made by the Shift Deputy. Hopkins theorises that the Deputy made this decision because he was told by the shift under manager that the mine "was so safe that he would go underground and 'kiss the seals' if necessary" (Hopkins, 1999, p. 59).

Other factors that may have affected this Deputy's decision making were that, besides not being told that the methane gas in the mine was in an explosive range, if the Deputy did not take his team to work in the mine that night the Deputy would be called a wimp and the mine would not have met its production target. The mine did not have a policy stating when Deputies could refuse to take their work crew underground due to safety concerns. The Deputy was expected to make a non-programmed decision with insufficient relevant information. This story highlights the importance of people being given enough information to be able to make informed decisions about safety, that peer pressure can influence decision making and that not having a clear policy about when it was safe for mine workers to work underground cost the life of 11 men when the mine exploded at 11.35pm that night (Jansz, 2011).

Group decision making can be an effective tool to collaborate with and expand cognitive capabilities within the workplace, however group decision making is often more time consuming and may have social pressures such as conformity (Lee & Stinson, 2014).

Workload

Mental workload is a term used to describe the level of mental activity devoted by a person to a task(s) over time (Young et al., 2014). Cognitive workload increases with the cognitive demand of work tasks and can lead to impairment of cognitive performance (Kalakoski et al., 2020). Excessive cognitive workload can lead to mental fatigue, monotony if the work is repetitive, reduced vigilance and mental satiation (Young et al., 2014).

Mental fatigue is directly influenced by the intensity, duration and distribution of mental workload. If a person is presented with too much information in a short period of time, it is likely this will exceed the cognitive capabilities, due to the limited capacity of short-term memory storage, resulting in cognitive fatigue (Kalakoski et al., 2020). A worker could also be given a task with too much scope or irrelevant information, again leading to mental fatigue. For this reason, it is essential for work systems to control intensity, duration and distribution of workloads.

Monotony is a result of repetitious, easy tasks devoid of variation over an extended period of time (Young et al., 2014). This results in a lack of stimulation and reduced levels of alertness, potentially leading to cognitive failure (Young et al., 2014). Controls to limit monotony in the workplace include increased task variety, regular breaks from work, adjustments to the workplace environment and job empowerment (increased autonomy) (Young et al., 2014). Reduced alertness leads to a reduction in vigilance negatively impacting performance and jeopardising workplace health and safety. The requirement for more than 30 minutes of vigilance should be, wherever possible, controlled or minimised. Mental satiation, similar to monotony and arises from repeated performance of a task. With repetition comes a reduction in competence required to complete the task, which undermines motivation negatively impacting the attention and application given to the task (Mojzisch & Schulz-Hardt, 2007). Similarly, mental satiation can be controlled with task variety, adjusted environmental conditions and job empowerment (Young et al., 2014).

The limited capacity for humans to process and pay attention to incoming information is the reason terms such as cognitive workload exists (Young et al., 2014). Task difficulty is not necessarily indicative of the level of cognitive strain it places on the worker. Workplaces must be biased against tasks that seem 'easy' or insignificant to one person but which may be difficult for another less skilled person, and this should be considered when allocating work.

Person machine interface

Person-machine interface is the medium to which humans interact with machines (Deng, Wang & Yu, 2016). This interaction includes the receiving of information via machine displays, the subsequent cognitive processes of the operator and a response provided through machine controls. Person-machine interaction interfaces should conform to the operator's cognitive ability for interface information (Deng, Wang & Yu, 2016). The design must take into account the human processes of receiving, processing and reacting to information and create a medium tailored to maximising those processes, or consider their limitations.

There are 2 main types of machine displays, digital and analog. Digital displays present information directly in numbers. An example of a digital display is a calculator. Digital displays of information provide fast accurate information. Analog displays present information using a pointer to numbers or letters or symbols or pictures. An example of an analog display is a car speedometer. Analog displays of information are best for providing information about changing conditions, such as the temperature of a car engine; whether it is cold, warm or hot. With analog displays the colour black may be used for normal operating condition numbers and red for dangerous situations. This assists with interpreting the readings on the dial (Jansz, 2011).

Displays need to be at a height that is easily viewed by the majority of the population that will view the display. The most important dials should be at the centre of the visual line with less important controls and displays to the side. An example of the use of the central principle is that in most cars the speed display is in the centre of the display panels with the other displays of information either side. Each car usually has a circular dial display with the background and numbers around the edge of the dial in contrasting colours and a red needle that points to the speed in kilometres (or mile) that the car is travelling. Having consistent, expected information in shape and colour makes driving different cars easier to adjust to and the meaning of the information easier to understand and use. Displays of information on computer screens need to have the characters large enough to read and to follow the design principles for other machine displays of information (Jansz, 2011).

Displays and controls should, as far as is practicable, be; appropriately and logically positioned, easily interpreted, align with user expectations and legible (Millot, 2014). Determining appropriate positioning requires consideration of human variability and biomechanics (design with the limiting user in mind). In determining what is logical or expected, designs should aim to not contradict widely held norms. For example; close proximity of controls would assume a related function, red and green would assume stop and go respectively, and a loud siren would assume there is an issue (Kaljun & Dolsak, 2012). Comprehensive information on the design of machine displays and controls is included in the book Ergonomic solutions for the process industries by Attwood, Deeb & Danz-Reece (2004) pages 169-212.

Performance and safety are directly associated with the complexity of the person-machine system and the capacity for the operator to understand and deal with it (Millot, 2014). Machine automation of work processes can limit the role of the worker to a position of supervision (Millot, 2014). Instead of carrying out the cognitive processes required to manually perform a task, operators are now expected to supervise and react to unexpected situations should they arise (Millot, 2014). Though a supervisory role may seem less exertive, it can be, at times just as cognitively straining (Boy, 2011). Operators are required to exhibit vigilance (sustained alertness), make programmed decisions, and potentially non-programmed decisions, in the case of a malfunction.

Conclusions

Cognitive ergonomics is the discipline concerned with studying, evaluating and designing tasks, products, environments and systems based on the cognitive processes and capabilities of humans. Recent technological advancements have led to a decrease in physical demands placed on workers. This has, however caused an increase in the cognitive demand of workers who are responsible for working with, or on, these new automated systems of work. Cognitive workload and the negative consequences of cognitive overload are well established principles which all workplaces should take into consideration. Work environments should aim to relieve cognitive strain wherever possible with the use of relevant risk control methods. Person-machine interface should be easy to comprehend, logical, align with user expectations and be reasonably legible.

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Would Educational Institutions Focus 'Health and Safety' More Efficiently as Covid-19 Reminded?

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Abstract

Many students have been killed in several incidents at educational institutions in past years. This research article considers **w**hether 'Health and Safety' in educational settings is the need of the hour as Covid-19 reminds us. At the same times, other questions are whether educational settings updated their safety and health practices post-Covid19, and whether would this make them more safety-efficient post-Covid-19? Personal in-depth discussions/focused interviews with 342 health, safety, environment (HSE), medical, education, management, and mental health professionals across the country recommended 'health and safety management system' in educational institutions in order to avert and combat the impacts of Covid19-like risks more efficiently. These institutions also updated their workplace HSE management due to the onset of Covid-19.

Key words: Safety. Health. Education. Students. HSE. Institutions. Covid19. India.

Introduction

The death of a student due to a snakebite in the State of Kerala in India raised questions on child safety in schools, and how to prevent such incidents further (Asish, 2019). Nothing is as important as creating a safe learning environment for children. The children's deaths due to building collapses and fire accidents make it necessary for continual vigilance to ensure the safety of students and staff in schools. An incident in India of fire that killed ninety three children reiterate the need to have school emergency preparedness and response plans and to schedule practice drills to respond efficiently to occurrences that might be encountered (Government of India, 2004). Hindustan Times (2017) reported 50 deaths in two months in India revealing educational coaching centers were driving students to suicide so the HRD ministry in November 2015 proposed setting up a regulatory mechanism.

Devastating incidents elevated concerns about the safety culture in academia. The safety culture of an institution is a reflection of the attitudes, and behaviours of its members concerning safety, an organisation's collective commitment (American Chemical Society, 2012). In a fire incident, 24 students and teachers died in a religious school in Kuala Lumpur. Malaysian local media reported that since 2015, there have been more than 200 fires at such schools (Pais, 2017). The recent changing scenarios necessitates workplace HSE review.

In the United States of America during 2018–19, there were 66 school shootings with casualties at public and private elementary and secondary schools (NCES, 2020). The National Crime Records Bureau, for the year 2016, reported 11,812 deaths in India due to road crashes near educational institutions. One reason attributed for these fatalities in this age group is their lack of experience; they are prone to bad judgments i.e. risk-taking, thus getting involved in road traffic crashes (Baskar, 2020).

Recently, there is an increased emphasis on HSE in educational settings across the globe, due to Covid19. 'Health and Safety needs to be on the syllabus at all education levels as a reinforcement constantly from school to university to employment to retirement. Life-long learning helps to achieve such a global perspective to save human lives. This mission is possible when it begins with family, school and social values and a long-term orientation.

Research objectives

Objective one was to explore the perceptions of, if 'health and safety" education was introduced as a subject at schools way back, would India have seen such a huge impact of COVID-19 on its citizens, as it is now? By the 13th of November 2020, India had recorded 8,728,795 cases [2nd highest number of cases in the world] and 128,668 COVID-19 related deaths [3rd highest number of COVID-19 deaths in the world]. The COVID 19 problem in India was because the public was not following COVID-19 safe guidelines.

The second objective was to determine whether educational settings updated their safety and health practices post-COVID-19, and if the need is felt to integrate HSE as an integral part of educational institutional management.

Methodology

Participants, measures, procedure, analysis

Open-ended questions based interviews and personal in-depth discussions with 342 HSE, medical, education, management and mental health professionals were conducted through remote data collection techniques over 3-months (June-August, 2020) in India from diverse locations and organisations. Interview results were thematically analysed using pattern matching and the responses of these professionals are presented in the following themes.

Results

Responses of HSE, medical, education, management, mental health professionals

All participants agreed that if 'health and safety" education was introduced as a subject at schools way back, India would not have seen such a huge impact of Covid19 on its citizens, as it is now. In this regard, the responses of the HSE, medical, education, management, mental health professionals are in affirmative and the broad themes emerging from these specific responses are as follows:

There is a need for Health and Safety education (99%)

b. Introduce Health and Safety as a subject (98%)

c. Role of Government and institutional leadership (95%)

d. Preparedness and Implementation (94%)

e. Infrastructure like safe design of educational sites (80%)

f. Priorities and Values (70%)

g. Risk is a part of our daily life, but accidents need not be (99%)

The need for health and safety education

The following is a summary of participants' answers on this theme. Safety education should be a part of the school curriculum (Azad, 2018). The tragic death of 14 and injury of more than 45 pupils of Kakamega Primary School in Kenya as they stampeded down their school stairs is yet another reminder that our children are not safe in schools. Unless the country rises as one to boost the safety of school children, more mass deaths will continue to be reported countrywide (Donline, 2020). The professionals (99%) in India who participated in this research agreed for the need for health and safety in educational settings. They expressed that with Covid19 storming the world and humanity at large, children and students are the roots of development. Schools and colleges are the best places to develop the habit of good health and safety practices. Health and safety education is important. That is why India is behind the western world as such practical topics are not part of curriculum in schools. Health and safety is lacking in Indian basic education. It must be included in education because then Indians are educated to be disciplined and follow the standard procedure of safety, which is required to be healthy and safe in the present pandemic situation. In India, we are not a clean city or nation as such. The condition today is due to lack of awareness among the citizens. Having health and safety taught in all schools would have helped lot. Research suggests that social distancing techniques, along with careful hygiene, cleaning, and use of quarantine, can reduce the spread of disease in schools, and protect the health and safety of students, staff, and families (Melnick, et al., 2020).

b. *Introduce health and safety as a subject*

The New Education Policy is restructuring the Indian education system after 34 years, and would possibly include a HSE subject in all educational levels (Nanjappa, 2020). The professionals (98%) who participated in this research recommended to introduce health and safety as a subject in educational settings. There are many incidents where it was understood that well educated/qualified people were not aware of emergency measures to be taken. This was observed in recent fire incidents in a few of the hotels in Mumbai, then in the Surat commercial complex where there were 22 student casualties from coaching classes (Mehta, 2020). One view is that India already has health and safety subjects taught in schools but there are only bits and pieces. For example students are taught about road safety and it's consequences, but if people do not have good behaviour, there are no consequences written in school textbooks. Enough is taught in school time about the environment.

HSE is a valuable addition to Indian education. As per Citation (2020), in schools, there are environments that are considered low risk, such as classrooms, but the risks in labs, toilets, playgrounds etc. need to be evaluated and controlled. These hazards need to be assessed and risk control measures for identified hazards be put in place in order to reduce the harm.

c. *Role of Government and institutional leadership*

Ninety five percent (325) of the professionals in India who participated in this research agreed that it was important for the Government and local leadership to implement health and safety in educational settings. The integration of occupational safety and health into the educational settings is an important aspect of developing a risk prevention culture. This allows everybody, teachers and students alike, to find out the ways to live and engage in a secure and healthy environment. The educational staff must become aware of the risk factors in their working environment (Rusu-Zagar et al, et al., 2013). Government of India has implemented teaching about the environment but still needs to include at school level education for safety particularly, for general safety, fire safety, road safety and, electrical safety.

The Supreme Court of India had listed detailed guidelines and ordered that all government and private schools in the country to follow the safety measures prescribed by the National Building Code of India 2005. Until 2017, out of 500 educational institutions with the Greater Hyderabad Municipal Corporation limits, only 29 adhered to the fire safety standards prescribed by the government. Four hundred and seventy one schools failed to get the No Objection Certificate from the District Fire Officer, which ensures that the school building is well equipped with all safety measures, as prescribed by the Education department. "Putting the lives of children at risk appears to be no great matter of concern" (Government of India, 2004, p7). The National Association of Secondary School Principals (2018) strongly emphasised the need to build a culture of safety. School safety issues, especially after the shooting, by an expelled 19 year old student [he killed 17 people and wounded 17 others], at Marjory Stoneman Douglas High School in Florida, energized students when 650 school students participated in a walkout with the support of the school administration (ABC News, 2018).

d. *Preparedness and Implementation*

The Ministry of Human Resources Development (MHRD) in India issued detailed guidelines on school safety in 2014, but the implementations and safety mindset are lacking. The murder of a Class 2 student in Ryan International School (student was killed by a bus conductor who tried to sexually abuse the boy in the school bathroom) raised uncomfortable questions, despite the large body of regulations whose implementation is sloppy (Chowdhury, 2017,).

For effective implementation of HSE, the educational institute is required to deploy structures such as annual risk assessments, planned walk-through inspections, training events, meetings, replacing sub-standard infrastructure, introducing new equipment and refurbishing key locations (Rapid Global, 2020). The Indian professionals (94%) who participated in this research stressed the requirement for the preparedness and implementation for health and safety in educational settings. Even now when the COVID 19 problem is at the doorstep, some state governments are playing politics rather than focusing on the problem.

It is important to build a positive safety and health culture, fixing the foundation to shape pandemic preparedness. If there are guidelines on infection control from when a student first commences school, the population would be safer when there was a pandemic. There are some very basic things also people cannot follow for health and safety because there is no orientation, hence they don't understand the importance. Broadly, there are three phases of preparing organisations for a positive health and safety culture. These are orientation and awareness, rollout action plan and implement it, monitoring and sustaining. Grenada Elementary School (2018) has a School Safety Plan that includes a comprehensive emergency management plan by which families are encouraged to establish major emergency family protection plans.

e. *Infrastructure like safe design of educational sites*

A question was asked whether education alone would make people safe? Some research respondents reported that infrastructure matters. Parents and teachers called for stringent safety measures in school buses, following a seven-year-old school-boy being run over by his own *school bus* while crossing the road (Iyer, 2019). Eighty percent of the 342 professionals interviewed for this research emphasized the requirement for infrastructure that included safe design of educational sites, the school building and buses etc. Interviewed respondents stated that the educational institutions should install a fire safety system under which mechanisms for the detection of a fire, the warning resulting from a fire and standard operating procedures for the control of fire are evolved. This may include sprinkler systems or other fire extinguishing systems, fire detection devices, stand-alone smoke alarms, devices that alert one to the presence of a fire, smoke- control and reduction mechanisms and fire doors and walls that reduce the spread of a fire. Students and staff should be trained to effectively operate the firefighting devices. Mock drills for fire situation should be undertaken at least once in a semester (University Grants Commission, 2020).

f. *Priorities and Values*

Statistics from the National Crime Records Bureau show that nearly 43 children die in road accidents across the country every day*, and i*n 2015 alone, more than 400 school-children were killed in bus related incidents and 15,633 children were killed in road accidents across India in 2015 (Bhatia, 2017). Indian traditional basic priorities are still "Roti, Kapda aur Makan" (food, dress, house) and the education system is also laid down on Indian basic priorities. Seventy percent (240) of the professionals who participated in this research emphasised the requirement for a change in the priorities and values of the educational institutions. It was stated that the safety and health concept has to emerge as an organisational value and priority. The school education on HSE alone, may not have brought the COVID-19 numbers to Zero, but definitely would have reduced the number of infections and deaths. In India the number of COVID-19 cases were also influenced by poor safety consciousness, poor knowledge, poor health infrastructure, over population etc. A behavioural change among people can be stimulated by:

a) Ideal behaviour has to be modelled and brought to light by social proof and

b). Change and adaptation has to be made easy.

As per Department of Education (2020), ensuring health and safety in schools is an essential part of any school manager's responsibility and to do this successfully, an effective health and safety management system needs to be in place.

g. *Risk is a part of our daily life, but accidents need not be*

For accidents not to happen, the inevitable risks need to be reduced to manageable level. Almost 99 percent of the professionals who participated in this research believed that the risk is a part of daily life, but accidents need not be. People take some calculated risk in life to see some achievement. Sometimes, there are some unknown risk not calculated and taken into consideration all the time cause trouble. If analysis on the unknown risks, such as natural disasters, was performed, accidents could be avoided. Risk involves uncertainty about the effects/implications of an activity with reference to something that humans value (such as health, well-being, wealth, property or the environment), often reflecting on negative, undesirable consequences. Accidents can be controlled only if risk is mitigated. An accident is result of risk overlooked or underestimated.

Believing that risk is part of our daily life but accidents need not be, schools need to make sure that staff, pupils and visitors are safe. Schools need to make sure that, as the citizens of tomorrow, pupils are helped to become risk-aware without becoming unnecessarily risk-averse. In this sense 'teaching safely' and 'teaching safety' need to go hand in hand (RoSPA, 2020, p3).

Conclusions, Recommendations and Implications for Social Policy Planning

Conclusions

Conclusions related to research objective 1

The first research objectives that was pursued was *if 'health and safety" education was introduced as a subject at schools way back, would India have seen such a huge impact of COVID 19 on its citizens?*

Many thousands of students were killed in road incidents around educational institutions as reports revealed and research shows more than half a million vehicle collisions on roads around schools in UK from 2006 to 2011, resulted in more than 85,000 child casualties (Withnall, 2013).

The concept of safety and health culture challenged the institutions once again due to COVID-19. The findings reviewed 'health and safety in educational settings' by way of seven areas of concern, such as the felt need and importance of health and safety education, introducing it as a subject, role of government and leadership, preparedness and implementation, infrastructure. For example, safe design of educational sites, priorities and values for educational institutions to focus on it in a systemic way, and the risk is a part of our daily life, but accidents need not be.

Research respondents said that if 'health and safety" education was introduced as a topic at schools way back, India wouldn't have seen such an enormous impact of COVID-19 on its citizens, as it is now. In this regard, a safety veteran said, "I endorse, support and advocate this since the day I opted to become a professional safety man" (Chakarborty, 2020, personal communication). A school Principal having 30 years of experience in education, Jose Kurian reiterated that no doubts about implementing health and safety in schools. Moreover, there are so many other very important value orientations like sense of cleanliness, social responsibility, respect for public property, respect for others and their belongings and many more. COVID-19 scenario is a reminder for all this, Research conclusions are that people need such orientation and reinforcements. However, the educational institutions needed expert guidance on implementation of health and safety standards and procedures. Importantly, the HSE professionals highlighted on HSE value as belief that if one firmly believed that all accidents could be avoided, then only one can avoid accidents, otherwise, they will keep happening.

Conclusions related to objective 2.

The second objective was *to determine whether educational settings updated their safety and health practices post-COVID-19, and if the need is felt to integrate HSE as an integral part of educational institutional management.*

The educational institutions acquired gains in HSE domains due to onset of COVID-19. Research findings were that schools are more safety conscious than before which needs to be sustained and become an integral part of their management system. It is necessary for schools to manage safety and security in order to prevent accidents/incidents, creating an environment for physical, emotional and social well-being. These institutions promote safety, only to meet regulations, without any sensitivity and commitment. It is necessary to mainstream safety processes integrated in school management, involving all the educational community (Vicario, 2017). A fire incident took place at Delhi University's College; two classrooms were charred, even as all universities and schools were shut across the country due to the coronavirus pandemic (Bhandari, 2020). Research results indicated that it is time for educational institutions to learn to manage health and safety more efficiently. The current situation requires institutions to consider and implement all possible solutions to ensure the safety of students, their parents and our staff (Awasthi, 2020). In Mumbai, the Early Childhood Association and Association for Primary Education and Research updated guidelines as well as allowing each school to have a safety coordinator to ensure the implementation of safety procedures and these guidelines (Borwankar, 2020).

Recommandationss and Implications for social policy and planning

UNESCO (2020) is engaged in empowering schools and their communities in the identification of the hazards and risks they are exposed to, their vulnerabilities and their capacity to manage them. The goals of this Comprehensive School Safety framework are: to protect children and education workers from death and injury in schools; to plan for educational continuity in the face of expected hazards; to strengthen a disaster resilient citizenry through education; and to safeguard education sector investment.

Recommendation 1

All professionals, participants of this study agreed that If 'health and safety" was introduced as a subject at schools way back, India would not have seen such a huge impact of COVID 19 on its citizens, as it is now. All educational institutions are recommended to prioritise and value the same. Hence to avert and combat any health and safety risk and its impact (such as COVID 19) more efficiently for the country's citizens, the main recommendations are in the areas that need to focus the attention of decision makers in education/HRD sectors, that there is a strong need for health and safety education to be emphasised by the Governments and the concerned stakeholders. It is recommended to include the introduction and implementation of health and safety as a subject to be prioritised and valued, and also to provide emphasise upon the infrastructure/safe design of educational sites.

Recommendation 2

Based on the research findings it is recommended that every classroom that can seat more than 45 students must have two exits and the fire drills should be conducted once in six months. Heads of such centers must conduct fire audits as recommended by Aditi, (2019). Like industry, HSE systems in educational institutions brings results when they are implemented successfully along with safe design of educational sites, safe infrastructure and procedures as well as regular behavioral reinforcements.

Recommendation 3

Research recommendation 3 is to introduce safety and health into the schools syllabus. Some of the HSE basics, need to be added in Indian school syllabus according to the level of education. For example, for kinder-garden students, there is a need to learn how to handle sharp needle pencils and how to wash their hands for their own hygiene. Similarly for the engineering or science students, an environmental and safety subject should be included. once it becomes the practice on their day to day activities. It is recommended that a positive safety culture be established as this would help removing industrial accidents. A safety professional said, "we should incorporate the inputs at an early level of the educational system. If we focus now on the generation who are going to take charge of society in coming years, then it will give results". HSE is an important part of all educational institutions to carry out risk assessments for buildings as well as school buses to foresee and minimise risk to students, staff and other stakeholders.

Recommendation 4

The educational institutions that don't implement HSE system for caring the human assets of their nations need to be warned for closure/ banned as they misuse public money due to the losses in the incidents and fatalities that take place, and then they claim the funds from insurance companies. Its a double loss of human life and public properties.

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Circadian Rhythms Safety Issues Associated with Lack of Sleep For Emergency Service Workers

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Abstract

Sleep is an incredibly important part of the human system and has a circadian rhythm of approximately 24 hours. If sleep is missed or interrupted constantly, the circadian rhythm desynchronises and therefore changes the homeostatic functions in the body. This has an effect on cell health and cell function and therefore can disrupt emotional stability, concentration, physical health and safety competency. This is especially important for emergency medical service workers as they are the first to respond to a health emergency scene or incident and as such are expected to make an accurate assessment and follow the correct procedure before deliverance to medical care in a hospital. Recommendations and reasons to provide better care and attention to the health and safety of medical services are made in this article based on a review of published literature.

Key Words: Circadian Rhythms. Sleep. Stress. Concentration. Shift work.

Introduction

Human beings are living organisms, and just like all living organisms' systems exist, especially for sleep. The human psychological system is cyclic in nature as humans eat, sleep and work in a cyclic natureand for sleep it should have a circadian length (Kuhn, 2001). A circadian length indicates that the activities conducted happen around the same time each day. For example, sleeping at night and waking up in the day is relative to the environmental cues presented by the light and dark cycle which are circadian in nature. However, this can also change due to seasonal variation with winter and summer, where the hours of daylight are longer or shorter (Kuhn, 2001). The body's natural processes of maintaining homeostasis (metabolism, hormone secretion, cardiac, brain and pulmonary activity) are all circadian in nature as well (Valdez et al, 2014).

Sleep is an essential physiological process that is required to give a rest to other body functions, to enhance the immune system and memory by reducing consciousness (Bryant, Trinder, & Curtis, 2004; Mignot, 2008). Sleep deprivation is the outcome of incomplete sleep or inadequate sleep or a combination of these factors (Malik & Kaplan, 2005). A healthy adult must stay in bed for nine hours to get enough physiological sleep time (National Research Council, 2012). However, some people are able to perform work at a normal pace even after 6 hours of physiological sleep each night, but ultimately this lack of sufficient sleep may result in cumulative fatigue and poor performance (Van Dongen, Maislin, Mullington, & Dinges, 2003).

Most shift work schedules that happen are commonly understood as being "nine-to-five" for a normal workday, however there are many different work schedules that are beyond this typical time, which can have early morning work, sometimes possible 12-hour shifts, or even night-shift, where the work begins at night (Boivin & Boudreau, 2014). According to an American and European survey 15 to 30 percent of adults who are working are engaging in some form of shift work. In this study 19 percent of the European population was reported to conduct at least 2 hours of work between the hours of 10pm to 5am (Boivin & Boudreau, 2014). With disruptions to sleep schedules, this can bring shift work sleep disorder which was found in 2-5% of workers (Boivin & Boudreau, 2014). It is characterised by excessive sleepiness, and/or possible sleep disruption for approximately one month and is in relation to an atypical work schedule. Part of the problem for this is the fatigue that workers face and the associated risks that come with fatigue (Castro et al, 2015). The management of fatigue is very relevant for the topic of ergonomics in many fields of work, particularly transportation, as operating heavy machinery or other machines has the potential to cause serious harm to other if not done so correctly (Castro et al, 2015). Fatigue is an especially important factor to keep in mind for shift work employees, such as flight cabin crew or those working in emergency services. Cabin crew have to deal with alternating levels of light and changing time zones. Medical service people have to face physical and mental health challenges as part of their work. All individual's bodies are unique and fatigue cannot be measured on a scale as it also changes for a person depending on their rest breaks, their workload and their current mental and physical condition (Castro et al, 2015).

Methodology

Resources were obtained using the Curtin University Library. The key words "Circadian Rhythms and work" were typed into the search bar, and from there the results obtained were filtered through a tag-based search. Only those that were 'peer reviewed', had a creation date within the years 1990 to 2020 were considered. Science Direct, as accessed through the Curtin University Library was the most favoured as a resource as there was readily available journal articles, documents and books with valid, correct information and facts and figures. 'Circadian rhythms' was used as the key words to search for sources. A total of 25 articles and 4 books are cited in this review.

Discussion

There are several factors that a worker has to go through with their daily life that can alter or affect their circadian rhythms in such a way that is extremely harmful to the person themselves, as well as potentially being able to cause harm to others from the person having a lack of concentration or awareness. If workers were able to be educated about quality of sleep and rest, and taught techniques to deal with fatigue, this would better everyone and create a safer working environment. This should be able to be done, even with seasonal changes and workload differences.

The Importance of Sleep

Sleep is essential for the brain to function properly, as well as maintaining proper homeostatic functions (Wilson & Nutt, 2008) and the loss of sleep can cause an assortment of problems, such as mood swings or changes, impairment in the cognitive department, abnormal and altered hormonal rhythms (Wilson & Nutt, 2008). Also, when an individual does eventually fall asleep, there is evidence to suggest that the increase in the homeostatic functions of the body is to compensate for the earlier lack of sleep – that is to say, the more tired you are when you fall asleep due to lack of sleep, the more you have to rest to recover (Wilson & Nutt, 2008). Adults, that is to say those over the age of 18 years old, are expected to sleep for a roughly 7 – 8 hours a night. Sleeping less than 6 hours can induce a sense of dissatisfaction within adults, in the form that they feel as though they haven't slept enough (Wilson & Nutt, 2008). This is because the way sleep is regulated by the body is through a circadian process and the recovery (homeostatic) process (Wilson & Nutt, 2008).

Figure 1

Bar Graph: Hours of reported sleep on weekends (dark blue) and weekdays (light blue).

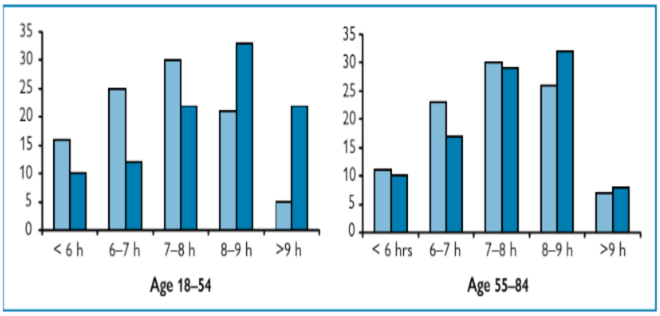
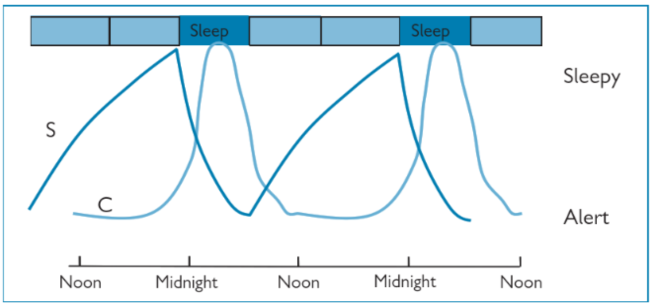


Figure 2

Line Graph: The process of sleep, indicated by circadian sleep propensity (light blue line) and homeostatic sleep process (dark blue line).



Note: From *Sleep Disorders* (p. 2) by S. Wilson, & D. Nutt, 2008. (https://ebookcentral.proquest.com/lib/curtin/reader.action?docID=975606&ppg=72)

As can be seen from the bar graphs, those aged between 18 to 54 years old have large differences between the hours slept on weekdays and weekends versus those that are of the older age group, 55 – 84 years of age. This is most likely because the workforce mostly consists of those aged between 18 – 54 and their recovery period is on the weekends, also as indicated by the graph (Wilson & Nutt, 2008).

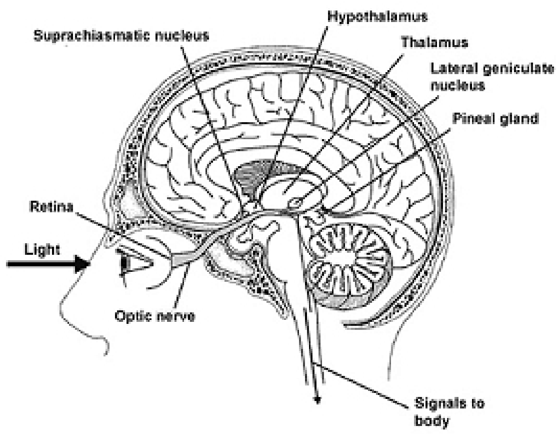
These arches seen in the second line graph are caused by the body clock cells within the body, the genetic mechanism is caused by a group of cells in the SCN (suprachiasmatic nucleus) of the hypothalamus (Vitaterna et al, 2019). These cells provide a pattern that oscillates with activity every 24 hours which also drive liver function, hormone release and other bodily functions (Wilson & Nutt, 2008). The only other factors this mechanism is affected by is mainly light, however temperature has a slight effect as well (Wilson & Nutt, 2008).

These ‘clocks’ are present in all animals; however their timing and period of oscillation are dependent on particular genes, and through the trough these genes we can also see where possible sleep disorders may be present (Vitaterna et al, 2019), as although this mechanism begins to drive at around 11pm, and reaches it’s peak at approximately 4am (as seen from figure 2), those with sleep disorders still find it extremely hard to sleep during this time period (Wilson & Nutt, 2008).

Circadian rhythms are physical, mental and behavioural changes that follow a roughly 24-hour cycle, responding primarily to light and darkness in living biological organism’s environment. Circadian rhythms are endogenous and they are continuously synchronised with the external environment (Curie & Franken, 2012). At present, there is a broad range of literature available that provides the evidence of circadian rhythms disruptions and its health effects on the population. However, due to circadian rhythm disturbance long latency period before having chronic ill health effects its importance has been largely ignored.

Every living organism has a body clock that helps them to keep their functions to follow a certain pattern. The biological clock produces and sustains circadian rhythms in order to maintain physiological, biochemical and behavioural parameters such as core body temperature, triacylglycerol, blood pressure, sleep wakefulness, alertness, mental performance, and the synthesis and secretion of many hormones including melatonin, cortisol, prolactin, and growth hormone (Rajaratnam & Arendt, 2001). The research on molecular studies proves that circadian rhythms are formed by interactions between body clock genes and body clock proteins which remains same between species (Clayton, Kyriacou, & Reppert, 2001). The suprachiasmatic nuclei, in which the human body circadian clock is located, are a small group of brain cells located on either side of the midline at the base of the hypothalamus (Moore, Speh, & Leak, 2002). See the following figure 3.

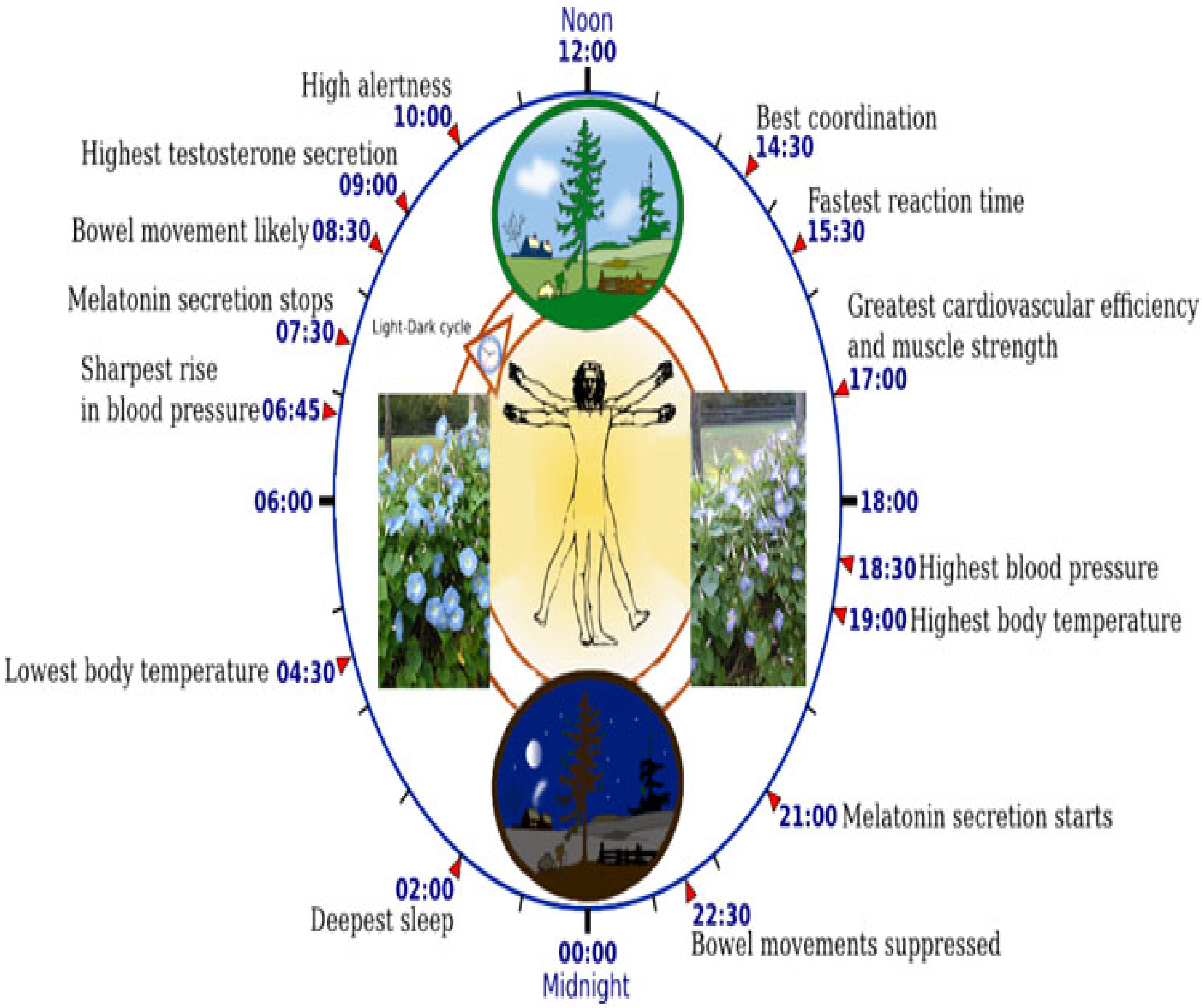
Figure 3.
Suprachiasmatic nucleus.



Note. From Sleep (p. 3), by L. Mastin, 2016. (http://www.howsleepworks.com/how_circadian.html)

Figure 4 is a diagrammatic representation of the human body’s activities in relation to their circadian rhythm.

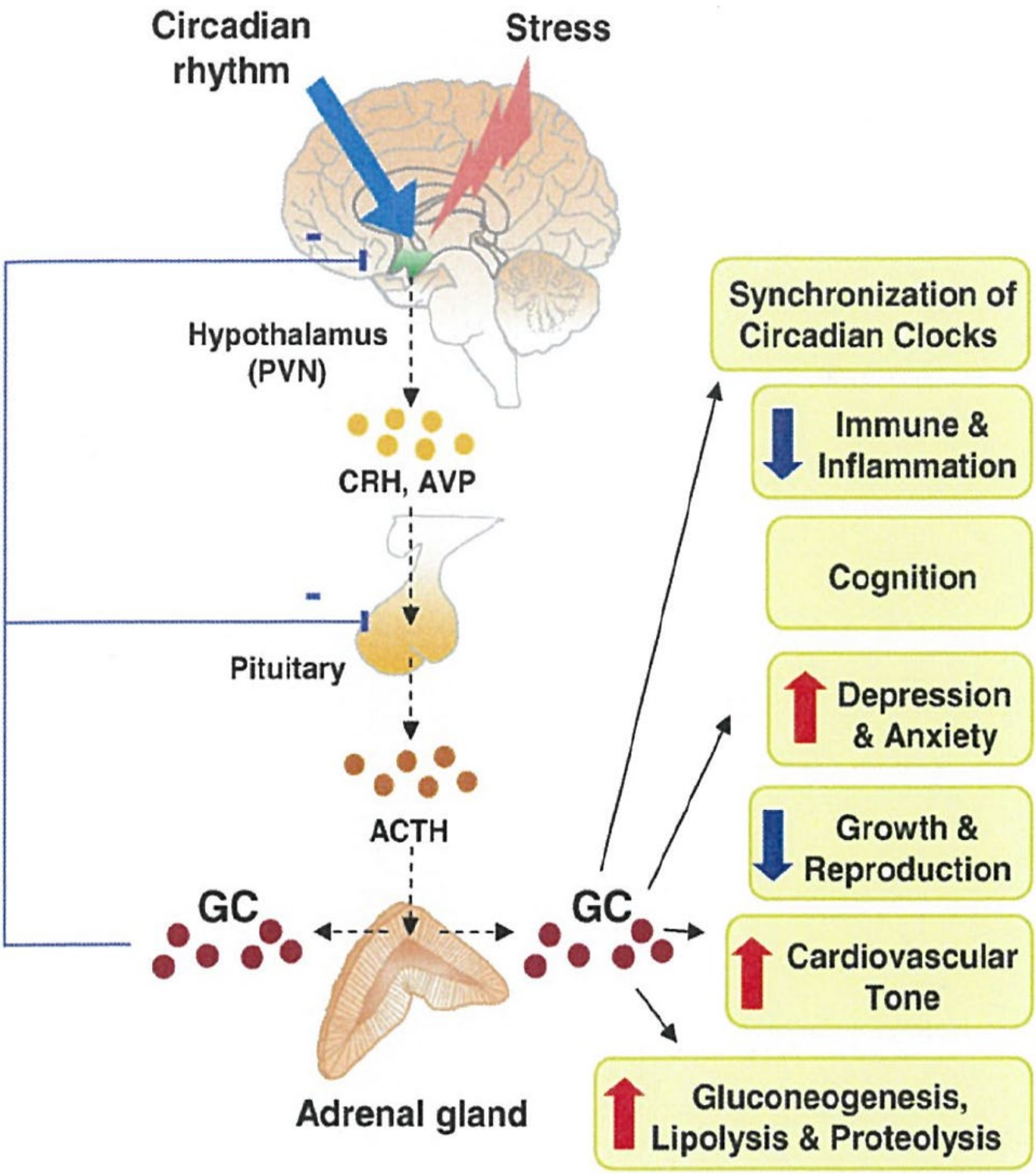
Figure 4.
Human biological circadian clock.



Note. From Sleep (p. 2), by L. Mastin, 2016.
(http://www.howsleepworks.com/how_circadian.html)

As part of the circadian rhythm cycle a very important hormone that is produced while the body is asleep is melatonin. When this hormone is produced it lowers the body's alertness level, causes drowsiness, lowers the body's temperature, activates the body's immune system, acts as an anti-inflammatory, is a powerful antioxidant and lowers the body's blood pressure (Bridger, 2009). Melatonin is mainly produced during the person's dream cycles in their sleep and production usually peaks in the middle of the night (about 2 am) (Bridger, 2009). During the awake cycle of the circadian rhythm the steroid hormone Glucocorticoid is produced by the adrenal gland. Figure 5 shows the pathway of the effects of this hormone.

Figure 5.
Adrenal Glucocorticod and its physiological roles.



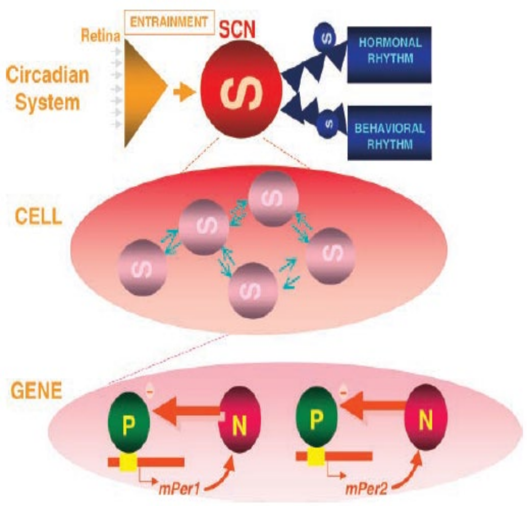
Note. From Circadian rhythm of adrenal glucocorticoid: its regulation and clinical implications (p. 584)*,* by S. Chung, G. Son &K. Kim, 2011, Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease, 1812(5), 581-591.

Figure 5 shows how the circadian rhythm affects the body through the Neuroendocrine regulation of adrenal glucocorticoid (GC). In the body the hypothalamic–pituitary–adrenal (HPA) axis is made of a connection between the hypothalamus, pituitary and adrenal gland that forms a circuit of the stress response system which becomes active when a person is awake to enable the person to cope with physical and emotional stress. The Hypothalamus contains the paraventricular nucleus (PVN). The rhythmic activity of Glucocorticoid plays an important role in human health and disease occurrence as it can disrupt lipid and carbohydrate metabolism, disrupt the cardiovascular activity, affect immune responses and cognitive and mood brain functions (Chung, Son & Kim, 2011).

Hormones secreted from the hypothalamus and the pituitary regulates the synthesis of adrenal Glucocorticoid. When circadian rhythms are disturbed neurochemical signals are transferred to hypothalamus paraventricular nucleus (PVN) that releases corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP) that passes through Pituitary to generate adrenocoticotropic hormone (ACTH). Adrenocorticotropic hormone promotes the adrenocortical cells to discharge adrenal glucocorticoid. Adrenal glucocorticoid interacts with the brain receptors to keep a circulation motion action. During the circulation adrenal glucocorticoid provides the negative feedback to the hypothalamic–pituitary–adrenal to turn it off to maintaining physiological processes and this affects the person's health (Stratakis & Chrousos, 1995).

Figure 6 shows the Circadian rhythm system in mammals across the gene, cell and system levels. It can be seen that each suprachiasmatic neuron (SCN) is coupled and amplified at the level of the suprachiasmatic nuclei forming a core loop to generate oscillation. These oscillation regulating the cells reaches the brain and another peripheral clock to create synchronisation (Balsalobre, 2002).

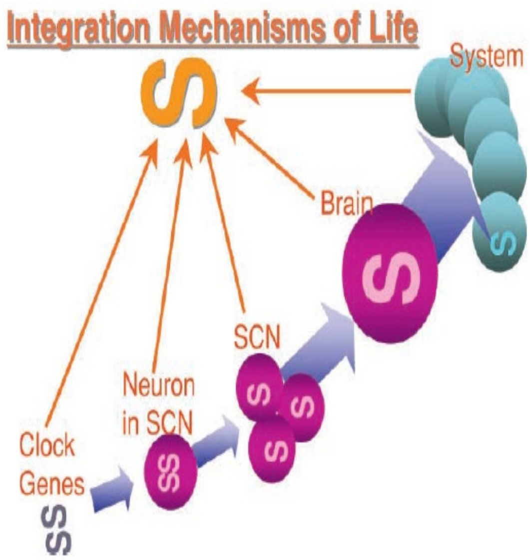
Figure 6
The Circadian rhythm system in mammals.



Note. From Molecular machinery of the circadian clock in mammals (p. 53), H. Okamura, S. Yamaguchi & K. Yagita, 2002, Cell and tissue research, 309(1), 47-56.

The nuclei containing melatonon type 2 receptors that receive light presence information by retino-hypothalamic tract when eyes are open (Waterhouse, Reilly, Atkinson, & Edwards, 2007). The information about physical activity and general expression is also transferred via inter geniculate leaflet (Waterhouse et al., 2007). When mammals are exposed to light their specific retinal cells' axon form a retinohypothalamic tract that end with suprachiasmatic nuclei (SCN) which is the site of central circadian clock (Okamura et al., 2002). That part forms a master biological clock and central pacemaker for the circadian system (Buijs, Van Eden, Goncharuk, & Kalsbeek, 2003).

Figure 7
The transfer of Circadian Rhythm from clock genes.



Note. From Molecular machinery of the circadian clock in mammals (p. 54), H. Okamura, S. Yamaguchi & K. Yagita, 2002, Cell and tissue research, 309(1), 47-56.

Figure 7, shows the transfer of Circadian Rhythm from clock genes, to nerve nuclei, to brain to system. The suprachiasmatic nuclei receives the signal from external environment about light and darkness, the timing of sleep or meals, social activities, physical movement and synchronises the internal rhythm with the external environment (Zelinski, Deibel, & McDonald, 2014). Once disturbed, the circadian rhythm reset by coordination between the above-mentioned zeitgebers (external cues which include day light) and the suprachiasmatic nuclei (Hastings, Maywood, & Reddy, 2008). The functions of the heart, lungs, liver, autonomic nervous system and the endocrine systems are all controlled by circadian rhythms (Bridger, 2009).

Effects of Disruptions

The disturbance in the circadian system affects the functions of the cardiovascular system to control postural stress ultimately resulting in greater vulnerability to presyncope during the night (Hu, Scheer, Laker, Smales, & Shea, 2011). People working during the night are exposed to postural stress that can cause syncope during which people suffers a temporary loss of consciousness caused by a low blood pressure (syncope) (Hu et al., 2011). Low blood pressure that causes loss of consciousness may cause further outcomes such as fractures as well the loss of control of motor vehicles and minor injuries such as lacerations and bruises, in some cases death and also, neurological disorders can develop (Olshansky, 1998; Ryan et al., 2015).

Sleep Disorders

A sleep disorder can be caused by numerous stimuli, such as changing eating and drinking times, or changes to daily activities such as work, however sleeping disorders can also be genetic (Wilson & Nutt, 2008).

The most common sleep disorder is Jet Lag, however it usually fixes itself within 5 days and it can be helped with medication however medication is usually not needed (Wilson & Nutt, 2008). The sleep disorders that are more severe are 'Delayed Sleep Phase Syndrome' (DSPS), 'Advanced Sleep Phase Syndrome' (ASPS), and 'Shift Work Sleep Disorder' (SWSD) (Wilson & Nutt, 2008).

Delayed Sleep Phase Syndrome means that people sleep at a delayed time, relative to the socially accepted time, and affects roughly 10% of young adults and adolescents (Wilson & Nutt, 2008) as at this age, most are students who are studying and also working and therefore have extremely varying sleeping patterns (Wilson & Nutt, 2008). Those with Delayed Sleep Phase Syndrome can either have hypersomnia (excessive sleepiness) or insomnia (inability to fall asleep easily) (Wilson & Nutt, 2008).

Advanced Sleep Phase Syndrome means that people wake up roughly 2 – 3 hours earlier than socially accepted. This condition rarely affects the younger age group but does affects roughly 1% of middle aged and older adults.

Shift Work Sleep Disorder is the interesting one as most people afflicted can easily change their work schedule to work either night shift or day shift but find it very hard to rest on a day off. They may be tired and have no work to do, but rest is still not easily achievable (Wilson & Nutt, 2008). The symptoms of Shift Work Sleep Disorder are unrefreshing sleep, excessive sleepiness when the worker is supposed to be active, insomnia on days off, impaired or lowered performance at work or when driving to and from work and this may persist on days off.

Of the sleep disorders mentioned, Shift Work Sleep Disorder is the most severe one as it has the potential to cause the most harm. For example, emergency departments are the busiest at night, which is when the circadian rhythm of the nurses and physicians would be demanding sleep (Kuhn, 2001). According to a survey by the American College of Emergency Physicians, 108 respondents were claiming the most stressful aspect of emergency medicine is the erratic schedule (Kuhn, 2001). Because there is such an erratic schedule, coupled with the stress of an emergency department, this causes a desynchronosis within the person.

Cause for Concern

This desynchronosis results in many symptoms such as malaise, gastrointestinal problems, fatigue and poor mood, and this is experienced by both shift workers and night workers and those travelling by air (Kuhn, 2001). The frequency of these disturbances would be intermittent and would also depend on the severity of the desynchronosis and would also lead onto affecting the three cognitive processes, attention, working memory and executive functions (Valdez et al, 2014).

This poses a cause for concern, as emergency service personnel work in shifts, they also drive ambulances at high speeds and also discuss possibly life-saving care with others before delivering it to the critically injured and ill patients in the ambulance, out in the field and in the hospital (Patterson et al, 2014). Approximately 1 in 3 of these shift workers in emergency services have reported to have poor performance at work, excessive sleepiness in the daytime, difficulties in remembering protocols, and difficulty driving the ambulance (Patterson et al, 2012).

It's clear that the problem lies with the workers' shifts as they are often extended, leading to prolonged periods of mental and physical fatigue, also as highlighted by The World Health Organisation (Patterson et al, 2012). This problem affects economics as approximately 28 billion dollars a year is wasted in additional health care costs that should have been deemed unnecessary (Patterson et al, 2012). A solution may exist where emergency service workers should work less, and theoretically they still have a job, still have an income and are able to get ample rest, however it is reported that it is not uncommon for emergency workers work multiple jobs at all, due to half of these service men and women earning only $31,020 dollars annually, or approximately $14.91 an hour (Patterson et al, 2014).

Conclusions

Overall, in the world emergency services are considered heroes. They do everything they can to save lives and prevent further pain or damage to people. At the same time, they also face possible abuse or harassment from others while working out on the field or in the hospitals and wards (Patterson et al, 2014).

The emergency service men and women do so much for everyone by taking care of them, responding to their emergencies, saving lives and doing check-ups to make sure that everyone is okay and well looked after. But often the stress of emergency service men and women are forgotten, and they're the first responders to scenes of horrific accidents and incidents yet they also often don't get the chance or time to get the help that they also need (Patterson et al, 2014).

The emergency service men and women and the medical team deserve to be paid more, so that they don't need to work such erratic schedules at different hospitals or medical facilities due to just over half of emergency service men and women in 2013 in the United States of America only earning just over 15 dollars an hour (Patterson et al, 2014). Things need to change, where emergency services who are responsible for human lives are also looked after and taken care for.

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Hazardous Drug Exposure in Healthcare

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Abstract

Hazardous drug exposure in healthcare is a growing concern for the pharma industry and workers. Significant risks may be present including cancers for those handling and compounding various therapeutic agents. Workplace exposure standards do not exist for those employed in the pharma industry. Recommendations of safety have used the, 'As Low as Reasonably Achievable' (ALARA) principle to control exposures for pharmacists and others that handle hazardous substances. Steps should be taken to systematically eliminate and/or minimize exposures to workers through safer handling protocols, approved safety cabinets, negative pressure rooms, local exhaust ventilation, health surveillance, training and appropriate PPE.

Key words: Hazardous drugs. Antineoplastic drugs. Oncology. Pharmacy industry. Drug safety. ISOPP standards.

Introduction

Antineoplastic drugs are used to treat more than 12.1 million individuals diagnosed with cancer worldwide each year (Graeve, Mcgovern, Alexander, Church, Ryan, and Polovich, 2017). According to NIOSH, approximately 8 million U.S. health care workers are potentially exposed to a multitude of hazardous drugs in the workplace (NIOSH, 2016). The drugs have been detected in the urine of workers and on the floors and counters of worksites (Randolph, 2012). Chemotherapy (antineoplastics) drugs, hormones, antivirals, as well as some monoclonal antibodies and other miscellaneous drugs are classified as a hazardous drug. They are used to treat cancers, human immunodeficiency virus (HIV) and some autoimmune diseases (Müller-Ramírez, Squibb and Mcdiarmid, 2017). As new drugs are developed to treat the numerous cancers and other diseases, the health effects and the toxicity of these drugs is not usually known. These drugs must be handled using special precautions not only by health care professionals, but by those who work in these facilities as well. Although the hazards associated with hazardous drugs are recognized, there is not an acceptable exposure limit to these drugs (Alehashem and Baniasadi, 2018).

Antineoplastic drugs

The health risks and toxicity associated with antineoplastic drugs are well understood. The International Agency for Research on Cancer (IARC) has classified antineoplastic drugs into three groups: Group 1 - carcinogenic to humans; Group 2a - probably carcinogenic to humans and: Group 2b - possibly carcinogenic to humans (Graeve, Mcgovern, Alexande, Church, Ryan, and Polovich, 2017). NIOSH (2004) stated that there are approximately 140 agents that fit the definition of a hazardous drug. Two-thirds of the hazardous drugs are determined to be antineoplastic drugs. Terms commonly known to describe the drugs are "antineoplastic" and "cytotoxic". "Hazardous drugs" is a broader classification that can be used to describe the drugs. The NIOSH Alert glossary defines cytotoxic as "a pharmacologic compound that is detrimental or destructive to cells within the body" (NIOSH, 2004). The International Society of Oncology Pharmacy Practitioners (ISOPP) defines cytotoxic drugs as "chemicals that affect cell growth and proliferation, most of which either bind to genetic material in the cell nucleus or affect cellular proteins synthesis" (ISOPP, 2007).

Health care workers are exposed on a repeated basis and experience side effects from these drugs that have no benefit to these individuals (Müller-Ramírez, Squibb and Mcdiarmid, 2017). Previously, safe handling guidelines have only included cytotoxic or antineoplastic drugs regarding health care worker exposure. Now, it has been expanded to include all hazardous drugs. There has been evidence that indicates that health care workers are at risk from the effects of occupational exposure to hazardous drugs.

Health effects

Prior studies have shown evidence of adverse health effects associated with exposure to antineoplastic drugs. These effects include acute and chronic outcomes. Acute responses can be nausea, skin rashes, hair loss, nasal sores, abdominal pain, allergic reactions, and dizziness (Müller-Ramírez, Squibb and Mcdiarmid, 2017). Chronic effects to hazardous drug exposures can be delayed conception time, spontaneous abortions, genotoxic changes, and cancers (Foxhall, 2009). Hospital personnel involved in preparation and administration of antineoplastic drugs may be at risk if exposed to these hazardous pharmaceuticals (Korczowska, Jankowiak-Gracz, Sessink, and Grzeskowiak, 2013). If there is contamination in the environment that healthcare workers are present, we can assume that the workers are being exposed as well (Foxhall, 2009). Small exposures to such toxic drugs can have adverse outcomes on the health of the healthcare worker. Most exposures occur in hospitals and oncology facilities during administration of the drugs and the compounding process in the pharmacy. The occupational risk for health care workers is unacceptable (Graeve, Mcgovern, Alexande, Church, Ryan, and Polovich, 2017).

Hazardous drugs can have multiple ways of getting into the body of a healthcare worker. They can be absorbed through inhalation, skin contact, ingestion from hand-to-mouth and injection. The main routes for exposure are believed to be inhalation and ingestion. Currently, it is not possible to establish a safe occupational exposure limit to these drugs. Any preventable occupational exposures should be avoided if possible and follow the "As Low as Reasonably Achievable" (ALARA) standard (Müller-Ramírez, Squibb and Mcdiarmid, 2017).

Healthcare workers and risk control

The University of Minnesota researchers conducted a study of 163 oncology health care workers to determine factors that could contribute to workplace exposure. The objective of the study was to identify possible exposures, as well as determining factors that direct the safety behaviour of employees. The study also conducted environmental hazardous drug wipe sampling on surfaces present in the workplace. There was surface contamination in areas that personal protective equipment was not expected to be used, which can lead to potential exposure (Graeve, McGovern, Alexander, Church, Ryan, and Polovich, 2017).

Many health care facilities that handle hazardous drugs have adopted the hierarchy of controls. The NIOSH Hierarchy of Controls has been identified and can be applied to this health care and the handling of hazardous drugs. These areas covered in the hierarchy of controls include elimination; substitution; engineering controls; administrative controls; and personal protective equipment. The basis behind the hierarchy of controls is that it uses a top-down methodology meaning that the most effective and protective are at the top and less effective and protective are at the bottom. Elimination of the hazard (material or process) is the most effective yet most difficult to implement in any process. In the instance of hazardous drugs, elimination is not possible, therefore diligent use of PPE, proper use of engineering controls and implementation of administrative control must be used. Substitution has the same issues as elimination.

In healthcare, substitution with a less hazardous drug is not possible. Patients are placed on treatments that work for their disease. Engineering controls are the first level that can be used in health care settings because of their designation to remove the hazard before it is in contact with health care personnel. Finally, administrative controls and personal protective equipment (PPE) is used when the exposures are not well controlled.

The first step is the engineering controls. When a hazard cannot be eliminated, an engineering control is recommended for use. In the case of compounding hazardous drugs, it should always be used for product and worker protection. Examples of engineering controls that provide worker and product protection are Class II and III biological safety cabinets (BSC) that are properly ducted with either a canopy or direct connection to an exhaust or a compounding aseptic containment isolator (CACI) that is exhausted to the outside. These engineering controls are placed within a controlled cleanroom environment that is negative pressure. The negative pressure cleanroom suite has pressure in the range of -0.01 to -0.03 inches water column (in. w. c.) and exhausted to the outside, as well. This is considered a secondary engineering control (SEC) (USP Chapter <800>, 2017). These primary engineering controls are often referred to as "hoods" in which the compounding activities are performed. They provide both product protection with an ISO Class 5 environment inside of the biological safety cabinet, as well as worker protection since the engineering control provides containment.

Another level of protection to use both for compounding and administration is the use of a closed system transfer device (CTSD). This system is needleless and attaches together to transfer the hazardous drug between the vial to IV bag without any exposure. It is an extra level of protection if used within a BSC or CACI. With regards to CTSDs, some facilities consider them as a secondary engineering control used within a primary engineering control when compounding and mixing hazardous drugs, to reduce the risk and exposure to the hazardous drug. Others consider a CTSD as PPE (Mathias, 2019). The U.S. Pharmacopeia (USP) recommends CTSD for compounding hazardous drugs and defines them as mandatory for administration of hazardous drugs (USP Chapter 800, 2017).

Next, the implementation of administrative controls should be used to help with guidance on processes within the health care facility. Some of the administrative controls are to use medical surveillance, training for employees who handle these drugs, cleaning, and decontamination of work surface sand disposal of hazardous drugs. PPE used to compound and any waste from compounding/ administration in the right waste containers (black or yellow), disinfect and deactivate the primary engineering controls (BSCs or CACIs), store hazardous drugs alone in a negative pressure room, define processes for unpacking shipping totes that have hazardous drugs, define a list of all hazardous drugs within the facility, etc. The administrative controls define processes that should be implemented within the facility to lower the exposure risk (Couch, West, and Niemeier, 2013).

A list of all the drugs used in the facility should be compared to the list to the drugs on the NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings should be created and made accessible to all the personnel for staff that could possibly be in contact with these drugs. It is important to identify which departments and/or personnel could potentially handle or contact the hazard (ISOPP, 2007). Once the hazardous drugs in a facility have been identified, an assessment of risk should be completed by identifying the path that the hazardous drugs follow from when they enter the facility to when they leave as patient waste, contaminated laundry, IV bags, contaminated medical equipment etc. All potential sources of exposure should be identified. It is also important to identify all individuals who have the potential contact or handle hazardous drugs. Contamination of the environmental can be determined by surface sampling for hazardous drug residue. It is likely that any area where hazardous drugs are used could be contaminated by those drugs. The hazardous drug residue wipe sampling is only available for approximately 12 drugs that are used because they can indicate exposure to any of dozens of drugs the facility uses (ISOPP, 2007).

Personal protective equipment (PPE) is the last area within the NIOSH hierarchy of controls. With proper handling, as well as implementation of proper PPE such as double gloving, use of gloves rated by the American Society for Testing and Materials (ASTM) for chemotherapy, chemotherapy gowns made of polypropylene which have taped seams and coated by polyethylene on the outside to prevent liquids from seepage through and onto the healthcare worker, face shields to prevent splashing onto the face and into the eyes and the use of respirator protection, the incidence rate of exposure is reduced (Couch, West, and Niemeier, 2013). The amount of PPE donned is dependent upon the drug and the procedure involved with handling the hazardous drug (Tomkins, 2015). CSTD systems can also be considered PPE and provide protection to the individuals handling these hazardous substances (Mathias, Mackenzie, Toennis, and Connor 2019).

Studies have shown that more workers are wearing gloves when handling hazardous drugs since the initial safe handling guidelines were implemented (Mathias, Mackenzie, Toennis, and Connor 2019). However, a recent large study of health care workers conducted by NIOSH (2016) found that one in seven of 2,069 reported not always using gloves while handling hazardous agents. These studies determined that a lower rate of use in PPE was reported. A study of 165 nurses also found personal protective equipment (PPE) use varied by activity, with the lowest adherence to recommendations about the handling of patient excreta (Mathias, Mackenzie, Toennis, and Connor 2019).

Currently, healthcare facilities and pharmacies that compound hazardous drugs are have a new guideline to follow for both non-sterile and sterile products. The United States Pharmacopeia released a new guideline, Chapter 800, that was effective in most States, on July 1st, 2019. All chapters in the USP Compounding Compendium under 1000 are enforceable by state boards of pharmacy. This chapter outlines safe handling, storage, compounding, room requirements, engineering controls and PPE requirements. The chapter was designed to be a guide to help facilities minimize and manage the drug exposures healthcare workers are exposed to, as well as give design elements for the rooms used for compounding. Previously, retail pharmacies had to follow USP Chapter 795 regarding non-sterile compounding rules, however, with the implementation of Chapter 800, it has now designated the same similar elements for pharmacies that compound non-sterile hazardous drugs, such as estrogen and testosterone creams, for hormone replacement therapies.

Conclusions

In conclusion, it is necessary to keep healthcare workers protected from hazardous drug exposures. Use of the proper engineering controls to keep the drugs contained when being stored, compounded, and administered is crucial to the health and well-being of these workers who are exposed daily. Policies and procedures designed around cleaning processes, proper PPE needs, waste disposal, medical surveillance, hazardous drug list, hazardous drug wipe sampling and continuing education are designed to help the individuals handling these drugs have specific operating procedures for their facilities needs that meet or exceed what should be done to protect the workers. It is mission critical to keep these workers safe. Without the implementation of the controls, more unnecessary exposures will occur which will lead to more adverse outcomes to the workers that are caring for some of the sickest patients.

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Check or Money Order payable to WSO may be mailed with application packet to: WSO-WMC, Attn: Membership Coordinator, PO Box 518, Warrensburg MO 64093 USA. International postal money orders or bank drafts with a U.S. routing number are acceptable for applicants outside the United States. For alternate payment arrangements, please contact WSO-WMC.

Annual dues hereafter will be billed and payable on the anniversary date of your membership. **U.S. funds only.**

By submitting this application, you are accepting that WSO will use the information provided to perform an independent verification of employer, credentials, etc.

Mail or email completed form, along with current résumé/CV:

WSO World Management Center

PO Box 518 | Warrensburg, Missouri 64093 USA

Phone 660-747-3132 | FAX 660-747-2647 | membership@worldsafety.org

Student Membership Application

WORLD SAFETY ORGANIZATION

Instructions | Complete all applicable fields and mail to **WSO World Management Center, PO Box 518, Warrensburg, MO 64093 USA**, email to **membership@worldsafety.org**, or fax to **1-660-747-2647**. For assistance completing this application, please call **1-660-747-3132**, or email questions to **membership@worldsafety.org**.

Membership Level | Choose One

❑ **College/University Student Membership – FREE**
*You will receive all member benefits including subscriptions to **WSO World Safety Journal** and **WSO NewsLetter**, as well as access to **WSO's Mentor Program**.*

❑ **Middle/High School Student Membership – FREE**
*You will receive all member benefits including subscription to **WSO World Safety Journal** and **WSO NewsLetter**, excluding access to **WSO's Mentor Program**.*

Last Name/Family Name

First Name/Given Name | Initial | ❑ M ❑ F (Gender)

Birthdate MM / DD / YYYY *(Application must include exact birthdate with year to be processed.)*

Current Street Address ❑ On Campus ❑ Off Campus *(Attach separate sheet if you need more room for your address.)*

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ❑ Landline ❑ Mobile (Type)

Permanent Street Address

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ❑ Landline ❑ Mobile (Type)

Send mail to: ❑ Current Address ❑ Permanent Address

Email Address(es)

COLLEGE/UNIVERSITY STUDENT

Category: ❑ Undergraduate ❑ Graduate/Post-Graduate

Degree(s) Sought/Obtained

Name of College/University | Campus

MIDDLE / HIGH SCHOOL STUDENT

❑ I am a Middle Schooler in: ❑ 6th Grade ❑ 7th Grade ❑ 8th Grade

❑ I am a High School: ❑ Freshman ❑ Sophomore ❑ Junior ❑ Senior

Name of School

Approximate Date of Graduation (MM / YYYY)
(For High School and College/University students, application must include approximate date of graduation to be processed.)

If you were referred by someone, please list name(s), chapter, division, etc.:

WSO Member: ____________________

WSO Chapter/National Office: ____________________

WSO Division/Committee: ____________________

Other: ____________________

What Interests You?

Please specify your area(s) of interest. These areas of interest will allow you to connect with others who share similar interests throughout the world.

[ ] Occupational Safety and Health (OS&H)
[ ] Environmental Safety and Health (EH&S)
[ ] Fire Safety/Science (FS&S)
[ ] Safety/Loss Control Science (S&LC)
[ ] Public Safety/Health (PS&H)
[ ] Construction Safety (CS)
[ ] Transportation Safety (TS)
[ ] Industrial Hygiene (IH)
[ ] Product Safety (PRO)
[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
[ ] Nuclear Safety (NS)
[ ] Aviation Safety (AS)
[ ] Ergonomics (ERG)
[ ] Petroleum (PS)
[ ] Oil Wells (OW)
[ ] Other: ____________________

Required Signatures & Permissions

I subscribe to the above record and when approved will be governed by the Constitution and By-Laws of WSO and its Code of Ethics as I continue as a member. I furthermore agree to promote the objectives of the WSO wherever and whenever possible.

X ____________________ ________
Applicant Signature | Date

FOR MID/HIGH SCHOOLERS ONY: WSO subscribes to the Family Educational Rights and Privacy Act (FERPA) philosophy in protecting student privacy and information. WSO may disclose "directory" information such as a student's name, WSO Student Chapter affiliation, name of school, grade in school, etc., along with group or individual photos in WSO NewsLetters, NewsFlashes, eNews, on WSO website, and on WSO's social media accounts.

❑ My student has permission to participate as outlined above.

❑ My student has permission to participate with exclusions:

X ____________________ ________
Parent/Guardian Signature (Mid/High Student) | Date

X ____________________ ________
WSO Student Chapter Mentor Signature | Date
(IF APPLICABALE)

WSO National and International
Offices and Directors

WSO National Office for Australia
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c/o Curtin University
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WSO National Office for Vietnam
Mr. Binh Pham, Director
Contact: binh@worldsafety.org.vn
Website: www.worldsafety.org.vn

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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