SAFENESS BY DESIGN

Enabling an Ageing Workforce

Using design to innovate the workplace and empower older workers

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Executive Summary

Australia's population is ageing, but with enhanced health prospects and insufficient retirement funds, and industries impacted by a dwindling itinerate manual labour supply, workers will want, and may need, to remain in the workforce for longer. However, as people age, they lose muscular strength, experience a decline in physical and cognitive performance, and are more vulnerable to muscular-skeletal issues caused by repetitive or awkward movement patterns. Consequently, ageing workers in occupations that require sustained physical activities are at increased risk of injury and exacerbated physical decline and may experience ageist discrimination in the workplace that impacts their psychological wellbeing.

This research, Enabling an Ageing Workforce, recognises the issues facing the older worker across a range of different workplace contexts and asks the question:

How can design and new technologies address the compounding factors of an ageing (working) population and enable older workers to continue to be productive and effective whilst ensuring their personal wellbeing?

Enabling an Ageing Workforce' is a collaborative research and design project between RMIT University's 'Safeness by Design' initiative and the Innovation Centre of WorkSafe Victoria. This project investigates ageing, wellbeing, and workplace safeness within specific industries to identify areas of concern, opportunities for design intervention, and the proposal of future-focused design solutions. The researchers conduct a substantial scope of enquiry, while concurrently undertaking a partnered design studio with Industrial Design students, to develop and respond with appropriate design solutions.

The research identifies that safeness issues exist across specific industry contexts because of workplace culture, practices and predominant behaviours, specific work actions and activities, workplace design, economic and time pressures, and poor risk literacy, training and awareness. The design studio component sees students addressing research-identified issues across many industry sectors and workplace contexts to:

- prevent musculoskeletal issues in healthcare workers in the homecare environment,
- correct harmful movement behaviours in manufacturing environments,
- support older workers in manual tasks, through assistive technologies,
- address mental health in the construction industry,
- reduce ladder injuries in the residential construction industry,
- reduce vibration related injuries in the agricultural sector.

This research reveals insights into how a 'safeness by design' lens can enable an ageing Australian workforce. Such an approach needs to balance pre-emptive and reactive safety measures, focusing on creating a safe and supportive working environment for all workers.

Whilst it is important to support older workers to reduce risk or injury and to promote their capability and performance, enabling longevity, it is also critical to implement measures that protect younger workers from unsafe workplace behaviours, processes and expectations that can lead to longer-term impairment, and may result in them leaving that industry prematurely.


RMIT
Building
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Background

‘Enabling an Ageing Workforce’ is the first collaborative project between RMIT University’s *‘Safeness by Design’* initiative and the Innovation Centre of WorkSafe Victoria.

The Safeness by Design research and design team have previously collaborated with the City of Melbourne and the Ajuntament de Barcelona on urban mobility projects, developing expertise in interdisciplinary design interventions, with a specific lens on actual and perceived safeness.

WorkSafe’s Innovation Centre looks beyond traditional policing and enforcement of workplace safety standards, looking forward to envision the future of work and workplaces, and to understand the trends and factors that may impact worker safety. Through this human-centred and future thinking approach, the Innovation Centre aims to support WorkSafe to enable the new services and controls to keep future workers free from harm, and to stimulate innovative change and pre-emptive strategies and actions within industry.

The collaboration provided an opportunity for Safeness by Design researchers and RMIT Industrial Design students to develop innovative design solutions aligned with WorkSafe’s current areas of priority, and to demonstrate the power of design to make a positive contribution to society.

‘Enabling an Ageing Workforce’ has been an inspiring and rewarding project for all participants. Emerging from an extensive list of potential investigations, this theme was chosen as an appropriate project for the first collaboration, a partnered teaching design studio project (over one semester) conducted with undergraduate Industrial Design students, underpinned by a corresponding research element.

In the partnered design studio, students were challenged to investigate ageing, wellbeing and workplace safeness within specific industries, identifying areas of concern and design intervention opportunities, before responding with future-focused design proposals and recommendations to the external partners and industry stakeholders. For researchers conducting a simultaneous and comprehensive investigation into the literature on the ageing workforce in Australia, the topic offered a large scope for inquiry across multiple industries and contexts, informing the design process and building a knowledge repository.

Whilst WorkSafe initially engaged with Safeness by Design hoping to receive conceptual design solutions, they did not foresee the value that they would get from the interaction with students and researchers, “finding the experience energising and enlightening, and triggering reflection on our own work” (Sean Burns, Innovation Ventures Lead).

Integrating the literature review with the studio, students worked across multiple industry contexts including agriculture, health care, SME manufacturing, and construction, resolving complex problems concerning mental health, musculoskeletal disorder, workplace accident/injury prevention and the application of assistive technologies. Design projects focussed on enabling the longevity and continued effectiveness of ageing workers, whilst protecting younger workers from work-related health issues that may cause them to leave industries prematurely.

It was hoped that students and researchers would be able to engage directly with target users in their workplace to gain a deeper understanding of the nuances of specific industries. Unfortunately, the extended lockdown enforced on Melbourne by the Covid-19 pandemic made ethnographic research less feasible, and it is a credit to all contributors that they were able to not only conduct insightful research, but to respond with well-considered design proposals, despite the enforced isolation. The outcomes have the potential to deliver tangible and achievable benefits to all stakeholders in response to the problems and issues identified, empowering end users and adding value to their communities and industries.

Figure 1: RMIT Swanston Academic Building

The Innovation Centre team at WorkSafe was surprised by both the range and quality of the design proposals. Students delivered solutions attuned to both the physiological and psychological needs of workers, but also effectively imagining and anticipating future behavioural, environmental and technical challenges. "The outcome for us is a combination of many things - high-quality work, desirable innovative concepts, inspiring dialogue, the experience of collaborating with students, and the new connections we've made - which we bring back to WorkSafe as motivation" (Sean Burns, Innovation Lead).

The Innovation Centre noted that "some of the concepts are 'accelerator ready' - even in this early stage, we have clear line-of-sight to tangible impact and benefit pools" (Cam Birrell, Director Innovation Centre). In this regard, Safeness by Design and the Innovation Centre are now engaging with the RMIT Activator to explore opportunities for entrepreneurial ventures and further development of these projects that may lead to solution implementation in industry.

Safeness by Design is appreciative of the opportunity to collaborate with WorkSafe Victoria and acknowledge the insightful contribution of Innovation Centre personnel, and their expertise in transforming workplace safeness.

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Figure 2: Worksafe Victoria Digital platform

SAFENESS BY DESIGN

Authors

Professor Ian de Vere Professor Ian de Vere is an award-winning industrial designer with extensive industry experience in new product development, design for the public domain, and commercial furniture design. Associate Dean in the RMIT School of Design, his teaching focuses on creativity and innovation, ethical and sustainable practice. Ian is keen to educate designers to contribute positively to global communities through a socially responsive approach and founded the *Safeness by Design* initiative in early 2019.

William Dim is an experienced senior designer who is passionate about tackling the world's complex design challenges and he brings wide-ranging industry expertise to any project. An Associate Lecturer in RMIT's School of Design, William has a learner-centred teaching focus, seeking to empower learners in their journey. His research is deeply engaged with design education, to reimagine learning for the contemporary period.

Jacob Sheahan is a is a PhD Candidate in the School of Design at RMIT University. Trained as Industrial Designer, he utilises a design anthropology and interaction design skillset, with a focus on the future of ageing, emerging technologies, and design for health and wellbeing.

WorkSafe Victoria project partners

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Sean Burns - Innovation Ventures Lead
Becky Walker - Senior Innovation Specialist

RMIT Industrial Design students

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Safeness by Design

Since 2019, *Safeness by Design* has been using research and design innovation to provoke conversations that may direct the creation of safer urban environments.

Design has the potential to significantly improve safety, reduce risk and save lives, either during the design phase or through targeted design interventions. Through employing user-centred design skills accompanied by behavioural considerations and a broad materials, manufacturing and technical knowledge base, designers form clear problem definitions through ethnographic discovery processes, creative design and innovative technical resolution in a socio-technical context.

Safeness by Design, an initiative emerging from RMIT University's School of Design, aims to enhance health, wellbeing, and social values by using design to achieve actual and evident safeness across a broad range of environments and contexts. Rather than a design specialisation, this forms a generalist and multidisciplinary approach to realise social impact through a safeness agenda. We advocate that designer use their understanding of user behaviour and situational contexts to identify and respond to safety concerns through design proposals and interventions.

In three previous collaborative projects, researchers and designers from RMIT's School of Design have collaborated with the planners and strategists from the cities of Barcelona and Melbourne. In each, Safeness by Design developed proposals that embrace holistic and multidisciplinary approaches to the issues of safety in the city on personal, social, spatial, and technological levels.

- The Safe Mobility with Covid-19 (2020) project in collaboration with the cities of Melbourne and Barcelona realised solutions for coronavirus impacted urban landscapes with a focus on safe solutions for public transport, personal mobility, sanitation and contact avoidance, smart city technologies, and reinvigoration of local communities,
- The Safe Mobility in Barcelona (2019-20) project delivered innovative solutions to the safety and civic planning issues surrounding the use of e-scooters in Barcelona's busy metropolis (including pedestrian and rider safety, helmet usage, docking infrastructure, education and rider behaviour change and remote scooter speed control), and
- The Safe City Smart City (2019) project with the City of Melbourne proposed design solutions that ensure a 24-hour city that is safe, inclusive, and welcoming for all users, focusing on urban mobility, and more specifically, the safety of women transiting the city at night.

This project, *Enabling an Ageing Workforce*, has facilitated a move away from urban contexts into new areas of contribution. Working across multiple industry sectors and workplace contexts with a more specific demographic focus, the researchers and designers further evidence the importance and benefits of targeted design inventions through a safeness lens.

Figure 3: Examples of Safeness by Design Research Projects


THE CONSIDERATE RULER

DONE
NEW TRANSACTION
OCTOBER 2015
REPORT
FEBRUARY
INCOME
THREE SIMPLE STEPS

Methods

The 'Enabling an Ageing Workforce' research and design collaboration between the Safeness by Design initiative at RMIT University and WorkSafe Victoria's Innovation Centre, was conducted through two main activities, extensive exploratory research through a literature review, and a design studio project where students responded to identified issues. The project realised several key outputs, this report, student awareness and learning, a public exhibition, and an entrepreneurially focused workshop.

The collaboration aimed to provoke conversation and stimulate new engagement between WorkSafe, RMIT and industry and generate a new awareness of the topic, in addition to identifying areas of concern and proposing targeted design solutions in response.

Literature Review

A literature review explores and evaluates existing publications on a specific topic or question. In this project, the literature review was utilised to focus and contextualise a range of subject areas, with initial research being conducted into the ageing workforce in Australia, before more directed research was conducted into specific industry contexts to support the design studio work.

Whilst most of the research was conducted by Safeness by Design researchers (authors of this report), the initial research conducted by student groups was invaluable in identifying specific industry issues that necessitated a design intervention, and which focused subsequent research.

Design Studio

In design education, the design studio is a practice-based learning space that allows students to engage with and inspire each other beyond the parameters of formal classes (Nicki Wragg, n.d).

In late 2021, Industrial Design students from RMIT's School of Design, were engaged in the Safeness by Design / WorkSafe Victoria collaboration through a 'Social Innovation' themed design studio. This studio enabled student designers working in small design teams to utilise a collaborative approach to problem solving, to construct meaning and innovate solutions to complex problems, supported with expertise from the Innovation Centre of WorkSafe Victoria.

Outcomes from the design studio are innovative and highly appropriate to the industries and context for which they are proposed. In this report, they are discussed within the six case studies that support the chapters.

Exhibition

The use of exhibition to provoke discussion, engage the public and stakeholders and disseminate knowledge is a well-established practice, and for this project has important value in raising awareness of the issues facing older workers and prompting interaction between WorkSafe and industry stakeholders. Unfortunately at the time of publication of this report, the planned public exhibition has been postponed until mid-2022 due to restrictions relating to the Covid-19 pandemic.

Entrepreneurship

WorkSafe Victoria's Innovation Centre aims to stimulate industry to drive innovative change. In this respect, they hope to encourage the designers involved with this project to continue their design development towards realisation/implementation. To achieve this ambition, a series of engagements between the project partners, the student participants and the RMIT Activator (which supports entrepreneurship and venture creation), aims to establish entrepreneurial pathways that may result in the implementation of the design proposals.

Introduction

Australians are living longer, richer, and healthier lives. As life expectancy has increased, we are also facing the complexities of an ageing population which puts pressure on the nation's healthcare sector, housing stock, social services, and the workforce. This dynamic is a combination of lower fertility rates and increasing life expectancy, which has seen an increase in the median Australian's age from 34 to 37 years over the past three decades (Radford et al., 2018).

These trends are driving two significant concerns for an ageing workforce: maintaining the health of increasingly older workers and dealing with the complications of their participation in the labour force. Research suggests this situation (and change) is occurring slowly, with a 12% increase over the last decade of Australians aged 45 and over who intend to work until age 70 (Heather Ikin et al., 2019). Yet, older Australians today are healthier and more educated than ever and more willing to work, which presents unique opportunities for employers and various sectors (CEPAR, 2021).

In realising and engaging with this rich and evolving context, this report seeks to contextualise the factors that will dictate our ageing labour force's ability to participate in the emerging discussion, most importantly around safeness in the workplace. Through chapters that frame individual industries and the issues they face, we look at ways of not only managing and dealing with barriers to workforce safety but also investigate opportunities for innovation.

The report identifies and anticipates issues that will arise in the near future for Australia's ageing workforce, providing designed measures that engage with these problems. Navigating these pressing concerns across the healthcare, manufacturing, construction, and agriculture sectors, we engage with wider notions of safeness in the promotion of healthy ageing, creating the environments, and opportunities that enable older workers to continue to make a valuable contribution to industry whilst maintaining quality of life.

This report contains an extensive literature review and six case studies. Chapter one presents an overview of issues concerning the ageing workforce, examining the effects of ageing, mechanisms of injury, ageism and bias in the workforce, and the challenge of designing for an aging workforce. With their embedded literature review, the following chapters examine a specific industry context, identifying areas of concern and then utilising case studies (student design proposals) to evidence possible approaches and solutions. These design intervention proposals frame the specific problem and the key design considerations and detail a design response that is supported by an implementation strategy, and an analysis of potential impact. Designs are considerate of the needs and physicality of ageing workers, supporting their longevity in employment, whilst proposing systems that aim to ensure younger workers are protected from work-related long-term deterioration.

It is hoped that the outcomes of this research and design project provide direction towards strategies, products and service systems that have the potential to deliver benefits to all stakeholders in the targeted industries, safeguarding future workplaces, and empowering and enabling older workers.

1

An Ageing Workforce

An Ageing Workforce

Healthy Ageing

The notion of healthy ageing, the aspiration of quality of life and ongoing autonomy into later life is an underlying goal for many Australians as they age. In declaring 2020 – 2030 the 'Decade of Healthy Ageing', the World Health Organisation (WHO) is responding to a rapidly ageing global population, building global commitments in a call to action to foster longer and healthier lives (WHO, 2020). Ultimately, within the context of an ageing workforce, the Decade principles seek to change how we think, feel and act towards age and ageing, and ensure that communities foster the abilities of older people.

While healthy ageing is targeted at developing and maintaining functional ability and wellbeing in older age, it is a concept that should be a 'whole life' consideration and highly relevant to all of us. Functional ability can be determined through several factors, be that our underlying physiological and psychological state, our health-related behaviours, or our environments that strongly influence our opportunities. As our report discusses, workers young and old, are affected by their social and economic equity, which is driven foremost by their working conditions. Disadvantages in health, education, employment and earning start early, they reinforce each other, and will be accumulated over a lifetime. Individuals who develop poor health will work less, earn less, and retire earlier, with working and ageing trajectories also influenced by gender, culture, and ethnicity.

Responding to the WHO's decade of health ageing, this report focuses on the barriers to employment in later life, while extrapolating the implications for their younger peers. The Decade of Healthy Ageing provides an opportunity and platform to address existing power relations and norms in light of an ageing workforce and influence how present and future Australians can develop throughout their careers. Because the barriers to longer and happier working lives are socio-economic, this holistic safeness by design approach will look to consider the following issues: health, finance, long-term care, social protection, education, labour, housing, transport, information, and communication, which are often beyond the scope of health and safety in the workplace.

When designing for an ageing workforce, it is essential to focus not just on those who are aged but those who, without appropriate intervention, may be forced to leave the industry early due to physical and cognitive decline or as a result of preventable injuries. Consequently, the approach taken in this project was to be responsive to the immediate needs of older workers, but also pre-emptive so that younger workers can ensure their longevity in the workplace and profession.

Effects of Ageing

The realities of ageing affect older Australians in many ways, but most notably, it complicates their efforts to navigate the workforce and maintain paid work. Research demonstrates that older age is a competitive disadvantage, with two-thirds of companies holding this belief (Premuzic, 2019). This situation can largely be attributed to how age affects the work we can do, as those in later life are more likely to have reduced physical and mental health, which directly affects their wellbeing. For example, as research indicates, our physical strength and ability to see and hear decline as we get older. However, cognitive abilities such as working memory, reasoning, attention, and processing speed do not generally show a decrease until after the age of 60 (Table 1).

Critically, the ageing process and its impacts are not uniform nor consistent across the population. Countless individuals in their 60s and 70s are actively engaged in their careers, valuing the purpose and networks they associate with their work. However, an individual's workability (the competence, health and virtues required to manage tasks) can also be perceived socially and culturally; for example, ageing males can be perceived to have reduced masculinity as their hormones and physical strength declines (Marchant, 2013). This intersection of ageing with societal norms can be seen in the generational stereotypes that exist in the workplace, with these attitudes and assumptions affecting a worker's behaviours and self-perception (Radford et al., 2018).

In supporting older workers, employers can make specific changes and adaptations to the work and workplaces they inhabit. As workers age, they are more likely to develop illness and disabilities, requiring reasonable adjustments to their duties, the premises, or providing them leave to undergo treatment and rehabilitation. While older workers do not have a higher likelihood of occupational accidents than other demographics, accidents can be more serious, as physical injuries can take longer to heal (Okunribido et al., 2011). These are more prominent in specific industries with more manual handling, generally requiring physical strength and stamina, producing more of these risks. Returning to work is not an easy journey for such workers, requiring extensive rehabilitation and long periods of recovery and absenteeism, with many never returning to work.

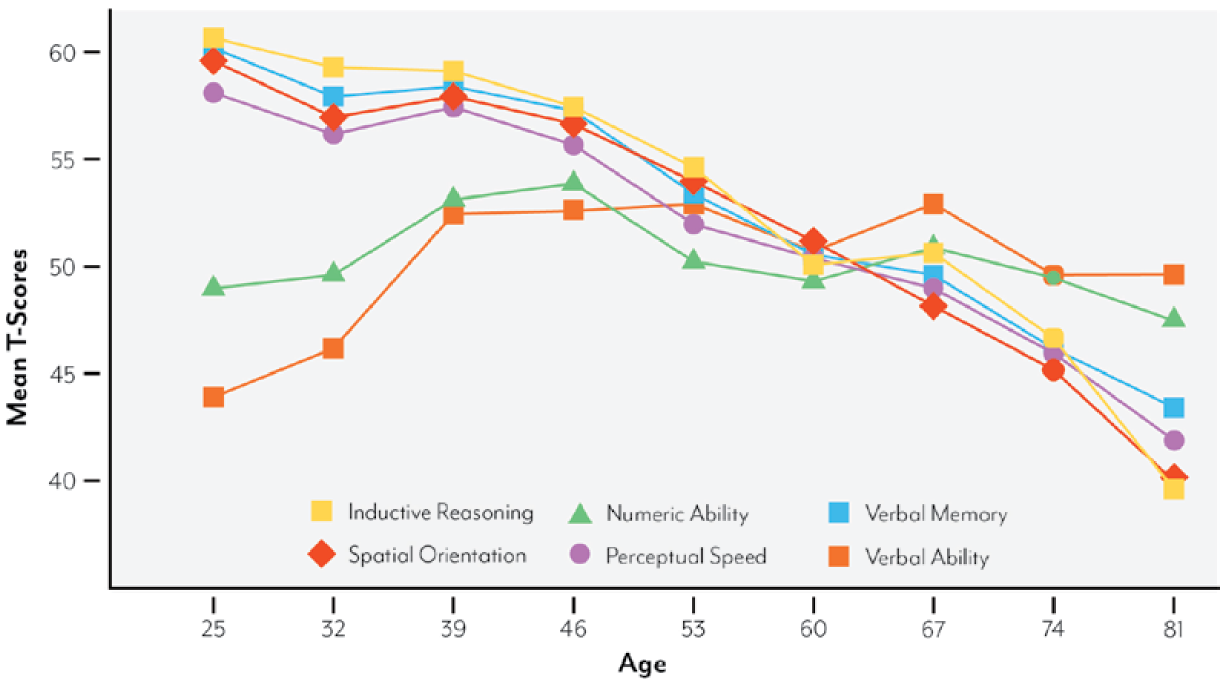


Table 1: Aspects of cognitive decline across population *(Ray & Davidson, 2014)*

These physical risks are exacerbated by the ageing process, which alongside a reduction in vision and hearing, affects perceptions and self-confidence. Having an injury can lead older workers to perceive additional barriers to their ability to work overtime, feel a loss of autonomy and self-worth; while at the same time they face ageism in their workplace, increasing physical and cognitive demands, and pressure to retire (Wegman & McGee, 2004). Like the general population, this can lead to additional stress, fatigue, and mental health issues for older individuals (Harncharoen et al., 2016). It is important to note that these are all complications or risks that can be mitigated through timely and considered responses in the workplace. These measures involve employers adapting to the older work's abilities, reducing duties, or changing the environment to suit their needs (UNISON, 2017). Workplaces will have to adjust to the prevalence of these chronic health conditions today, to address the larger issues and barriers an ageing workforce brings tomorrow.

Beyond these health-related characteristics, additional aspects of work can also become complicated with age. The primary of these is the capacity to learn, which directly affects workers' abilities to be valuable to their employer. While older workers have been seen to benefit from training, they are generally slower and less effective than younger people in learning new skills (Picchio, 2021). As a result, many older workers and their workplaces associate ageing with loss of usefulness, opportunities, and time loss (Ng & Law, 2014). The speed and unpredictability of the workplace only adds to this issue of worker obsolescence, a concern for older workers in our digital era.

The Older Australian Worker

Being employed longer and transitioning from career development to career maintenance is a reality many older workers face. While chronological age is not often the sole determiner of an older worker, those 45 to 55 years old are increasingly considered in this cohort (Gahan et al., 2017). Yet as we see this trend towards an ageing population, the threshold for being an older worker in Australia will increase. The Australian Institute of Health and Welfare (2018) has determined that around 1 in 8 older people are employed nationally, with their workforce participation increasing. Further, while the average intended retirement age is 65, 1 in 4 will work beyond 70: some voluntarily, however many are seeking to supplement their income or save more for retirement.

As a diverse demographic, older workers are found across various fields and occupations, with many sectors reliant on their ongoing participation in the workforce. Trends indicate that more older women are located in the healthcare and agriculture sectors, with older men engaging in manufacturing and agriculture (CEPAR, 2021). These industries are dependent on older workers remaining in employment, as their workforces age faster than most. Most older workers seek flexible work arrangements to remain in the workforce (Australian HR Institute & Australian Human Rights Commission, 2021). Employers are also quite aware of the complex and increasing chronic health conditions older workers have, with increasing diabetes and chronic pulmonary obstructive disease rates over the coming decades (Australian Human Rights Commission, 2016).

Mechanisms of Injury and Injury Factors

To contextualise the effects of ageing in the workforce, we have sought to emphasise the complexity of occupational health problems. Foremost, the associated risks form a significant burden for individuals and a high cost to the healthcare, industrial, and government sectors. As a leading cause of work disability and sick leave, Work-related Musculoskeletal Disorders (WMSDs) are a wide variety of injuries to the muscles, tendons, and nerves, which develop gradually over time (Smith-Young et al., 2014). Leading to this type of workplace injury is exposure to manual handling, forceful exertion, highly repetitive motions, awkward posture, and vibrations (Okunribido et al., 2011).

WMSDs continue as the leading work health and safety (WHS) problem in the Australian workforce, with neck and lower back areas of increased risk (Oakman et al., 2019). The tasks which can cause or aggravate issues can involve working with a bent back, carrying and lifting, working with arms above shoulder height, or kneeling and stooping (Boschman et al., 2012). Almost all workers will have to complete such tasks, and over time many will have to deal with unpleasant sensations from the musculoskeletal system. However, this discomfort can be worsened and prolonged; if unattended, it can reduce workability or quality of life (Hagberg et al., 2012).

Considering how prevalent these disorders are across the workforce and how they become more severe with age, it is important to highlight which industries will see faster ageing and predominately older workers. Research conducted by the ARC Centre of Excellence in Population Ageing Research (CEPAR) (2021) has indicated that healthcare, agriculture, transport, and trade sectors presently rely more heavily on older employees. This reflects data that indicates healthcare, manufacturing, construction, and trade see the most claims of serious WMSD in Australia (Oakman et al., 2019). While understanding that these issues are complex and dynamic and cannot be easily attributed, this relationship between the ageing workforce and work-related musculoskeletal disorders in these sectors offers designers and researchers opportunities to target and respond to the risks. In doing so, we explore how older workers negotiate these factors and risks in occupational, health, and social contexts.

Impact on Workplace and Industry

As part of this overarching trend in the workforce, industries have seen a shift in the ratio of dependents to workers, with a growing percentage of Australians who rely on a dwindling labour force. This situation has two key impacts for employers; fewer and older candidates for jobs and existing employees remaining in service longer into their later life (Victorian State Services Authority, 2008). This ratio of dependence has only been exacerbated by the COVID19 pandemic, as older workers have faced higher health risks for working than their younger peers (Radpour et al., 2020). The pandemic has also resulted in a dramatic decline in immigration, an issue for countries such as Australia, where migrant and itinerate workers are a panacea to support a 'greying' economy, labour intensive industries, and the ageing population (Yahya, 2013).

The workplace itself has evolved dramatically throughout the lives of many older workers and now needs to incorporate their needs in later life. Workplaces are complicated places, which can influence our perceptions of organisational culture and acceptance, directly impacting our motivations to leave or continue working, as well as our capacity to cope with job demands (Buckle et al., 2009). During their careers, older workers have had to utilise various strategies to adapt to such demands and maintain their functionality and capability in the workplace (Ng & Law, 2014). Workplaces are now becoming focused on supporting both organisational and self-development opportunities for learning, offering more support to older adults and reflecting the desires of younger workers (Bingham, 2019).

Ageism and Bias in the Workforce

Older workers offer our society immense value and labour, both paid and unpaid. Yet stereotyping, discrimination and malpractice continues to be experienced by mature-age workers, with two-thirds of individuals aged 45 to 74 having experienced age-related discrimination (Bersin & Chamorro-Premuzic, 2019). Typically, negative attitudes toward older workers are that they are poor long-term investments, as they may lack the ability and desire to develop or retrain themselves, cannot use new technology, or are inflexible and unwilling to change. As a consequence of these biases, employers have been inclined to screen out older adults in often obscure ways, such as to limit their access to roles via Internet advertisements and word of mouth, while also preferencing younger workers (Harris et al., 2018).

These generalised assumptions of the capabilities of older workers have had a direct impact on employment opportunities in later life, with many older workers working fewer hours than desired, resulting in Australia recording a rate of underemployment which is much higher than the OECD average (J. Li et al., 2015). Worker underutilisation, combined with the age-related discrimination, disrupts task performance and may negatively affects an individual's motivation and engagement, further impacting both individual productivity and company efficiencies. (Kulik et al., 2016).

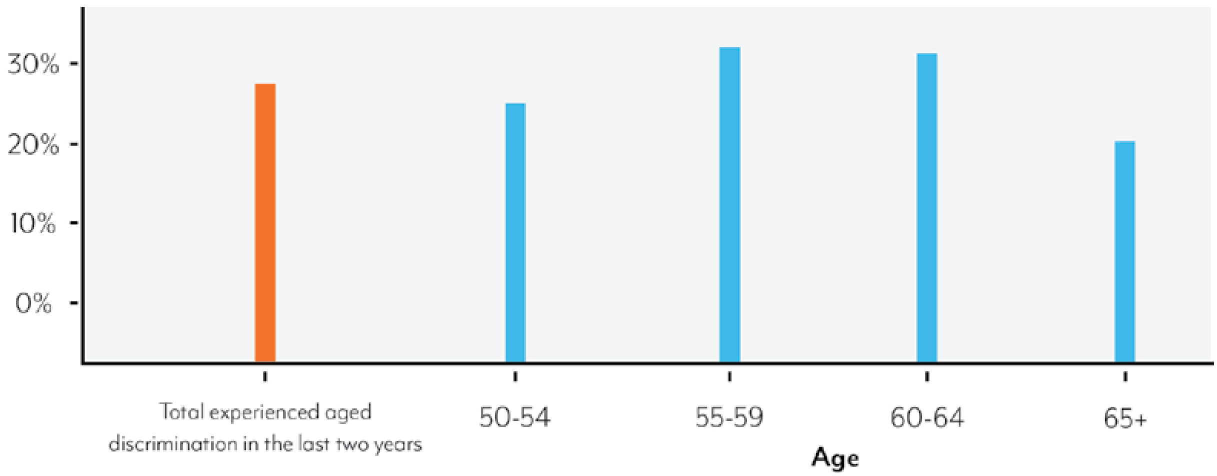


Table 3: Prevalence of discrimination by Age *(Centre for Better Ageing, 2021)*

Attitudes and Perceptions towards Older Workers

Engaging with older workers, younger workers, management, or even customers, can form certain attitudes and perceptions that can be inaccurate or misguided. These have been documented as being predominantly negative in the past, however, ongoing research gives hope that negative views of older workers may be shifting (CEPAR, 2021). At present, the data suggests that many organisations prefer retaining an existing ageing worker as they are perceived as having specific skills and experience rather than recruiting a worker who may need to be trained. (Blomé et al., 2020).

Employer opinions on older workers are frequently the subject of research studies, as their attitudes and perceptions can bring obstacles and opportunities while having implications for job retention (Frøyland & Terjesen, 2020). Scholars have demonstrated that many employers hold negative attitudes towards older workers in general terms, however less so in their ability to cope with changes or learn new things (Kadefors & Hanse, 2012). In addition, outside management and employer views, colleagues can often hold particular perceptions of their older co-workers. For example, older workers are perceived as more conscientious than younger workers yet display lower friendliness, activity level, and cheerfulness (Truxillo et al., 2012). This is further confirmed by the perception that older workers are "solid employees, but do not participate so much socially at work" (Frøyland & Terjesen, 2020).

Alongside external opinions of them, older people also form self-perceptions in the workplace. Negative self-stereotypes have been demonstrated to affect cognitive and physical performance, exacerbating underlying conditions or worsening workplace relations (Truxillo et al., 2012). However, it was noted that experienced older workers also tend to be more outspoken and challenging to manage than younger workers and may be socially isolated in the workplace. (Frøyland & Terjesen, 2020). For job seekers, negative personal opinions such as feeling too old or too unskilled to qualify for roles, can result in a lack of self-esteem and motivation. (Kadefors & Hanse, 2012).

Digital Literacy

Technological and digital literacy, how well someone understands and utilises digital technology and its surrounding issues, has become a significant factor in the workforce. Being digitally literate requires ongoing professional development, and research indicates that older workers can adapt to new technology as well as their younger peers (McIntosh, 2020). Unfortunately, this reality is not so evident in the workplace, where discrimination based on age is based on claimed technological incompetence of older workers. Yet older workers predominantly see themselves as competent with technology (Dymock et al., 2012) while negotiating such ageism (Harris et al., 2018).

However, factors related to having digital literacy are quite nuanced due to varying skill levels across the workforce. Research indicates that older, semi-skilled and unskilled workers are often the most resistant to new technologies (Victor Gekara et al., 2019). The technology-driven rapid and radical transformation of work and the workplace is harder to manage for these older workers, with a pronounced impact on their behaviours (Tams et al., 2017). Resistance to work changing technologies and anxiety from disruptions to 'normality' can also negatively impact their personal lives.

Learning has become a critical tool for workers in addressing such disruptions. Employees in any sector, especially older ones with lower confidence or technological competence, need continuous training to remain competitive in the workforce (Lee et al., 2009). The ramifications of which are both positive and negative. While this could exclude groups who lack specific digital skills or access to technology, the opportunity for those willing to maintain or improve skills, barriers such as geographic distance and physical functionality are significantly improved (Mason et al., 2017). Either way, lifelong participation through digital technologies may be the reality for younger generations and reducing exclusion by supporting ongoing learning must become a tenet for working into later life.

Designing for a Safer and Older Workforce

In attempting to eliminate the hazards that pose a danger to workers, the role of design in safety is two-pronged: early preventive development, alongside ongoing reactive refinement of equipment, systems, and services. WorkSafe Victoria's (2021) defines designing for workplace health and safety as follows:

'Safe design identifies hazards and ways to control associated risks and then incorporates this knowledge into the design of end products to eliminate or reduce harm to people exposed to the products."

Risk reduction is a complex and multifaceted issue that the designer can engage with by eliminating or controlling the risk and reviewing outcomes. Furthermore, the direction taken in eliminating or reducing the risk is often reflective of the context and different approaches, i.e. procedural safety methods, for example, a human activated fire extinguisher, active methods such as an automatic water spray activated by a signal, or passive approaches such as fireproof building insulation, which is continuously and immediately available (van't Land, 2018). The concepts behind preventative and reactive approaches to safe design are discussed in the following sections to understand the approaches we have taken in our design process.

Accident Prevention through Design

Designers in Australia have a duty of care and are responsible for worker safety while building, which means they must consider the consequence of placing an unnecessary burden on operators while equally maintaining high levels of regulation that reduce liability (Bong et al., 2015). The design stage is fundamentally positioned for prevention and is critical in refining engineering, reallocating controls, and implementing personal protective clothing or equipment. If well-designed safety practices are in place, estimates suggest nearly 50% of fatalities can be prevented, making the inclusion and effectiveness of this stage imperative to long-term health and safety (Palumbo, 2010).

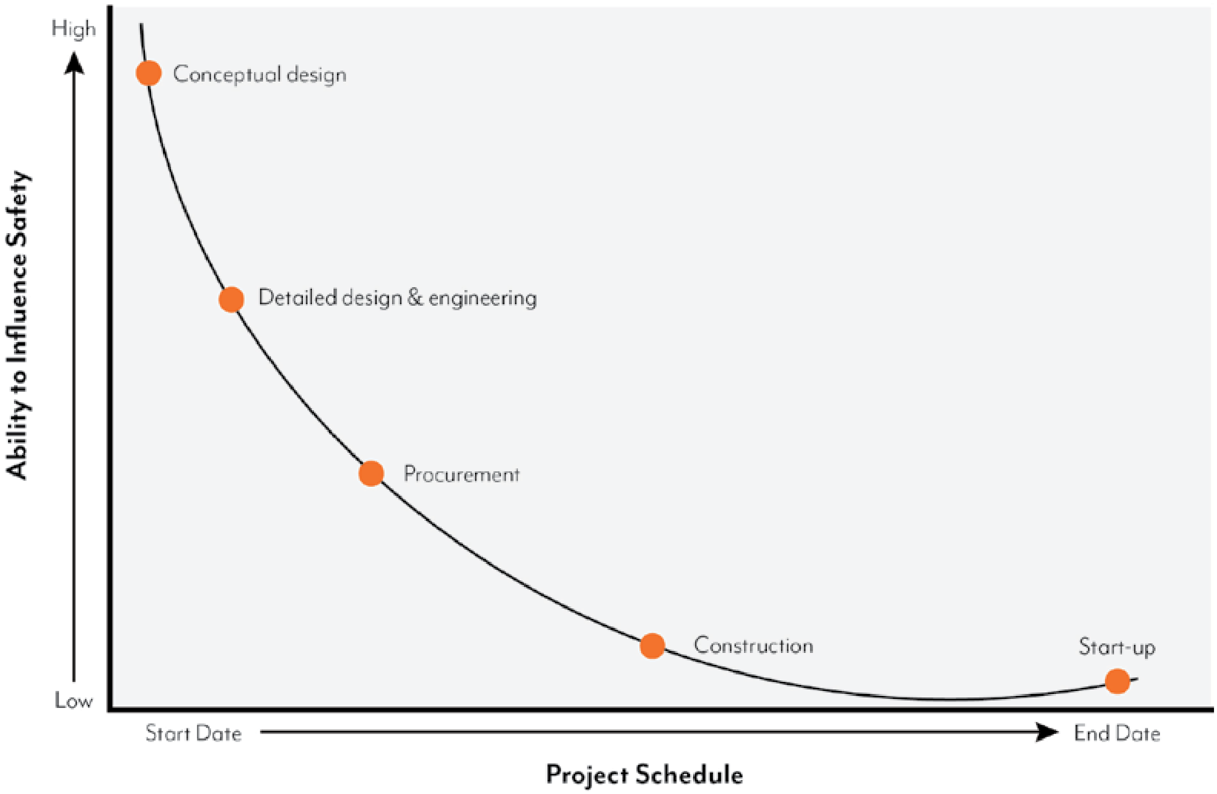


Table 4: Project schedule versus ability to influence safety *(Horberry et al., 2014)*

Design for construction workers' safety, Prevention through Design (PtD), has been well documented as being the most effective in eliminating potential hazards at the source before their implications are experienced on site (Gambatese et al., 2008; Kamardeen, 2015; Lyon et al., 2016). As shown in Table 4, the PtD process is most efficient in the conceptual, detailed and engineering stages, where the definition of work scopes, potential risks, and controls for hazards are considered and employed. However, there are some limitations to implementing PtD, some examples of which include, a narrow exploration of safety risk types, inadequate risk checking methods that do not fully leverage available safety knowledge, or the inability to review or check risk models for specific contexts (Yuan et al., 2019).

Designing for Reactive Safety Systems

While industry standards continue to impress the importance of proactive and preventive approaches, often only high performing organisations employ them, and most are still reactive in identifying hazards and implementing adequate controls (Brady, 2019). When dealing with reactive systems, the later methods of a preventive approach are employed, investigating incidents to identify how tasks are performed towards developing appropriate strategies (Horberry et al., 2014). While a necessary tool in the safety toolkit, reactive approaches forgo the opportunity to place safety at the centre of workplace and task design.

Fundamentally, designing for reactive safety involves dealing with problems and accidents after the fact. For example, mental health risks should be a preventive design concern that limits the potential for injury or fatality as reactive solutions come too late. In best practice, reactive systems require continuous improvement through an ongoing process, not unlike lean manufacturing, which sees workers' conditions and wellbeing of workers consistently improve over time. Employing a user-centred approach to designing for safety, in contrast to a technology-centred one, could be more effective across both preventative and reactive measures. This is most apparent in Safety in Design Ergonomics (SiDE) methodology, which focuses on operator risks related to equipment design, helping designers to identify, understand and provide solutions (Horberry et al., 2014) (Table 4). Here, solutions form from prioritising risks based on individual feedback and become part of an ongoing refinement process in the workplace.

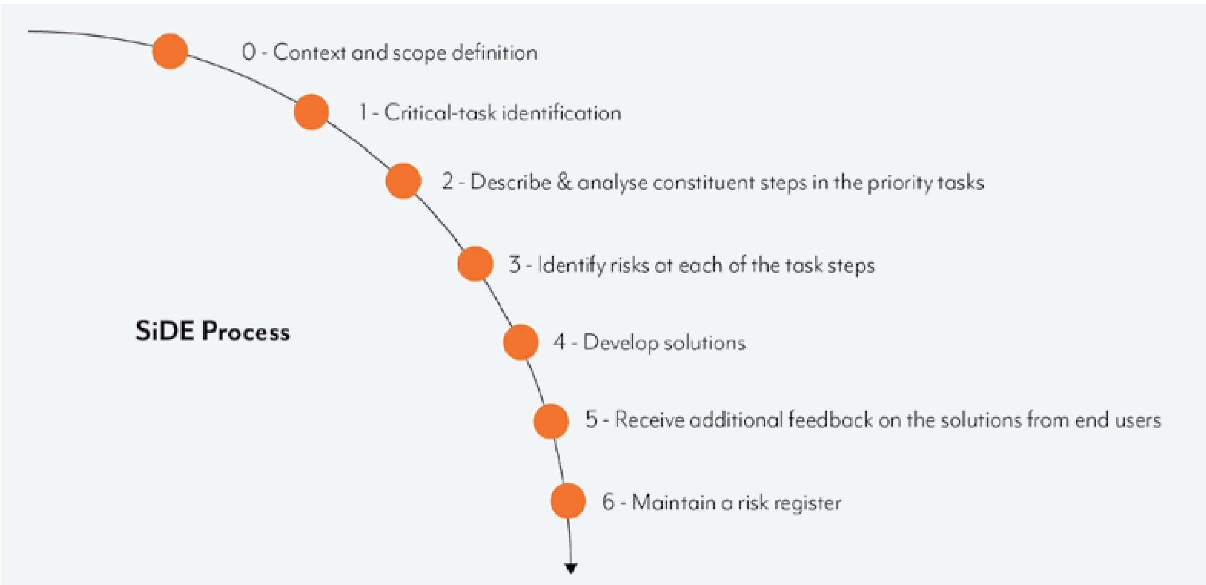


Table 5: The SiDE process *(Horberry et al., 2014)*

Design for Safeness

The need for industries to respond in a preventative and responsible way to safety in the workplace obliges consideration of a multidisciplinary and social lens of safeness embedded throughout the design process.

Safety is a challenge for designers, except where are they forced to address specific design standards and safety compliance regulations. Moreover, in their focus on fulfilling customer wishes and the demands of commercial expectations, it can be challenging to imagine and/or prevent unintended functions or scenarios (Rajabalinejad, 2019) and the consequences of misuse or reckless and harmful human behaviours.

Existing engineering design processes have safety retrospectively applied (as risk analysis), usually after the design phase, and analysis tools (e.g. FMEA) typically focus on component failure and are incapable of capturing a situation that may be unsafe but not initiated with a failure (Rajabalinejad, 2019).

Designing with a safeness lens implies a more holistic approach, with a strong understanding of human behaviours and cultures. It is critical for the designer to design not just for physical hazards but also for the users and the context and environments of use, with a strong understanding and empathy for human behaviour and awareness of the impact of rapid and disruptive socio-technical change. Risk-taking behaviours, team working dynamics and interpersonal relationships (e.g. supportive, competitive, intimidatory, discriminatory or exploitive), product interactions (both planned and unanticipated), individual perceptions and expectations of safeness (whether explicit or implicit), mental health and wellbeing, and the anticipation of long-term physical and cognitive degradation caused by prolonged and repetitive activities, are key considerations in designing for safeness.

This involves interrogating how our values, attitudes, and beliefs help or hinder our engagement with daily life and safety in the workplace. The proposition of Safeness by Design is to respond to the complexity of our worlds, considering the tensions of new technologies and practices while attuning to the behaviours and cultures that make us human. In positioning this paradigm of safeness in design, de Vere, McLeod and Wagenfield (2021) offer a strategy towards critically examining safety contexts and intervening within them:

1. To identify and frame problems within a more local and accessible context,
2. To work quickly and broadly across multiple contexts with a social and community focus,
3. To evidence capability to enable early engagement in future design cycles.

This holistic approach to managing and mitigating work risks sees designers align their design decision-making process with workers' perceptions of safety. Such a strategy places the responsibilities of designers for safety beyond just liability for the creations, but to actively prompt socially meaningful design initiatives within the context of safety, as 'design activists' (Manzini, 2014).

In this way, the burden of safety does not solely fall on designers, employers or workers. Instead, the designer can empower them to be autonomous by being transparent and accountable and forming safeness into their practices.

Project Outcomes

This research aims to identify the issues facing an ageing workforce across a range of industry sectors, to develop more supportive products, systems and processes that encourage longer and more productive and rewarding working lives.

This studio has sought to explore various aspects of the working lives of older adults by anticipating and addressing the issues that can cause unnecessary health problems and unwanted or early retirement from the workforce. The design students have utilised both available ethnographic research and human-centred design to capture an understanding of an ageing Australian workforce and then used this knowledge to inform their design process and final outcomes. The participating students worked in six small design teams investigating issues across five workplace sectors, and realised the following outcomes, which will be discussed in detail in the following chapters:

1. Reducing Injuries to Healthcare Workers during Home Visits
   Airlift – Homecare Patient Transfer Device

2. Enabling Ageing Manufacturing Workers in Small-Medium Enterprises
   POSCOR – Reducing Musculoskeletal Disorders in the workplace
   Lift+ – Mechanical knee brace for ageing manufacturing workers

3. Mental Health in the Commercial Construction Industry
   WAGS & SNAGS - Addressing mental health in the construction sector

4. Reducing Ladder Injuries in the Residential Construction Industry
   Breakfall - Ladder Safety System

5. Reducing the Impact of Vibration on Ageing Agricultural Workers
   SPIDER V1 – Vibration Dampening Tractor Seat System

The designers have also addressed each of these topics by exploring opportunities and concepts that can reimagine the future of longer working lives. Through extensive research and design development, the designers have realised impactful propositions which address existing concerns and offer unique solutions. The future-focused design solutions aim to enable our ageing workforce, by enhancing the opportunities for older workers, and improving the health and wellbeing of everyone in the workforce for tomorrow.

Reducing Injuries to Healthcare Workers during Home Visits

Reducing Injuries to Healthcare Workers during Home Visits

Home-based care is an essential function of everyday life for many Australians, enabling those with varying health care needs to maintain independent lives in their communities. These support services, made up of informal, paid and professional workers, are experiencing a growing workload and client base due to an ageing population, as well as having one of the most dramatically ageing workforces in Australia (CEPAR, 2021). It is anticipated that the trend towards more home-based care, expedited by policy that prioritises its funding and technology over shared facilities, will see around 80% of aged care services in Australia provided in the community (Palesy et al., 2018).

These tensions, between the increasing dependence on this sector and the pre-existing compromised service, are being played out in the lives of carers and recipients, their families, and communities. With 2.65 million unpaid carers in Australia, much of the care provided and received is informal or unpaid, with many workers supporting the system through their volunteered hours (Gusheh et al., 2021). Even for those with formal roles, the home environment can be unpredictable in caregiving services, requiring high levels of individual responsibility for safety, health, and wellbeing (Grasmo et al., 2021). Older care workers encounter these issues as much as any carer; however, their risk of injury is heightened.

This chapter will investigate the complexities of this workforce and their work environments, understand the complications of remote solo working and compromises for an older worker, and propose innovations to support carers in their daily duties. We first discuss the home and community care sector, detailing the roles and responsibilities, the humans giving and receiving care, and the potential dangers and issues which can arise from this work. This helps us frame the role of technologies in supporting home-based care, the complexities of modifications to the home, and where more solutions are needed to support HCWs working alone or in precarious conditions. Then, in acknowledging the stressors on this ageing workforce, this section seeks to respond through a creative and innovative design process, offering a conceptual system that can enable individual carers to provide appropriate and dignified support for their patients within the home environment.

Home & Community Care

As public spending on health and social care has shifted over the last few decades, care has increasingly been undertaken in the home, rapidly developing the home and community care sector. Australian policy has driven many of the home-care services available today, covering three primary domains of care: disability, aged care, and 'hospital in the home'. These three areas are supported by a workforce built on informal and professional carers, with the need for their service expected to only grow in the coming decades.

Aged care is a burgeoning sector that provides help through services that enable older people to live at home for as long as possible (Palesy et al., 2018). Australian policies, notably the Home Care Package, has seen the promotion of such 'ageing-in-place' arrangements of the last decade as a way to reduce pressure on residential aged care and support independence and quality of life (Harrison et al., 2019). Those choosing to stay at home were generally below 75 years of age, are most likely to do so in suburban areas and own their house (Kendig et al., 2017). While ageing longer in place is something many aspire to, staying put can add further burden through deteriorating health and increasing care needs (O'Loughlin et al., 2017). Finding the right 'fit' for housing is a key concern over later life, requiring home and community care service to plan and adapt to the individual's changing health, a less frequent occurrence in the disability sector.

As a cohort with long-term physical, mental intellectual or sensory impairments, people with a disability require an environment that can facilitate their daily lives and activities. The reasons for needing care are as broad as the barriers faced by people with a disability, with not only physical but attitudinal, institutional, and communication barriers reducing their participation in society (Gusheh et al., 2021). Considering this, many require home-based care and support with tasks around their homes or personal needs. The provision of these services has seen large-scale transformations in Australia in recent years, with the introduction of the National Disability Insurance Scheme and the emergence of specialist disability support services. Current data suggests some satisfaction for those who access this service, however, there are many important aspects of their lives that are not covered by the scheme (Australian Institute of Health and Welfare, 2020).

In comparison to the often more permanent or longer-term applications necessary in aged care and the disability sectors, hospital in the home (HIH), which covers sub-acute (rehabilitation and palliative), and acute care, can often be a more temporary situation. At present, hospital in the home is utilised in 5% of Victorian in-patient care (Montalto et al., 2020) and has seen increased popularity due to perceived safety, availability and cost-benefit compared to in-hospital care (Caplan et al., 2012). So far in Australia, only professional and multidisciplinary teams provide daily clinical care in this space, resulting in a minimal difference in care to in-hospital (Davies et al., 2000), however, cost up-front and ongoing cost has been a concern (Leff et al., 2006).

Across all these domains, there are potential and unforeseen dangers that can affect the wellbeing of home-care clients and carers in various ways. Physical deterioration, especially with musculoskeletal disorders resulting from the manual handling of patients, is of major concern to carers and staff (Caponecchia et al., 2020). Home care workers are also more vulnerable to moral distress due to institutional constraints and acting in contrast to their perception of good and bad (Burston et al., 2017). Recipients are at frequent risk of unmet needs (where a physical, psychological, social, or environment-related problem exists for which no adequate solution has been offered), and these pressures on the sector and its workforce threaten the safety of all those involved in home-based care (Kalánková et al., 2021).

A notable form of unmet need within the care sector is dignity, which can encompass a spectrum of problems that led to its loss and which can be associated with high levels of psychological distress, and loss of the will to live in older people (Goddard et al., 2013). Treating someone with dignity means respecting them as valued individuals, whether it is a patient receiving care, or the worker providing it. For recipients, perceptions of care can be linked to their vulnerability, such as with older people in residential age, where up to 50% fear abuse, which directly undermines their dignity (Gallagher et al., 2017). Further forms of patient dignity are often developed in the actions of care professionals, for example, through recognising and prioritising patient preferences and needs. Maintaining dignity is an ongoing and complex aspect of care, with certain tasks such as the use of hoists a challenge, with skilled patient handling requiring the right equipment, communication, and policies to be in place (Pellatt, 2005).

Alongside providing dignity in their care, workers also seek and need their personal dignity to be respected in their roles. Many home care workers struggle with the compromises and constraints on their services, finding their work meaningful even though it can be a highly stigmatised occupation (Stacey, 2005). However, caregivers can often feel unrecognised or undervalued in their role and seek to be acknowledged (Kuluski et al., 2018). Whether formal or informal workers, all make significant sacrifices to provide support and have care needs of their own that often are not prioritised. Dignity for workers can form in many ways (Stacey, 2005):

- through being provided practical autonomy to enable workers to create and manage their own environments within certain constraints,
- in recognising their work as not generic and 'anyone can do' but rather a unique caregiving skill set,
- a sense of pride from doing 'dirty work' such as personal care and hygiene, as well as positively affecting the emotional state of clients.

In exploring the role of care cultures in providing dignified care and support, and the existing issues across nations and society, research indicates a need for further innovation as this field expands. Cultures of care form through awareness and competency in supporting different traditions, national cultures and ethnic groups, as well as the practices and values associated with particular workplaces, organisations and professions. Taking a design lens to the topic, Laurene Vaughan's (2018) *Designing Cultures of Care* speaks to how to care in new and creative ways, advocating for co-creating and open-ended design which speaks to care in specific contexts. Such work puts emphasis on supporting marginalised and disempowered people to be their own activists, and considers how designers, healthcare professionals and caregivers can engage in this discourse.

Older Care Workers

As one of Australia's fastest growing (and ageing) workforces, the home care sector employs a variety of professionals across several contexts. This sector is divided into licensed health care professionals, nurses, physiotherapists, occupational therapists, and unlicensed home care workers (who account for more than 75% of the workforce) (Palesy et al., 2018). Work in home-based aged care can be irregular, with rotating shifts, and just under half of those workers are dissatisfied with their hours (Lewin et al., 2016).

While those in aged care and disability often work in very different contexts, these workforces share many characteristics, including demographics, skills and tasks associated with their roles and employment conditions. Specifically, there is a high representation of female workers with compressed working hours, and as interactive care work often involves personal and one-to-one support with significant emotional content (Alcorso, 2017). In addition, while they are often lower-skilled than their medical peers, clients rely on their home care workers for health advice and perceive them as trusted professionals (Palesy & Jakimowicz, 2020).

Alongside these factors, older care workers also face hazards, not only in age-related deterioration of strength, dexterity, hearing or vision, but they are also vulnerable to work-related repetitive strain injuries, overexertion, fatigue, slips, trips and falls (Johnson, 2015). Globally, it remains unclear if home care work exploits older workers, but the work remains low-wage, is perceived as low-status, and is overwhelmingly done by older women (Lee et al., 2009). Compared to their younger peers, older aged care workers are as productive as those in high cognitive roles, such as nurses, gaining productivity and experience as they age (Wei & Richardson, 2010).

In addition to formal home-care staff, informal carers play a significant role, with around 1 in 10 Australians acting as unpaid primary carers for someone with long-term health conditions and disabilities (Australian Institute of Health and Welfare, 2021a). These family, friends, or neighbours, who are caring for a loved one in the home environment, can find it a rewarding experience, however, they can struggle with being relied upon to coordinate and supply long-term care. Sadly, research indicates informal carers have the lowest collective wellbeing of any group, particularly female carers, leading to mental and emotional turmoil (Cummins & Hughes, 2007). Although we note older carers cope better with their responsibilities than younger ones, this has been attributed to more experience, better social and financial support, and overall enjoyment in caregiving (Mohanty & Niyonsenga, 2019).

For both professional and informal carers, challenges to safe home care are related to environmental, equipment and process. Safety risks form in access, communication, working alone in an uncontrolled environment, and the provision of equipment (Hignett et al., 2016). These factors are more prevalent in-home care than nursing homes, with issues more prominent in daily care situations, particularly regarding moving and handling clients (Kromark et al., 2009). Work-related musculoskeletal injuries are common where caregivers work in home environments, with a lack of pre-emptive steps before strenuous movements, inappropriate use of assistive devices, and the development of potentially hazardous movement patterns and behaviours has been evident (Roberts, 2020). Assistive technologies have in the past been considered as a hypothetical substitute for human help (Allen et al., 2001), although today's workers are augmented, not replaced, by various assistive equipment.

Equipment & Systems

The technology utilised in the home care repertoire is diverse and often personalised, providing clients access to the community and independence they seek. This can range from simple mobility assistive devices to electric wheelchairs to smart home systems, all of which have reduced the amount of informal care needed, but not the need for personal services (Anderson & Wiener, 2015).

In the disability, aged care or hospital in-the-home context, caregivers see assistive technology in conjunction with the care they provide, offering safety, security and supporting basic daily living activities (Anderson & Wiener, 2015; Sriram et al., 2019). However, the effective use of assistive technologies can be impacted by a lack of information leading to uncertainty about appropriate intervention, the need for support from formal health and social care services, as well as individual comfort levels (Yusif et al., 2016). Home care workers and their clients must balance the caring needs and abilities, the funding methods, and the learning curve associated with ongoing or technical assistive systems.

As an area of concern for both carers and their clients, mobility and patient transfer or repositioning can lead to safety issues and long-term harm for carers. Many systems have been developed to reduce or replace the workload involved. A typical daily task in the hospital, aged care and the disability sectors, changing a patient or client's position can often range from awkward and difficult to potentially dangerous with a novice caregiver, whilst an experienced HCW will demonstrate a better methodology; with stronger communication and working closely with the patient to coordinate the movements (Daikoku & Saito, 2008). However, most patient transfers in a controlled environment (hospital, aged care facility. etc.) are done with colleague support and significant equipment installation and availability, whereas the home care environment typically involves the HCW working alone, in domestic bedrooms, where patient access and environmental control is more difficult. In home care, easily portable equipment, such as slide sheets, transfer boards, mobile hoists or slings, are used to reduce rates of injury for both parties, as well as reduce the need for expensive home modifications (Barker, 1995; Gusheh et al., 2021).

However, even with safe patient handling policies in place, there is evidence that home care patient transfer can involve unnecessary or preventable patient handling, potential risky HCW movement patterns, and a reluctance to report risks to superiors (Skatssoon, 2019). While allocating two care workers to such duties reduces such risks of manual handling injuries and unsafe handling of clients, it is not cost-effective and consequently is not common practice in-home care (Kayess et al., 2013). Agencies and policies continue to see one worker as sufficient in most circumstances; however, practical training, suitable environments, and appropriate equipment are necessary to reduce risk. These issues are compounded for informal carers, who reported technical troubles related to the design and usability of these solutions, finding them time-consuming and requiring ongoing training (Hassan, 2020).

Case Study: Airlift

Homecare patient transfer device

Designers: Maireid Carrigg, Fergus Davidson, Maneet Singh

Figure 4 Airlift System on a bed

AirLift is a specialist product addressing the musculoskeletal issues ageing healthcare workers face, with a specific focus on care in the home context.

Problem Statement

According to an article published by the Australian Government in 2021 (AIHW, 2021), the demand for home care has tripled since 2010. In addition, by 2031, 20% of the Australian population will be over 65 (increased from 16% currently) (CEDA, 2021), highlighting the demands the healthcare industry is facing.

Unfortunately, as older female nurses near the end of their careers, the recruitment of healthcare workers is lagging behind the demand, with CEDA (2021) predicting that there could be a shortfall of 110,000 healthcare workers (HCW) if recruitment is not significantly increased. The healthcare workforce within residential, hospital and community nursing/caring is ageing, with the median age of Residential Care workers in Australia being 46 years, a figure that is increasing as many repurposed older workers join the healthcare industry (CEDA, 2021), as well as school leavers choosing alternate professions.

This situation is further complicated by many healthcare workers leaving the industry prematurely. While there are many reasons for this, we note that nurses and carers experience high rates of musculoskeletal issues from long-term patient handling movements, with 60% of HCW reporting back problems. Alongside the physical risks, workplace pressures such as high service demand, inadequate salaries, demanding working conditions and challenging and/or unpleasant experiences, are known to lead to mental health issues.

The healthcare sector has benefited from technical interventions in monitoring, workplace equipment, and company systems; areas that will become critical, as the move to distributed and mobile caregiving continues. A combination of forward-thinking strategies and pre-emptive solutions is required to cope with future shifts in the industry and retain healthcare workers in often unsupported and resource-poor environments, such as home care. Home visits from workers such as nurses and personal carers are increasing in demand rapidly as the industry strives to maintain independent living for its patients, provide a better quality of life, and alleviate the demands on the hospital and aged care sector. However, these environments can be challenging for a healthcare worker due to unpredictable patient behaviours, the risk of patient or family violence towards the HCW, and the potential for HCW injury due to a lack of colleague support, especially during patient transfer or repositioning.

Within this context, injuries to HCWs are prevalent as they are required to individually and manually reposition patients through a range of movements (lifting, turning, transfer, etc.). Frequently, this is without specialised lifting hoists or the assistance of a colleague to help with the use of a slide sheet. This situation results from the budgetary and logistical demands of the homecare sector, which often struggles with a lack of HCWs. As a result, many healthcare workers conduct homecare visits alone, with minimal resources and equipment. This is a striking contrast to the carefully controlled and monitored environments found in hospital and healthcare facilities, where colleague assistance is readily available.

Figure 5: SlipperySally Single Patient Use Slide Sheet

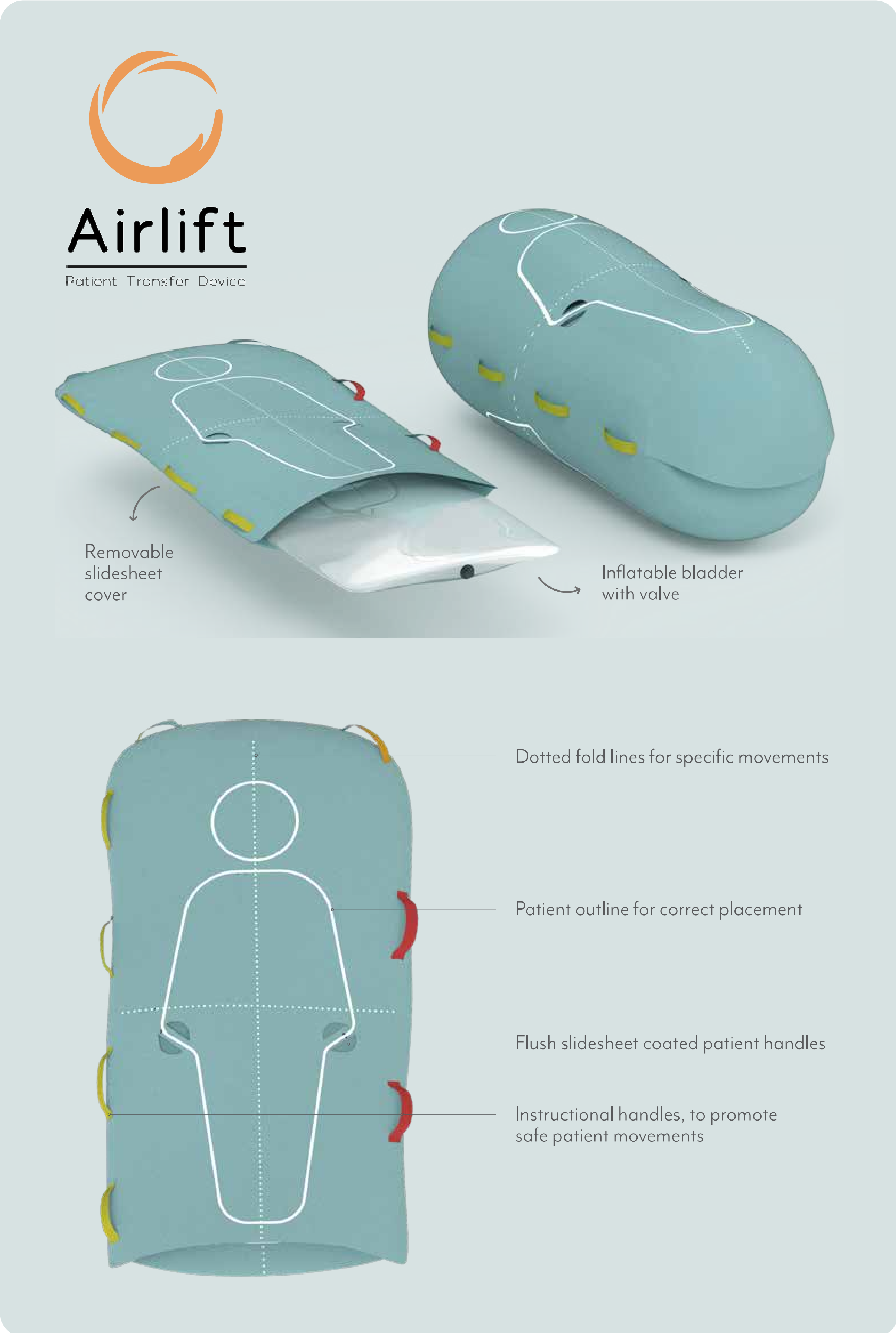


Figure 6: Airlift Key Elements

Slide sheets are an inexpensive and ubiquitous health care tool, allowing the movement of patients in and out of bed. They are made of a sheet of fabric, most commonly nylon, with a slippery silicone coating, which, whilst aiding patient transfer, can be difficult to hold by an older HCW with reduced grip strength. Although HCWs value slide sheets for their versatility and simplicity, they are intended for use by two able-bodied professionals, not an ageing HCW working alone and unassisted in a patient's home. Using a slide sheet in a single healthcare worker context exposes the HCW, whether young or old, to the risk of immediate or long-term injury or physical decline. It can also be a traumatic and undignified experience for the patient as they suffer the humiliation of powerlessness during a difficult positional transfer.

It is vital to protect and support the ageing HCWs and ensure that younger workers are protected from long-term musculoskeletal issues that may cause them to leave the industry prematurely. Thus, a portable solution is required for homecare use to enable a single HCW to effectively transfer and reposition patients in a dignified and calm manner without the need for complex and expensive lifting equipment.

Key Design Considerations

"Any piece of equipment that removes the need for a second person has significant potential."

- use by a single healthcare worker within uncontrolled environments (i.e. patient homes),
- need to conduct three key patient transfers; sit up/lift, roll over and translate (repositioning patient relative to the top of the bed) with ease,
- educational/instructional aspect to reinforce safe patient transfer movements,
- ease of use for older HCW with reduced grip strength,
- maintaining patient dignity,
- hygiene - easy clean/sterilisation for patient safety,
- lightweight and portable,
- battery-powered - possible lack of access to a power supply.

Project Outcome

The AirLift is a hybrid inflatable slide sheet device that replaces the conventional slide sheet in the home care setting. It aims to promote corrective behaviour change, reduce grip related accidents, and allow safe, independent patient handling.

The device is made of nylon fabric with a slippery coating and an inflatable rubber tube inner. When uninflated, the AirLift is flat for storage and transport and easily positioned under the patient (similar to a slide sheet). When inflated, it expands to a cylindrical shape to assist the HCW in lifting and repositioning the patient.

The AirLift consists of an inflatable plastic bladder with a valve on one end. This bladder is wrapped in a removable slide sheet cover with handles and educational/instructional markings. The cover is shaped like a pillowcase with a Velcro opening on one end to facilitate removal and replacement between visiting patients, ensuring adequate hygiene is maintained.

In use, the Airlift can be gently tucked or slid underneath the patient before inflation. When inflated, the layer of air between the patient and the bed drastically reduces friction forces, making translating them significantly more manageable. This allows the HCW to easily shift them up the bed by pushing on the patient's feet, raising them to a sitting position, or rotating them to the edge of the bed using the integrated handles to stand up.

The device is inflated using a rechargeable battery-powered pump controlled via a discreet remote-control unit that can be clipped onto the HCW's clothes during operation, keeping their hands free to secure the patient as the Aircell inflates.

Airlift ensures proper patient handling techniques using instructional graphics printed onto the cover sheet and several integrated handles placed along the perimeter of the device. To aid older HCWs, silicone grips are attached to the underside of the ripstop handles, which reduces required grip strength, making slide sheet and patient handling easier and safer. Yellow handles are used for insertion, orange for removal, and red by the patient when a reposition is performed. This design encourages a collaborative series of actions with the HCW and the patient working together, maintaining patient dignity, and reducing perceptions of helplessness.

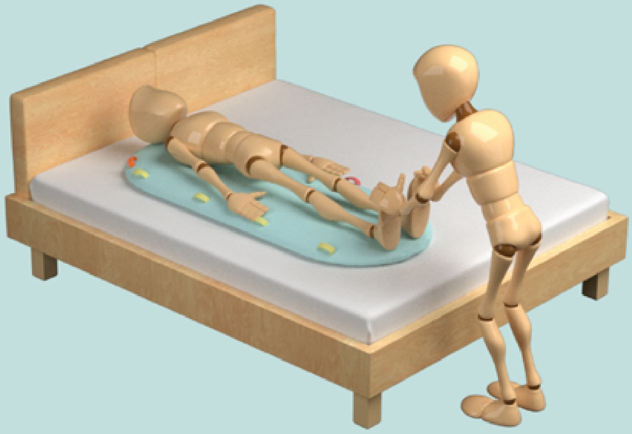
The combination of the inflatable Aircell, the instructional graphics, and the strategically positioned soft-grip handles enable a single HCW to undertake patient transfers, whilst removing the need for the HCW to perform potentially unsafe patient movements. As a result, the AirLift should mitigate musculoskeletal injuries in HCWs caused by solo patient transfers, supporting career longevity and older healthcare workers.

Implementation Strategy

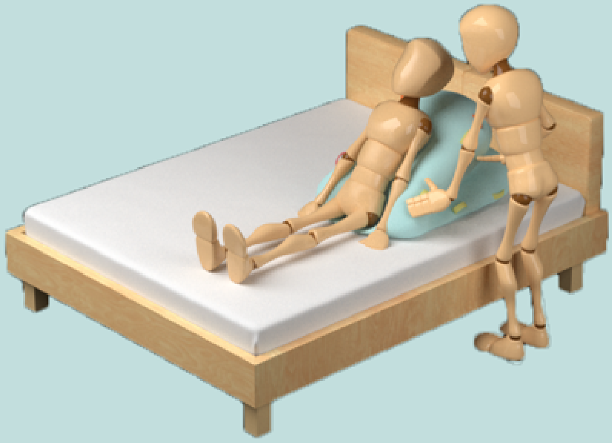
The Airlift system could be promoted through avenues such as NDIS, local council community care, or larger private healthcare companies. Ideally, it will replace the existing slide sheet as a low-cost, practical, and straightforward patient transfer device, with the potential to significantly reduce HCW injuries and long-term physical impairment.

Both older and younger healthcare workers will benefit from its implementation. Older workers will be able to continue to serve their patients longer into their careers, whilst younger workers will be less likely to suffer injuries or long-term impairment that would cause them to leave the profession prematurely.

The Airlift device can be used in a more traditional slide sheet manner (without using the inflation Aircell) but with the added benefits of the integrated handles and instructional graphics. Providing this agency to HCWs allows a better chance of product implementation, especially for those who have worked in the industry for a long time and are used to the simplicity of using a slide sheet. However, the full assistive benefit comes with the use of inflation to reduce transfer loads.



Translation up the bed



Sit patient up

Roll patient on side

Figure 7: Patient Movement

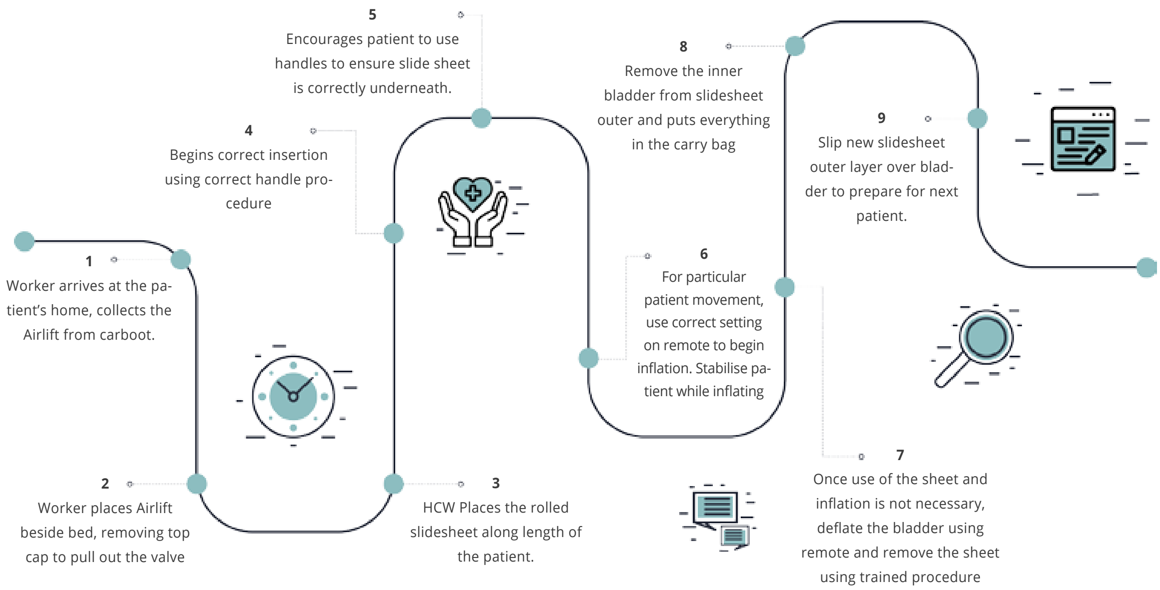


Figure 8: Airlift User Experience Map

The Airpump and Remote page- can you reword to
'Remote attaches via magnet to housing in the pump,
where both can be charged through USB-C in a car.

Figure 9: Airlift Accessories

Review of Potential Impact

The Air Lift replaces the need for a second HCW when performing potentially harmful patient repositions, lifts and transfers. The low-tech, simplistic design effectively replaces the existing slide sheet with a device that is designed for single HCW operation and still utilises existing patient transfer methods, but in a more supported and safer manner.

Benefit to the Ageing Worker:

- reduces overall risk of musculoskeletal injuries,
- makes sheet grip easier to maintain and therefore ease of use is increased,
- provides safety in reduction of patient lifting load due to inflatable aircell,
- ease of transportation,
- increases ability to provide better care for the patient.

Benefit to Younger Worker:

- reduced overall risk of long-term musculoskeletal injuries,
- implementation of correct behaviour and good decision making as habits,
- increases the likelihood of employment longevity in the healthcare industry.

Benefit to the Patient:

- overall sense of safety and assurance increased due to the use of patient handles,
- understanding that the healthcare worker is following correct handling practices,
- overall risk is lowered when the worker stabilises the patient through the process,
- empowers patients to be involved through the process,
- patient dignity is enhanced.

Benefit to Healthcare Provider and Broader Industry:

- a product solution that responds to the shift towards one worker funding, allowing the provider to deploy one healthcare worker to each house,
- offers duty of care solution from the provider for employees – responding to identified risks,
- decrease in healthcare worker injuries and time off work.

The Airlift enables healthcare workers to make informed decisions regarding patient handling when working unsupported in homecare. The colour coded handles and instructional markings aid the healthcare worker with correct handling and practice, whilst the inflation process lessens the physical demands of patient transfer and removes the need to perform dangerous patient repositions and transfers. When used in practice, these tools will help inform correct patient handling for those entering the workforce, enable ageing employees and prevent musculoskeletal injuries, keeping front line workers happier, healthier and at work for longer.

Enabling Ageing Manufacturing Workers in Small-Medium Enterprises

Enabling Ageing Manufacturing Workers in Small-Medium Enterprises

An essential and integral cohort of businesses, small and medium-sized enterprises (SMEs) provide the economy with an essential point of employment and innovation. In Australia, where they represent a significant portion of the industry, small businesses employ up to 20 people, or medium-sized ones employ up to 200 in their workforce (Hardie & Newell, 2011). Due to their size, SMEs are viewed as agile and pioneering, with much potential for growth, although many carry some risk in their ventures (Islam & Tedford, 2012). Workers are often more likely to be casual or part-time, with a minimal amount of permanent employees (Sargent et al., 2018).

Many challenges with worker safety are faced by both of these stakeholders in this environment. Workers encounter an elastic and/or less structured workplace, limited resources, hazy oversight of their daily tasks, and with less operational, automation and safety systems in place. Businesses have a lower capacity to control and assess occupational and workplace-related risks such as, health issues, accidents, and injuries (Al-Ibyari, 2017). Because of these risks, older workers face reduced employment and training opportunities, increasing discrimination and disparities in health, leading to more challenging workplace conditions (Yahya, 2013). Responding to these issues, we highlight two overarching domains of measures, active and passive, which seek to increase safety and reduce the risk associated with SMEs.

In this chapter, we contextualise the state of the Australian SME workforce, with specific emphasis on the manufacturing sectors and the issues for older workers. We explore contemporary approaches and solutions to reducing physical harm and fatigue by discussing the long-term and present risks to health and safety in these workplaces. As this group of businesses engage older workers and an ageing workforce, innovations in this space will be critical in developing assistive technology for everyday tailored programs and workflows. This chapter introduces two case studies that explore active and passive measures in dealing with health and safety for the worker in the SME context.

Australian Small-Medium Enterprises

Small to medium enterprises provide many Australians with employment and are a fundamental component of the broader economy. This is most apparent in the over 2 million small businesses in Australia, accounting for 97 per cent of Australian businesses, alongside 51,000 medium enterprises (The Australian Small Business and Family Enterprise Ombudsman, 2016). In addition, SMEs are a significant driver of innovation, growth, investments and exports (Johansson et al., 2019). As the literature describes them, Australian SMEs are the 'lifeblood of the economy', possessing invaluable dynamic capabilities (Weaven et al., 2021).

Manufacturing is one of the most diverse industries in which SMEs engage, with capabilities ranging from construction products, defence industries, mobility to energy technology. Australian manufacturers continue to exhibit the advanced characteristics required to be successful, developing complex processes and building valuable industry and business knowledge (NSW Department of Industry, 2018). Maintaining these qualities, and being competitive in this dynamic environment, sees SMEs require a high level of workforce agility, a critical resource (compared to larger firms) in being proactive, adaptive and resilient (Alavi, 2016). Due to this, workers need to be multiskilled, adjust quickly and easily to new tasks, and are often very valuable in managing situations that machines are ill-equipped to handle. This informs expectations on their capacity to embrace dynamic workplaces and be involved in experimental innovation on the factory floor.

Considering how saving time and increasing efficiency is more likely to produce greater outcomes in this industry, SMEs must also be aware of the potential risks and dangers of this space. With this in mind, SMEs often have characteristics that can make health and safety policies challenging to implement. They generally run with less and limited resources, relying on a larger pool of casual and part-time workers (Sargent et al., 2018). Workers are more likely to be exposed to dangerous situations and suffer more work-related injuries and illnesses than those working in large manufacturing environments with automation and assembly line controls, where worker actions are carefully monitored (S. Legg et al., 2009). With ageing workforces and shifting demographics globally, the manufacturing sector must manage more complexity from workers, an issue worsened for SMEs. In this context, an ageing workforce will need further support and options to reduce the likelihood of injury and maintain long-term health.

Older Workers in Manufacturing

Employees in this sector tend to be older, associated with lower labour mobility, increased risk of unemployment, and an overall disadvantage (Productivity Commission, 2003). Compared to other industries, manufacturing remains one of Australia's largest full-time employers, yet workers are increasingly working across occupations while also facing the pressures of flat wages. Meanwhile, manufacturers compete with other industries for skilled labour, with many employers expecting to have issues recruiting skilled workers (Australian Industry Group, 2019). Manufacturing has historically seen low education rates from employees. However, this trend has changed dramatically in recent decades, with older workers needing to upskill and receive training to remain competitive (State Government of Victoria, 2017). This job market has also been impacted by Australia's migration policy, which targets skilled immigration, such that immigration is the principal contributor to labour supply (Callahan & Bowman, 2015). It's evident that while manufacturing, and notably SMEs, have survived many existential challenges in the last decade, necessary rebalancing and upskilling has left the sector and its workers vulnerable.

Considering the roles of manufacturing workers more closely, they require effective near vision, upper extremity strength, grip strength, mobility and dexterity, and endurance, making physical health important. Unfortunately, older workers face a loss of nearly 30% of their physical strength and endurance by age 60, with estimates at a loss of 1% a year from age 30, though higher physical demands throughout a career will result in a more significant decline in physical capacity (Sanders, 2018). Their ability to find work is often hindered by low language, literacy and numeracy skills across mature workers in the sector (Callahan & Bowman, 2015). In addition, automation is increasingly replacing workers in complex, high precision, repetitive, dull or hazardous tasks (CSIRO, 2016). Considering the barriers they face, the ageing manufacturing workforce will need to change their work style, learn new skills, incorporate new ways of working, and increasingly rely on co-workers for assistance.

The manufacturing industry has one of the highest rates of illness and injury and some of the highest levels of older workers amongst any sector (Sanders et al., 2014). The physically demanding work provides risks of injury and fatigue, which are amplified as aged-related issues, such as a decrease in muscle strength, bone density, and increased chronic conditions. In addition, SME workers are often lower-income earners who can most benefit from health improvements in their workplaces (Sargent et al., 2018).

These are issues that all workers face, whether young or old, however it's important to note their needs do differ in several ways. For example, older workers are more likely to benefit from increased autonomy, flexibility and task specialisation. However, they are also likely to associate work pressures with poor psychological health (Dollard et al., 2012). This sees the workplace as a critical area in which individuals, co-workers, equipment, and risks intersect; where the health and wellbeing of older workers need to be addressed.

Workplace Health & Safety

As an evidenced and increasingly important issue that SME businesses need to deal with, it is apparent efforts to support health and wellbeing are mixed. Few workplaces have adopted health promotion into their shops, with employees and employers seeing time constraints as a critical barrier to implementation (Sargent et al., 2018). Ginny M. Sargent and colleagues (2018) have detailed the barriers to better workplace health and safety, determining managers can often withhold opportunities for health promotion through employment contracts and their perception that "that time at work is time for work". There is evidence that SME workplaces can be particularly poor in their response to health and wellbeing when compared to larger organisations (S. J. Legg et al., 2015) and do not always apply standards for risk control (Bluff, 2017).

These factors form a particular perspective and lens through which SMEs view health promotion and the risks to their workers. In many ways, managers are more likely to be aware of workers' health and wellbeing problems because they have personal contact with their staff. Yet, these organisations are likely to implement low financial or time costing solutions foremost (Banwell et al., 2019). As such, many small businesses see a need for the burden of responsibility to be shared (Mckeown & Mazzarol, 2018). From this perspective, the issues of risk and injury should be a joint endeavour, reflecting the need to retain skilful older workers in an ageing workforce and reduce the chance for hazards and chronic conditions in the workplace. Responding to this context, we discuss enabling ageing manufacturing workers in SMEs through two approaches: active and passive workplace health and safety practices.

Active Practices

Active measures are those in which workers are provided responsive hazard control measures to reduce human workload and increase performance. In practice, these are work modifications that directly enhance or support workers in their tasks, thus actively improving workplace health and safety. Most are assistive technologies, alongside some orthotics, which can influence the neuromuscular and skeletal system characteristics. For example, older workers may use lifting equipment to compensate for diminished upper body strength, magnifying helmet visors or goggles to view parts, or modified tool handles to enable better grip and control (Sanders, 2018).

The development of ergonomic solutions, which limit work demands to reduce exposure to working stresses, has resulted in manufacturing becoming safer during the last century (Panjaitan et al., 2020; Reiman et al., 2021). Such efforts in the workplace were located in refining seating, operating tables, handheld equipment, or consoles to suit human characteristics, offering a healthier position and posture (Cheng, 2011). Combined with lean manufacturing trends, these developments resulted in the reduction of production costs, whilst improving working conditions (Colim et al., 2021). However, whilst these developments attempted to mitigate risk in tasks, emerging innovations are more about displacing or negating workplace risk.

Over the last decade, the implementation of new types of technology and workplace innovation has significantly impacted manufacturing environments. Traditional tasks have been augmented by new workplace equipment and procedures, with robotic arms and exoskeletons reducing stress and physical workload, and collaborative robots (cobots) replacing humans in hazardous tasks. Implementation of exoskeletons, and other wearable mechanical devices to increase worker strength and endurance, has been rapid in automotive and other manufacturing sectors, with significant literature evaluating their effectiveness (Fox et al., 2020; Peron et al., 2020; Rashedi et al., 2014). Early results indicate the implementation of these assistive technologies results in worker injuries initially dropping, but not in the long-term; however, back and shoulder pressure is reduced with no evidence of strength loss (Workers Health & Safety Centre, 2021). This suggests that the technology supports the worker and offloads effort sufficiently to avoid immediate injury, but that the risk of muscular-skeletal injuries from prolonged and repetitive activities still exists.

Further removing the worker from hazards, cobots are industrial robots that perform repetitive and non-ergonomic tasks and are notable as an example of an active approach. They work in collaboration with workers without the need for safety barriers. However, both innovations come with caveats, particularly for the SME sector. First, these innovations can be expensive and highly specialised, and are often more beneficial on a standardised factory production line than in a dynamic SME workshop, where tasks vary on a daily basis. Second, in being responsive and reducing human workload, they often remove specific risks rather than proactively managing the individual's wellbeing, a consideration again in the SME context.

In contrast, active measures that focus on enabling the individual directly are often interventions in the workplace and worker training. Traditionally, the primary way of managing musculoskeletal disorders, has primarily been through ergonomics and education (Muñoz-Poblete et al., 2019). Workplace physical activity interventions such as resistance and aerobic exercises combine these features, effectively improving worker physical health and performance (Matsugaki et al., 2019). Alternatively, insoles are supplied to workers to reduce pain and injury, targeting the low back pain of factory workers (Jefferson, 2013). Evidence suggests that supportive braces may also be beneficial, but are dictated by worker preference, comfort, and cost (Bisset et al., 2014) rather than task related. However, to be effective, a professional intervention by a physiotherapist or occupational therapist, is required to achieve individualised adaptations and/or workplace redesign.

Passive Practices

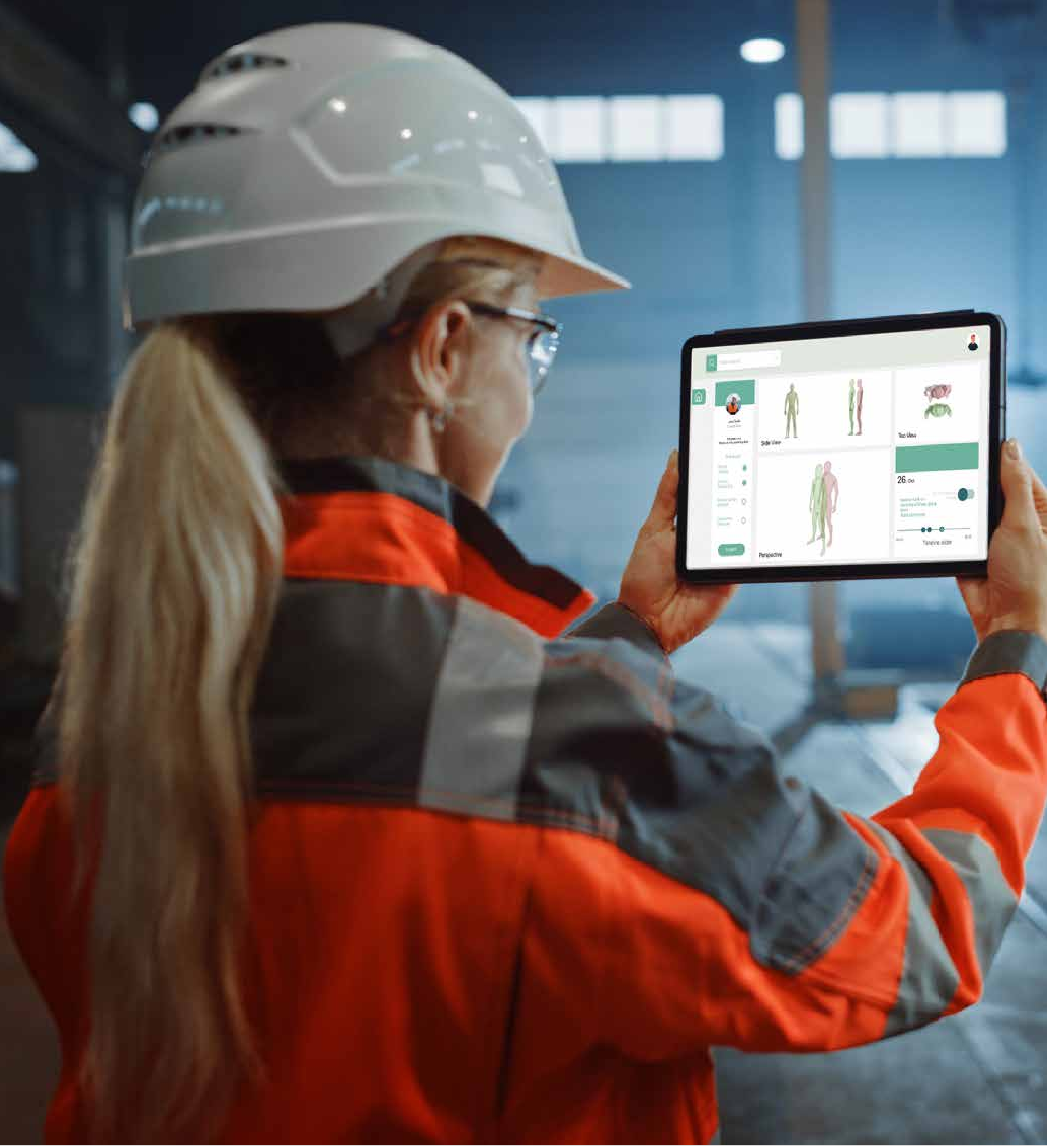
Where active practices in workplace health and safety are responsive, passive practices are often more preventative in approach, with worker maintenance and wellbeing monitoring. While more conventional maintenance in manufacturing might be considered overhauling industrial machinery or equipment and facilities, worker maintenance means preventing issues from unravelling, sustaining, and preserving capacity, and stopping injuries from occurring (Taib, 2016). Maintenance in the context of falls accidents, for example, might involve the installation of safety nets and guardrails, using workers monitoring systems and audits of construction sites (Umer et al., 2018). Self-regulation and monitoring of performance and medical status, rather than organisational risk management, are more prominent in the SME contexts (Bluff, 2017), though technologies are changing how we monitor workers.

While worker safety monitoring systems have traditionally been integrated into the workplace, such as in the cabin or as part of hazardous equipment, the accessibility of highly accurate sensors in the decade has made wearable technologies and devices more viable for workers in dynamic environments (Horrey et al., 2012; Stojadinovi et al., 2015). As Ibukun Awolusi and colleagues (2018) have detailed in the construction and manufacturing industries, this offers a new way of monitoring workers' physiological data, such as heart rate, breathing rate and posture that can provide early indications of high-risk health issues. While present solutions are highly targeted and have strengths and weaknesses, the opportunity to make such discreet systems complementary or develop multi-modal sensors, remains.

While such monitoring does well to indicate the needs of workers, particularly transitioning older ones, occupational healthcare, and physiotherapy continue to offer interventions and prescribe solutions to managing long-term health. In the preventative space, this has seen the targeting of workplace ergonomics e.g. footrest interventions (Aziz et al., 2020; Colim et al., 2020), health through education programs (L. Li et al., 2019), and dietary intake and education (Rueff & Logomarsino, 2016). In much of the above work, monitoring vital signs and indicators of health remains a key to tracking and modifying interventions over time, with evidence that having workers monitoring can reduce exposure to hazards (McTague et al., 2013).

Designing Workplaces for Workability

All of these interventions discussed above contribute towards improving 'workability,' focusing on the workplace as the space for promoting health for older male workers, who are considered less proactive about preventive health (Sanders, 2018). In enhancing employees' work-life and promoting productivity and longevity in the workplace, workability involves interventions that adapt the work environment, the organisation or working conditions to reduce work-related stress or physical demands (Sippli et al., 2021). Increasingly, these interventions are human-centred design, which focuses on the operator as much as their task, enabling the redesign of workplaces to focus on improving workers' wellbeing (Colim et al., 2019, 2020; Papetti et al., 2020; Peruzzini & Pellicciari, 2017). However, more is needed to address the workability for older workers in supporting them in physically demanding activities, providing job rotation, and improving their perceptions of being valued in their workplace.



Case Study: PosCor

Reducing Musculoskeletal Disorders in the workplace

Designers: Tony Lin, Shashank Rathor, Jasper Tarran, William Harden

Figure 10: PosCor Overlay Interface

PosCor is a product-service system that allows physiotherapists to move from reactive treatment to pre-emptive educational interventions, to facilitate behaviour change and reduce workplace injuries in the manufacturing sector.

Problem Statement

With the average life expectancy and retirement age increasing, there is a rising trend of older employees working past traditional retirement ages. However, current workplaces are not typically designed to facilitate an ageing workforce, especially in physically demanding industries such as SME manufacturing, where a lack of appropriate policies and plans to help prolong people's work lives, is restricting the full potential to which older workers can function.

Consequently, a growing proportion of older workers in the manufacturing industry are susceptible to musculoskeletal injuries. This trend is likely to continue, with the Australian Workers Compensation Statistics from 2017 to 2018 showing that 48% of serious claims are related to musculoskeletal disorders. These incidents resulted in an average of 9.8 weeks off work, and an increase of 168% in compensation payments between 2000 and 2018. In addition to short term (recoverable) injuries, the impact of long-term health degradation and decline in physicality is significant. This is an issue that needs to be addressed not just by supporting older workers, but also through targeted behaviour change in younger workers to ensure non-damaging movement patterns and behaviours.

Posture and Movement Pose Long-term Risks

By understanding the types of risks presented at the workplace, physiotherapists can introduce pre-emptive actions to prevent immediate injuries or long-term impairments. Harmful movements typical in SME manufacturing environments include:

- bending the back sideways and forward more than 20°,
- bending the head/neck- sideways and forwards more than 20°,
- bending back or neck backwards, especially under load,
- object Handling – awkward lifts and handling due to exceeding safe dimensions (e.g. more than 500mm),
- twisting the neck more than 20°,
- lifting objects – exceeding safe weights of 20-25kgs,
- quick and sudden movements,
- pulling objects (rather than pushing using bodyweight).

These movements may not be particularly harmful in isolation (as an individual movement), but their culmination can be. Sustained and repetitive movement cycles greatly exacerbate the risks of injury or physical degradation, as does the addition of load-bearing into these movement patterns. It should also be noted that whilst some movements are immediately identifiable as harmful (e.g. through instant nerve response), the impact of many harmful movements will only become apparent after a prolonged period, by which time long-lasting impact and/or permanent damage may already have occurred.

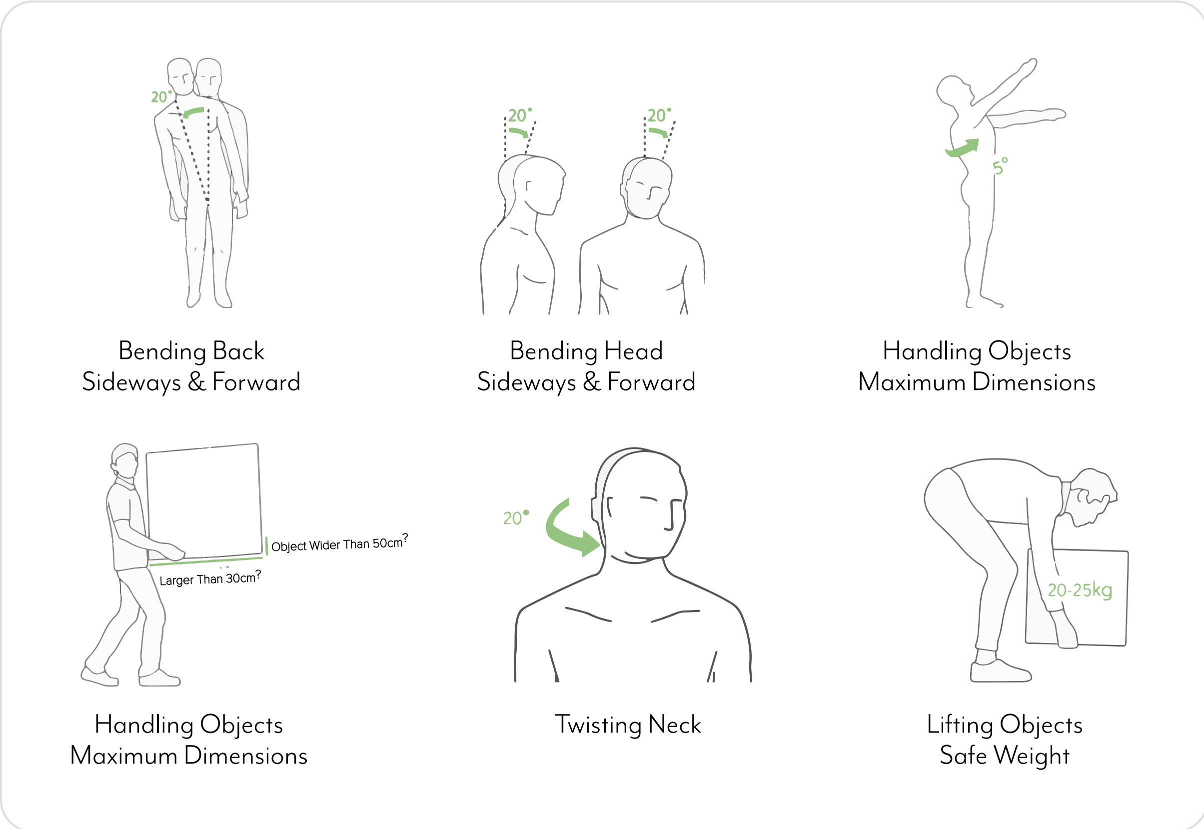


Figure 11: Posture & Movement Risk

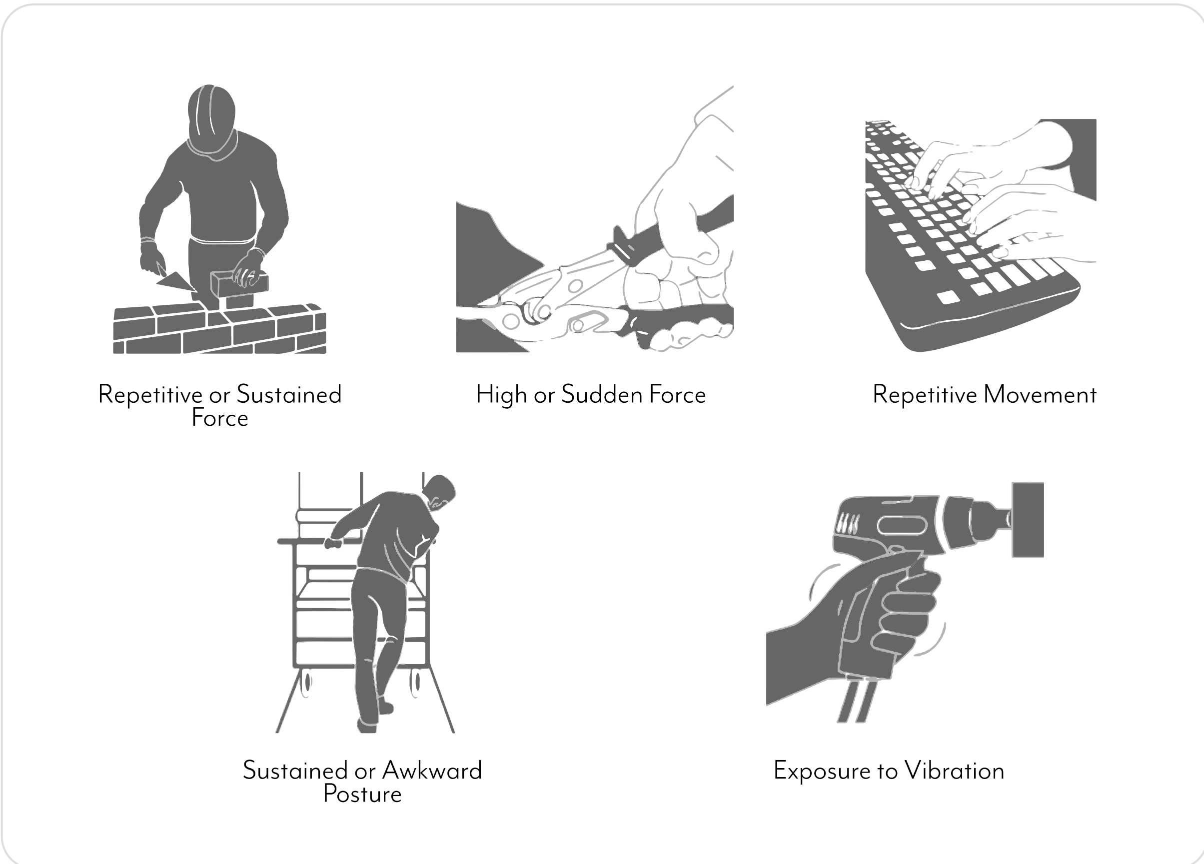


Figure 12: Hazardous Manual Tasks

WORKERS COMPENSATION CLAIMS

48%

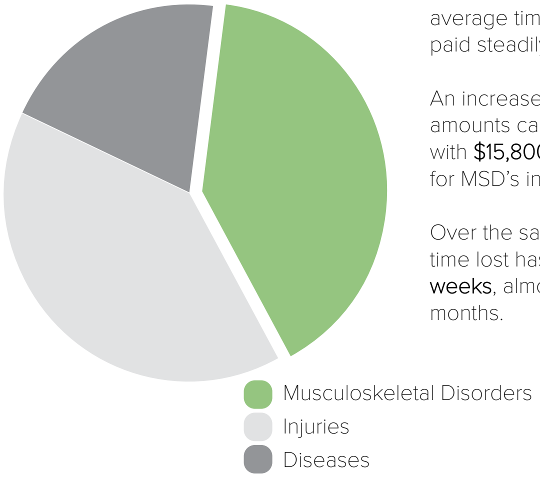
Serious Claims

9.8 Wks

Average time off Work

$**15,800**

Average Compensation



The Australian Workers Compensation Statistics from 2017 to 2018 show that 48% of serious claims are related to musculoskeletal disorders with average time lost and compensation paid steadily increasing over time.

An increase of 168% in payout amounts can be seen since 2000 with $15,800 stated as the average for MSD's in 2018.

Over the same period the median time lost has lengthened to 9.8 weeks, almost two and a half months.

Figure 13: PosCor Statistics

Figure 14: PosCor Approaches to Key Considerations

Hazardous Manual Tasks

A hazardous manual task, as defined in the Work and Health Safety Regulations, means a task that requires a person to lift, lower, push, pull, carry or otherwise move, hold or restrain anything involving one or more of the following:

- repetitive or sustained force,
- high or sudden force,
- repetitive movement,
- sustained or awkward posture,
- exposure to vibration.

These factors (known as characteristics of a hazardous manual task) directly stress the body and lead to injury. Unfortunately, the demands of SME manufacturing environments and the distinctly varied work patterns and outputs make it an industry where movement behaviours are hard to monitor and control. Unlike a mass manufacturing environment with an assembly line where worker movements and actions can be carefully designed, controlled and supported by assistive technologies, the ad-hoc nature of SME environments has an increased likelihood of movement behaviours that can lead to immediate injury or long-term acquired musculoskeletal disorder.

It is important to develop a pre-emptive response to this issue through a targeted intervention protecting all workers before injury occurs. Rather than just responding to the needs of aged workers who may already be suffering from work-related muscular-skeletal disorders (WMSDs), it is beneficial to identify behaviours and activities that lead to them.

Key Considerations

A solution is required that is not workplace or task dependant but more closely aligned with worker training and awareness, good practice and movement behaviours at an individual level, combined with supervisory monitoring and enhanced workplace design.

Functionality:

- instant feedback for awareness, training and injury prevention,
- movement capture/data gathering /diagnostic tool for physiotherapists.

Outcomes:

- education and awareness,
- movement training,
- workplace redesign.

Project Outcome

PosCor is a product-service system that enables a physiotherapist to develop a comprehensive understanding of an individual's movement patterns and behaviours within the workplace during a prolonged monitoring period, using a movement monitoring suit and data analysis software.

In existing interactions, the physiotherapist is merely treating/responding to existing injuries with minimal understanding of the underlying causes and the context and environment within which they occurred. The PosCor model enables a pre-emptive intervention by the physiotherapist, whereby the service provided is not reactive treatment, but rather a close working relationship between physio and client, facilitated by the employer company, to enable redesign of worker movement in the workplace.
The service comprises four distinct action sequences:

- a mobile physiotherapist consultation with workers at their workplace,
- specific motion tracking as the worker completes daily tasks wearing a specially designed sensor suit that monitors all movement actions,
- a review and further consultation aided by the analysis of captured data, and
- data-driven solution implementation to drive awareness and change in movement patterns and workplace redesign where appropriate/necessary.

The key components of the service are the movement monitoring suit, the app interface and the software tool used by the physiotherapist for data analysis and movement visualisation.

Movement Monitoring Suit

The suit is a wearable movement monitoring device integrated into everyday workwear, with sensors located across all major joint centres of the body. It is expected that the suit would be worn for a 2 to 4 week monitoring period, enabling all typical movement patterns to be captured for analysis.
Data must be captured over an extended period to allow the worker to become comfortable or relaxed with the suit, in order to fall back into normal behaviours, without being conscious of movement in a way that may influence the findings.

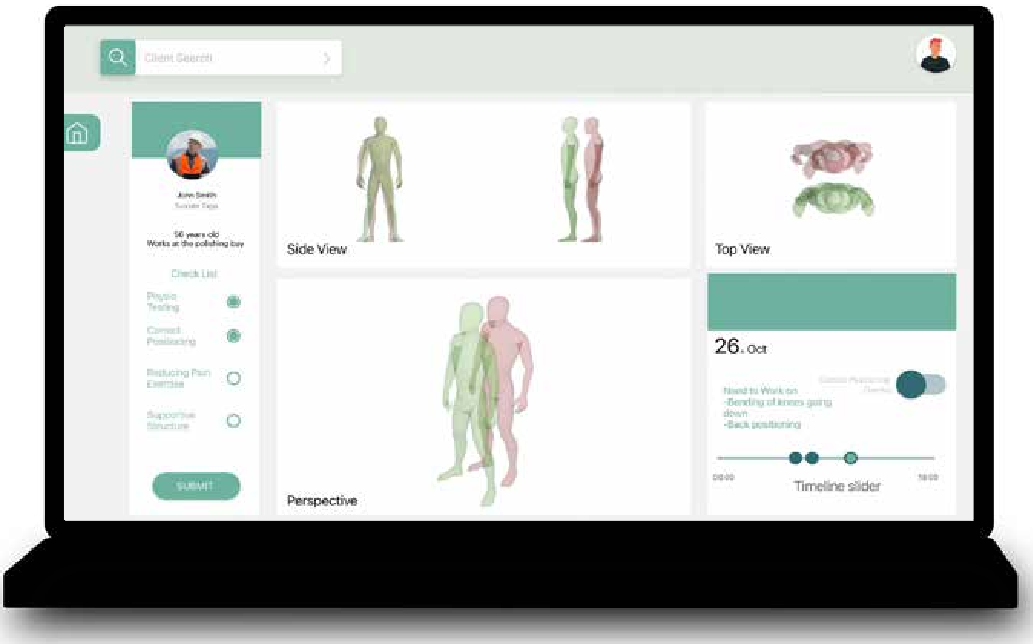
The suit monitors movement patterns using a combination of sensors, including:

- an accelerometer to calculate the forces applied, the speed of movement and actions,
- a gyroscope to map body tracking and track repetitive actions, and
- a muscle sensor to capture the muscle contractions and measure the strength required for workplace movements.

It has a rechargeable battery integrated into the belt, which distributes the weight across the hips by placing it close to the centre of gravity and the suit is washable, with all electronics in sealed waterproof cases.

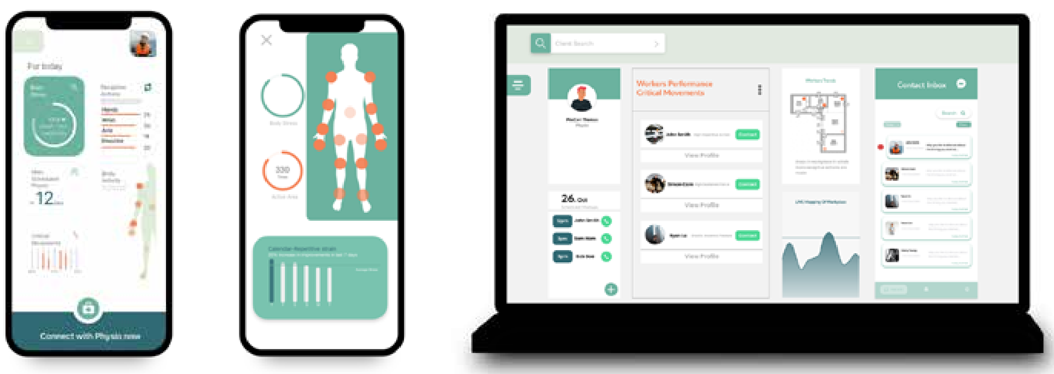
Whilst the suit's main function is monitoring and data collection for later analysis, it can also work proactively if required. This functionality uses integrated vibration devices in the sensors to signal the wearer dynamically, if unsafe movements are detected.

Figure 15: PosCor Artefact Overview



COMPARISON OVERLAY

Figure 16: Realtime 3D Modelling Overlay Visualisation



LOOKING INTO
DAILY STATISTICS

UNDERSTANDING
PERSONAL BODY
ACTIVITIES

PHYSIOTHERAPIST
MONITORING
DASHBOARD

Figure 17: PosCor Digital Outcome Interface

App Interface

A mobile phone app function, targeted at the worker, is employed to raise awareness and understanding of the suit wearer's movements. By pairing the suit with the app on their phone, workers can access their day-to-day movement patterns and understand which sets of actions and periods have increased the chances of Musculoskeletal injury. The app can also be used to directly contact the physiotherapist for live chats, to ask questions and seek advice, or book a check-up at the workplace or clinic.

Physiotherapist Data Analysis Software

The software tool interprets the captured data to allow the physiotherapist to visualise the individual worker's activity during the monitoring period. It allows for quick identification of extreme or injury-causing movements, whilst analysing the data to identify areas where remedial training is required. This is achieved through an overlay system where the worker's movements and posture are overlaid with an ideal scenario for comparison.

This allows the physio to have a timeline animation of all the individual worker's relevant activities and to highlight those which may cause the most harm. It is shown in three different perspectives of 3D animations that accurately depict the worker's exact motions, providing the physio with enough information to uncover any areas of concern, highlighting the difference between potentially harmful and/or ideal movement. These visualisations are valuable tools for educating and retraining workers to correct their occupational movements across various tasks and activities.

Implementation Strategy

This proposal has the potential to become an innovative business model for physiotherapists, has great potential for the sector, and its associated industries.

To further develop the strategy, this service/agency will need to have detailed consultation and buy-in, with a number of key stakeholders such as trade unions, employer industry groups, work cover insurance agencies and government safety/regulatory agencies, lobbied to raise awareness for the potential benefits of the service.

It is anticipated that it may also be possible to attract National Health and Medical Research Council funding, to evolve the system, ready for implementation.

Review of Potential Impact

The PosCor system has the potential for significant impact in the areas of behaviour change, workplace redesign and industry reform. Essentially, it allows physiotherapists to be proactive in industrial environments rather than waiting for injured patients to present. This is achieved through bringing their clinical expertise to workplace risk identification, long-term injury prevention and training and awareness.

Behaviour Change

The primary function of the PosCor monitoring and data analysis is to create a comprehensive picture of movement and behaviours to stimulate awareness and understanding in workers and employers, and to develop movement retraining to prevent future injuries.

Workplace Redesign

Analysis of the captured data may help create informed decisions about workplace design. For example, with more detailed information on how processes and tasks are completed, workplaces could be redesigned to reduce repetitive processes and potential injury-causing movement patterns, and to incorporate appropriate assistive technologies.

Industry Reform

Data may not be limited to a single workplace. As the movement database grows, so does the knowledge, which may help raise awareness and drive industry-wide reform.

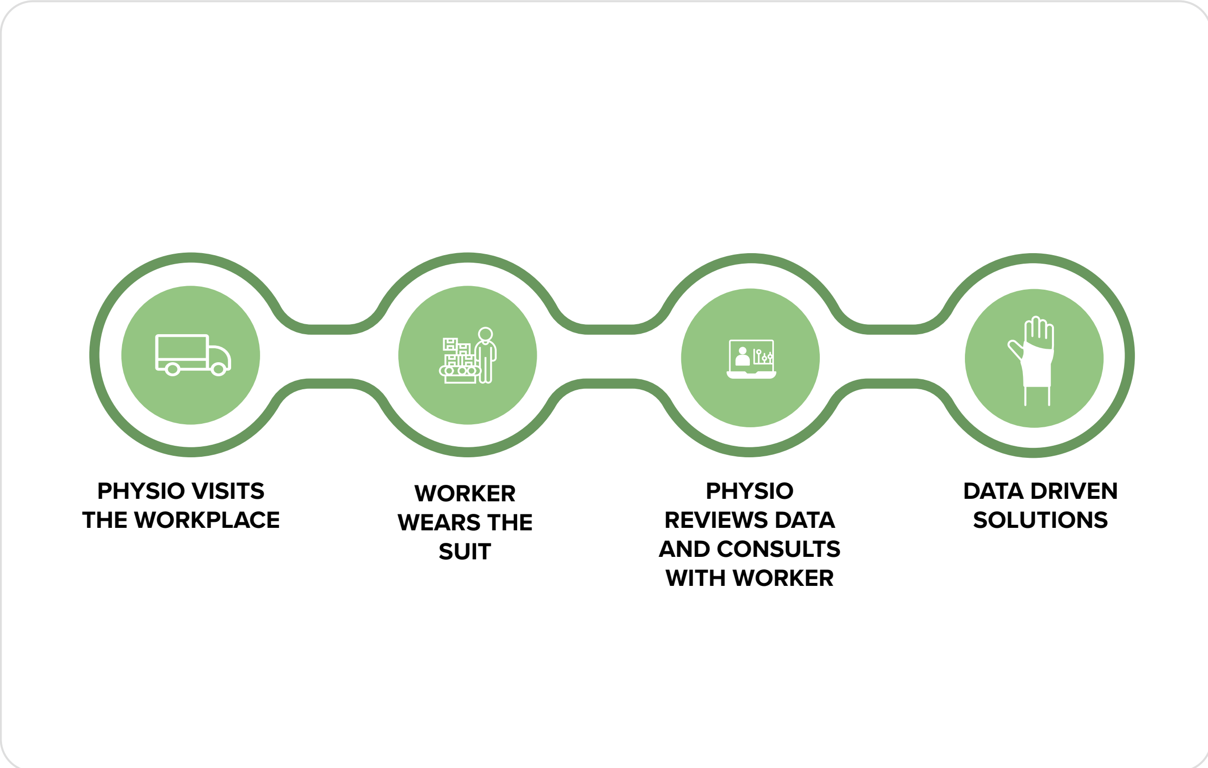


Figure 18: PosCor Data Service Stream

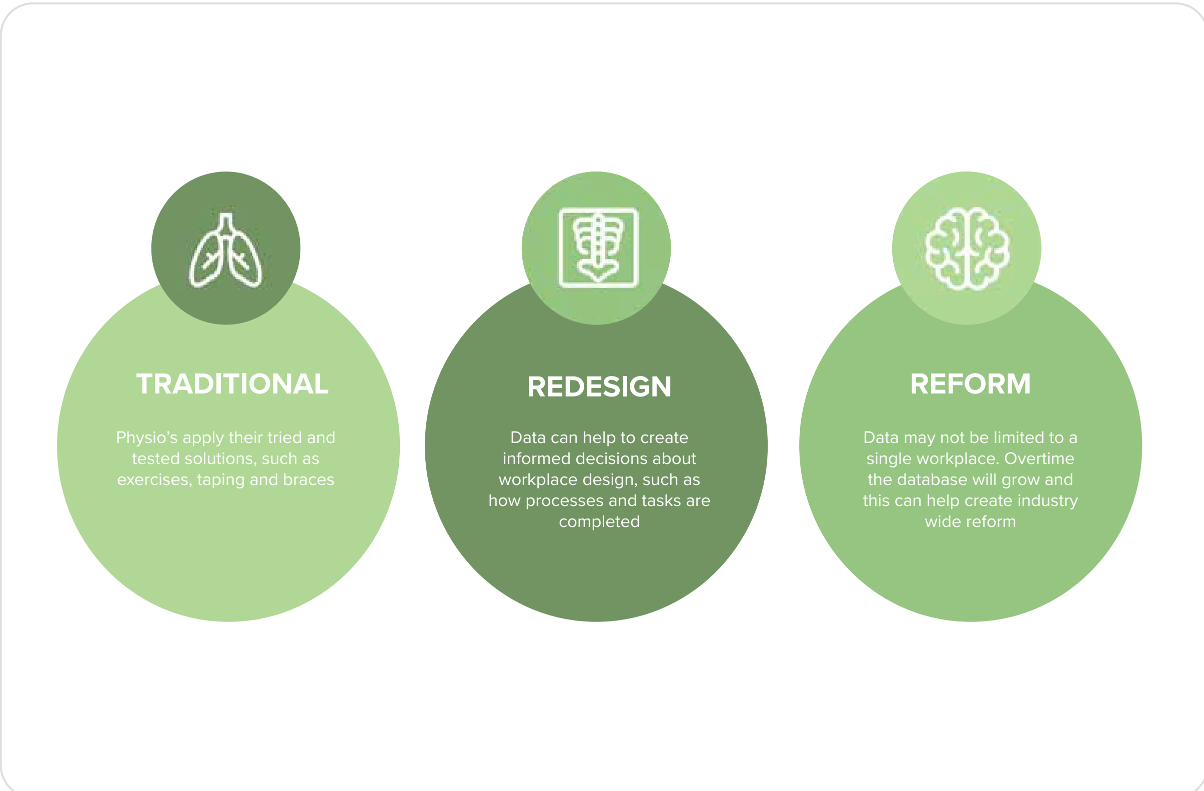


Figure 19: PosCor Data Outcomes

Case Study: Lift+

Mechanical knee brace for ageing manufacturing workers

Designers: Dawei Cao, Cao Nguyen Ho, Haochen Li, Milan Momiroski

Figure 20: Lift+ Artifact Outcome InSitu (A)

Lift+ is a mechanical knee brace that provides not only physical reinforcement and knee stability but supports older workers in manual tasks by providing active load bearing assistance.

Problem Statement

SME manufacturing is a national priority of the Australian Work Health and Safety Strategy 2012-2022 due to high fatality and injury rates. The sector has the most numerous and diverse types of businesses combined with the highest number of aged workers, whose duties require an extensive range of physical movements and equipment operations. This industry sector is characterised by both skilled labour and unskilled manual work and a large casual workforce, often with minimal education and poor literacy and language skills. Workers are typically on their feet for most of the working day. Many roles require strength and physical dexterity for manual handling tasks (e.g. lifting, carrying and supporting) and involve awkward or repetitive movement patterns.

As with many Australian industries, SME manufacturing has been impacted by an ageing workforce, with the median age of manufacturing workers in 2019 at 43 years (Labour Market Information Portal 2021). These older workers are vulnerable to the impact of osteoarthritis on their ability to undertake manual tasks or prolonged standing activities in the workplace.

22% of Australians over the age of 45 have osteoarthritis (Australian Institute of Health and Welfare). Osteoarthritis is a chronic condition characterised by deterioration of the cartilage that overlies the ends of bones in joints. It is mainly caused by accumulated pressure, regular wear and tear over time and lack of exercise, and results in the bones rubbing together, causing pain, swelling and loss of motion. Osteoarthritis primarily affects the hands, spine and joints such as hips, knees, and ankles, and usually gets worse over time. Knee osteoarthritis (which is exacerbated by repetitive joint-loading tasks such as kneeling, squatting and heavy lifting) can cause pain, stiffness, locking or clicking, inability to straighten the knee, and a sensation of the knee 'giving way.' These symptoms can severely restrict mobility, personal stability, and balance.

In SME manufacturing workplaces, workers must consistently shift positions and manually lift and transport raw materials or finished products. An older worker suffering from osteoarthritis is at risk of knees buckling under load, increasing the risk of falls or injury, which may compromise workplace safety. Aside from the physical impact, having weak knees can also reduce older workers' confidence in their ability to successfully meet their employer's expectations regarding physical activities, leading to depression and feelings of inadequacy and impacting their longevity in the manufacturing sector.

Figure 21: Problem Knee Joint X-ray

Key Considerations

A knee brace system that actively assists the wearer by off-loading some of their body weight to improve mobility and workplace capability, supporting the knee during physical tasks and difficult movements, and preventing injuries caused by knee buckling.

Functionality:

- partial off-loading of user's weight or load (up to 25 kg) through mechanical assistance,
- capability in heavy lifting, turning and carrying,
- capable of supporting repetitive sitting, standing and squatting movements,
- adjustable lifting assistance force,
- lateral knee support.

Wearability:

- wearable over clothes,
- easily removable during work breaks,
- adjustable to accommodate different limb sizes and shapes,
- unrestricted movement,
- comfort,
- cleanability.

Project Outcome

The Lift+ mechanical knee brace returns strength to the wearer by providing both support and stability and force assistance/weight off-loading to assist osteoarthritic sufferers with physical tasks. The spring-loaded action functions as a shock absorber, reducing impact stress through the joint, whilst significantly enhancing lifting power.

This adjustable support system is achieved with a flat spring, a 3-gear tuning rail, and a pull-release locking mechanism. The load offset assistance can be adjusted through a slide adjuster where the spring can be moved up and down on the assistive strength tuning rail, enabling the wearer to tune the level of assistance to either the task they are performing or in response to their daily physicality. The three gears allow the flat spring to have three different effective lengths, with the gears providing equivalent assistive forces options of 10 kg, 15 kg and 20 kg. The springs are also interchangeable so that performance can be customised to a specific user, or for increased levels of assistance.

The brace is shaped so that it is naturally rigid in some areas while being flexible in others, all without compromise to the system's mechanics. Flexibility ensures that the brace creates a better fit and allows a full range of movement, whilst rigidity provides the support the worker needs, and ensures even and biometrically aligned application of assistive force.

In terms of comfort and wearability, large surface areas are provided for the cushioning portion of the brace to more evenly distribute the pressure and forces, increasing comfort and ensuring blood flow is not impeded. In addition, the design incorporates nylon straps with a familiar quick-release buckle-clip system, allowing the user to easily tighten and adjust their knee brace to the appropriate fit.

Figure 22: Lift+ Artifact Outcome Overview

Figure 23: Lift+ Artifact Outcome InSitu (B)

Figure 24: Lift+ Artifact Outcome Detail

A critical design decision was that the brace would be worn outside of work clothes. Whilst typically braces are worn in a concealed manner for user modesty, in a workplace context the need to easily adjust the assistive force, or release the spring when resting/sitting, was of utmost importance. The issue of vulnerability to negative colleague feedback was also considered, with concern that wearing the brace may result in stigma. However, as the device supports work performance, rather than merely aiding a disability or impairment, it was felt that it might be worn by all employees, not just the older workers. In SME manufacturing environments, the brace could be supplied by the company as personal protection equipment (PPE).

Materials were chosen based on their relative comfortability and durability within this design. Thermoplastic-polyurethane (TPU) leather is used over the closed-cell foam padding for cost-effectiveness. It also has great resilience to wear and tear, washability and general effectiveness at providing comfort and grip. In addition, a breathable mesh is used to combat sweating and overheating in high contact and focused-pressure areas where the brace contacts directly with the back portion of the thigh.

Implementation Strategy

A level of stigma exists around the use of assistive products, with people often unwilling to publicly declare the limits of their physicality, or show vulnerability or weakness in the workplace.

This could be a barrier to initial acceptance of this product, so it will be necessary for a universal rollout with accessibility to workers of all ages to avoid stigmatising the older workforce. On the other hand, younger workers may find the brace beneficial to their ability to perform work tasks, and with fatigue and minor injury reduction. The role of unions in lobbying for this type of assistive technology as part of standard PPE would greatly assist initial uptake.

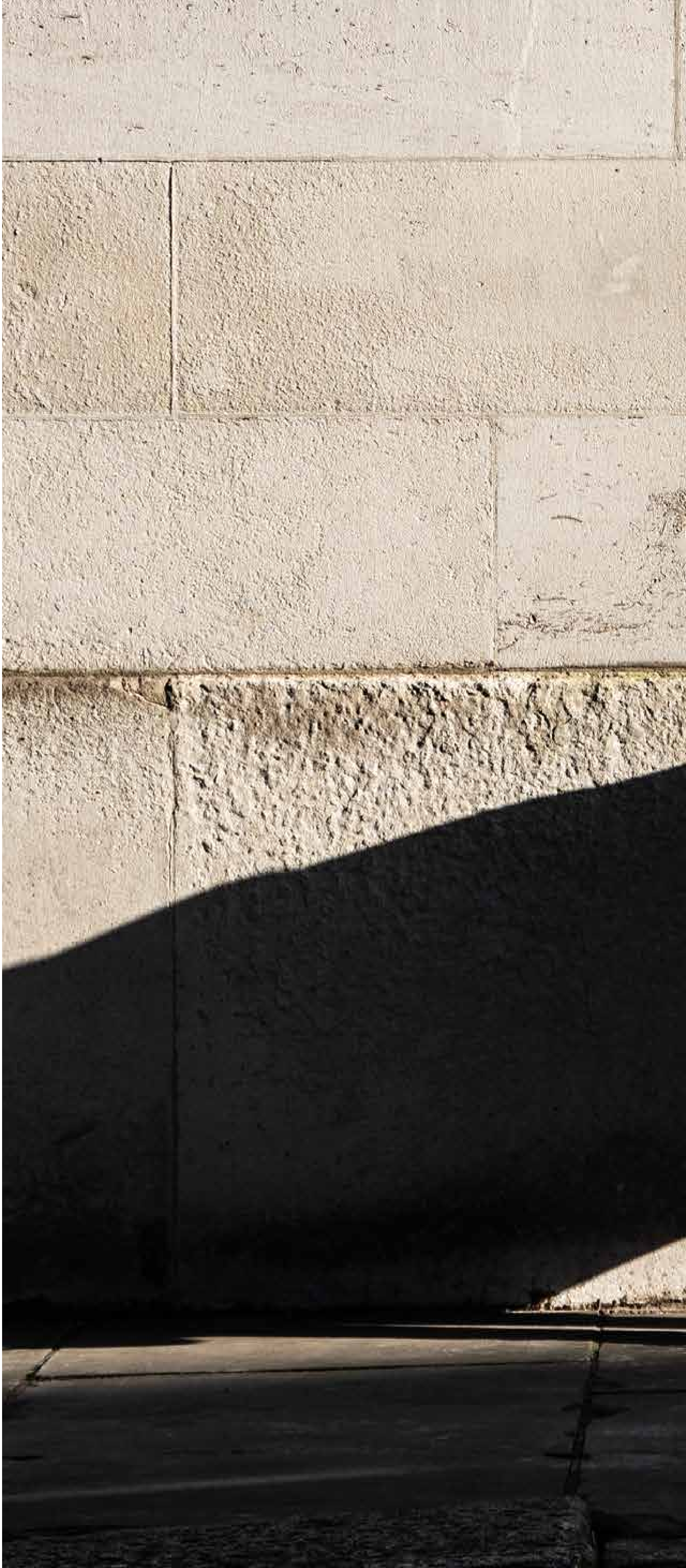
Review of Potential Impact

Lift+ is a mechanical knee brace that has the potential to extend the working life of older workers in the manufacturing sector, whilst limiting some of the long-term effects of manual labour, particularly the repetitive joint-loading tasks such as kneeling, squatting, and heavy lifting that are common movements in this sector.

The ability to tune the amount of force delivered by the spring system to the individual workers' requirements or the demands of the workplace task, provides an unprecedented level of adaptability. In addition, the offsetting of up to 20kg of load will significantly reduce the impact forces on the knee, reduce workplace fatigue, reduce pain, and add a perception of lightness that will enhance worker wellbeing, self-esteem and confidence.

While the Lift+ brace is primarily focused on supporting ageing workers with osteoarthritis in their knees, it has the potential to reduce injuries in all workers, and provide support and assistive forces that may delay the onset of workplace induced physical deterioration in younger workers.

Mental Health in the Commercial Construction Industry



Mental Health in the Commercial Construction Industry

As one of the chief drivers in the Australian economy and key to national productivity, the construction industry is a major employer. However, the industry is encountering an overall skills shortage. This results from impending retirements across the ageing workforce, industry-wide shifts in digitisation, mismatched skills, qualifications of workers, and barriers in engaging employees. (Construction Industry Training Board, 2020; Sivam et al., 2017; Watson, 2012).

Further to these industry pressures, serious physical and mental health impacts are suffered by this cohort. Workers experience unpredictable and diverse types of workplaces and are vulnerable to numerous hazardous conditions within them, such as exposure to environmental factors, dangerous equipment and intense physical labour. These conditions are further exacerbated by high levels of stress, tight deadlines and long hours (Cook et al., 2009).

Construction workers face the same effects associated with ageing as anyone else, however unlike the wider workforce, a construction worker often experiences the effects nearly 20 years earlier (Cook et al., 2009). Physically, we see elevated rates of lung cancer and musculoskeletal disorders, while mental health incidences are twice as high as the general population (Eaves et al., 2015; Lingard & Turner, 2015). These debilitating issues affect everyone in this labour force, as younger workers form problematic habits that their older counterparts are trying to manage.

The construction industry and its primary sectors (housing, commercial and civil) are at a critical crossroad, which has a direct impact on its workers, with a high incidence of mental distress and a death by suicide rate that is 53% higher than the Australian average (Incolink, 2021).

This chapter explores key concerns and complexities within the construction industry and examines efforts to reduce the mental health issues in this workforce. We consider the workplace cultural landscape, alongside approaches and strategies that lead to progressive initiatives and reform in Australian construction. The chapter concludes with a case study that outlines a design proposal to engage construction workers in the mental health conversation, raising awareness and providing tools for self-diagnosis; important steps towards a healthier and more resilient workforce.

Australia's Commercial Construction Sector

As Alpana Sivam and colleagues (2017) detail, the Australian construction industry can be described as "a significant driver of both economic activity and a key indicator of the social and physical wellbeing" of the nation. This is not only because it is one of the most significant contributors to Australia's gross domestic product (GDP), but it is instrumental in producing the housing, commercial building, and infrastructure that supports Australians.

The construction industry's workforce composition across its housing, commercial and civil sectors, all have a younger than average workforce, where women are significantly underrepresented and the 'megatrends' / challenges faced by the industry, are skill shortages, low training rates, rapid technological change, and the COVID-19 pandemic (Construction Industry Training Board, 2020).

In particular, the commercial construction sector is involved in the construction of non-residential buildings. It is a mature, yet highly fragmented one, comprising of diverse mix of large organisations and many competing small-scale enterprises that maintain impressively high, though, apparently unsustainable, performance outcomes (Chan & Martek, 2018).

The sector increasingly relies on contracted labour, with workers often on individual contracts, which requires them to manage their own equipment, insurance and risks (Bryan et al., 2017). Similarly, the risks of entering the industry are also on workers, with many companies citing inadequate apprenticeship rates, making it difficult to attract employees (Sivam et al., 2017). This contrasts with the wage pressure facing businesses in this sector from established workers, whose wages have increased by approximately 60% (Watson, 2012).

The commercial sector is well placed, only recently having weathered the economic fallout from the pandemic, to address the impending changes in their work and workforces, balancing both the issues facing the industry and the projections of growth out on the horizon (Kelly, 2021). However, firms will need to invest in skilled workers to ensure different skill specialisations, especially with regard to technological change. The long-term shortage of skilled construction tradespeople will see older workers remaining integral to the workforce make-up, such that it will be vital to the sector to improve their retention and minimise the risks they face.

Ageing in the Construction Industry

Despite the developing role of older workers in the construction industry, many will leave the industry prematurely because of excessive job demands. Staying, is usually driven by individual financial situations and cultural expectations (Cook et al., 2009). Older workers face very different challenges in the workplace to their younger counterparts, brought on by a decline in their health and physical work capacity that isn't consistent nor linear (Peng & Chan, 2020; Zafar & Chileshe, 2018). To understand the risk to construction workers, we explore the matching and adapting of working conditions.

In what has been considered a 'push' out of the industry for older construction workers, job demands cover many factors that affect their physical and mental health. Hard physical labour, static work, exposure to noise and dust typifies the construction site (Haupt et al., 2005). While younger workers are more prone to workplace safety incidents, older workers experience higher rates of severe and fatal injuries on-site and require more time to recover from injury (Zhang & Lingard, 2019). Resultantly, workers can suffer physical 'burnt-out' and experience health issues faster, to such an extent that the issues of ageing are exacerbated (Marchant, 2013). In addition, casual or self-employed workers may suffer more physical health problems due to stress with casualisation or work/life balance (Lingard & Turner, 2015). This physical toll means that workers are physically and mentally older, at a younger chronological age.

Alongside these physical factors, the stress and psychosocial hazards of this occupation have an evident impact on the mental health of construction workers. With mental distress and disorders found to be twice the level of the general male population, construction workers are at high risk of suicide (Lingard & Turner, 2015). On the other hand, factors such as job satisfaction and autonomy are protective for older workers (Lingard & Harley, 2020), with older workers less likely to see treatment sources as beneficial (King et al., 2019). Tania King and colleagues (2019) found that younger workers have poorer suicide prevention and mental health literacy than older workers. Younger workers are more likely to want the workplace to take responsibility for mental health and wellbeing, whilst older workers are more likely to reinforce traditional masculine norms.

Contrasting these demands of the job, which often push older workers out, the factors which 'pull' them into the industry are often financial and cultural. For example, construction workers frequently indicate that they enjoy their jobs and believe retirement would bore them; moreover, older workers also stay due to poorer than expected financial resources, or a lack of suitable and experienced replacements for them (CIOB, 2007). Notably, as old age in this workforce is perceived at 45 years of age, the 50s may be a critical transition point in staying in or exiting the industry. This decision is based primarily on physical capacity; however, limited perceived options or lack of financial resources play an important role in continuing to want to work in later life (Marchant, 2013).

Mental Health On-site

Whilst physical health issues experienced by construction workers can be addressed by investing in supportive technologies and adapting workplaces, the complexities and opacity around mental well-being remain. Nearly 40% of those who die by suicide do not seek professional help. Whilst construction workers are exposed to a broad range of physical hazards and poor environmental conditions, psychosocial hazards and workplace behaviours have a measurable impact (Engineers Australia, 2019). In particular, Bryson & Duncan's (2018) scoping study of mental health in the construction industry explicitly identifies the following key factors that are central to a worker's poor mental wellbeing:

- *a macho culture where workers are told to "harden up",*
- *high drug and alcohol use amongst workers,*
- *intergenerational and multicultural workers on sites together.*

Exacerbated by precarious employment security and sleep problems (Eyllon et al., 2020), workers are vulnerable to workplace bullying, violence, aggression, and traumatic events or discrimination, all of which are commonplace in a macho culture that makes it tough to speak up (Engineers Australia, 2019). Such is the prevalence of these issues that many may unknowingly experience mental health problems, which means they might not know that they need, or feel confident enough to seek the support they require (Turner & Lingard, 2020).

Furthermore, from an employer's perspective, increased work demand, low support and isolated work, poor workplace relationships and organisational management are all factors that can lead to prolonged or severe psychological and physical injury for the worker (Safe Work Australia, 2020). Michelle Turner and Helen Lingard (2020) describe how construction workers 'workability declines as they experience poorer mental health, leading to reduced performance on the job, which intensifies with age.

Considering the scope of the mental health problem in the construction industry, legislation and wider recognition require targeted initiatives to deliver better mental health outcomes across the sector. There is currently genuine interest in supporting and participating in the growing evidence and research around suicide and mental health, by engaging interventions to support the construction workforce.

The Australian Building and Construction Industry (2020) Blueprint for 2018-2022 offers several goals that firms across the sectors are working towards: understanding the challenges facing its workers, targeting the areas where the best effect could be achieved, learning from other industries, looking to display leadership, and working to an agreed roadmap and timetable. Such unilateral efforts to promote the positive impact of work on mental health, offer hope to disrupting such concerning trends, by seeking to reduce harm, provide literacy on mental health and suicide, and facilitate ongoing support / treatment.

Several initiatives are seeking to respond to these mental health issues in the construction industry by seeking to change the culture of workplaces and worker behaviours. A notable exemplar, is the charity MATES in Construction, which seeks to reduce the high rate of suicide in the Australian construction industry. Their work is orientated around three key training programs: General Awareness, Connector, and Applied Suicide Intervention Skills (ASIS). Each involves disrupting the industry's cultural assumptions around mental health by connecting co-workers to support their colleagues within the workplace. For example, ASIS training enables individuals to recognise at-risk people and conduct interventions (Neis & Neil, 2020). In addition, mental health training is a powerful way of supporting and educating workers; the proper development can see construction teams thrive, both on the job and off (Long, 2021).

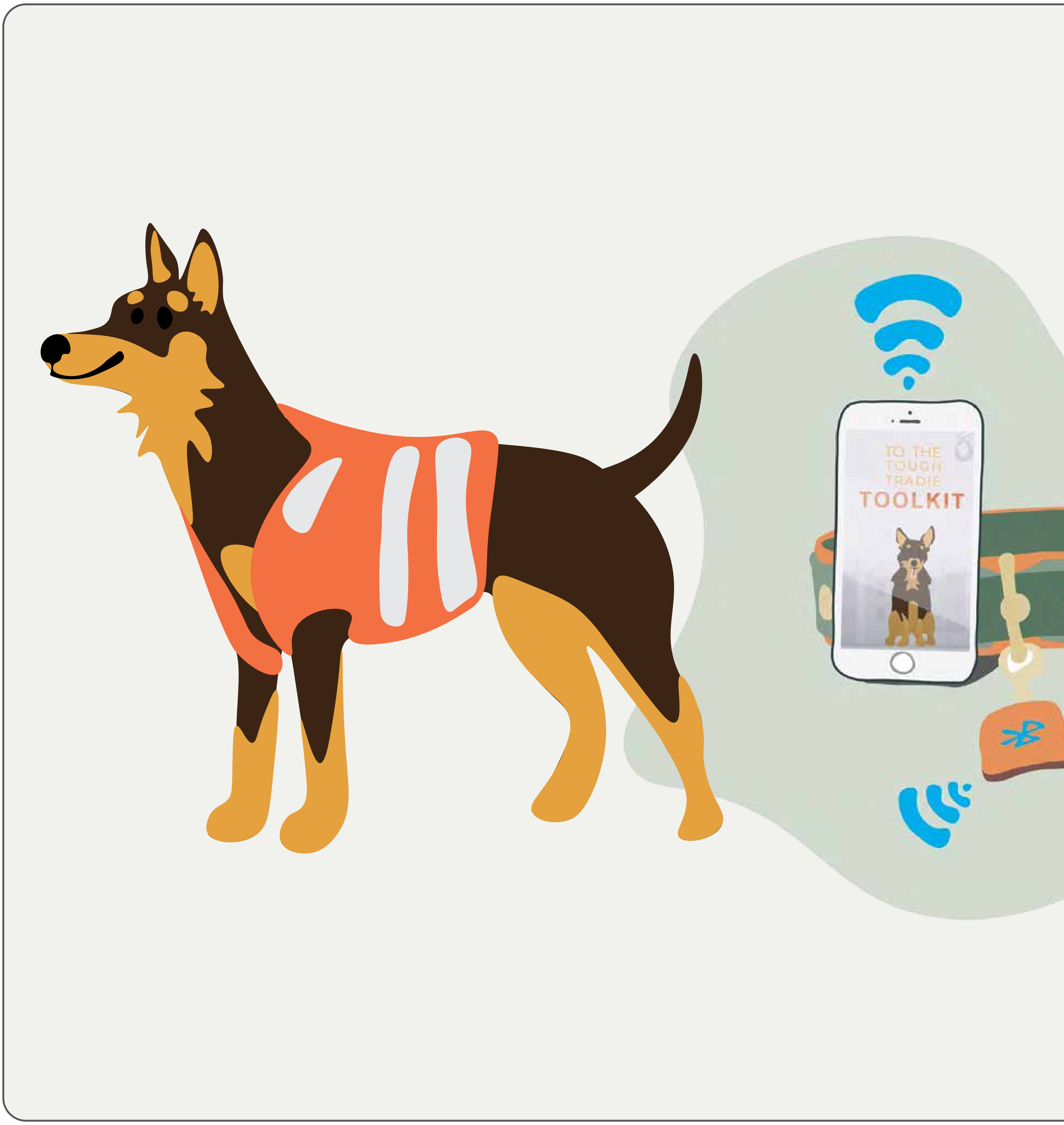
Similar programs are being developed by organisations locally and globally, and there is evidence that the most 'appealing' and effective programs, are ones that offer the least interference in the worker's schedule (Hengel et al., 2010). For example, a Victorian program, Bluehats, provides General Awareness training to workers, empowering individuals to recognise issues. Whilst this training was based solely through on-site activities, during the Covid-19 pandemic they developed an online model, which enabled them to support volunteers remotely (Beavis, 2019; Bridges et al., 2019; Incolink, 2021). Being responsive to the needs of workers and including them in the development of such a scheme is vital, as workers need to be considered 'change agents'. Alongside the tailored service of MATES and Bluehats, other providers such as Beyond Blue offer training packages designed in conjunction with construction managers who have the required knowledge, skills and confidence to deliver mental health 'toolbox talks' to their team.

Supporting these industry-based training programs, alternative interventions also prove beneficial in highlighting mental health risks and stimulating conversation within the industry. For example, a Queensland study evaluating a compressed week model (where the working week is reduced in length by increasing the length of the working day), found a measurable improvement in employee work-life balance, enabling higher performance systems in construction (Lingard et al., 2007). In addition to these interventions and investigations, there is also evidence to support the use of Animal-Assisted Interventions (AAI), such as dogs, which have been found to promote mental health in other diverse workplaces (Etingen et al., 2020; Foreman et al., 2017; Rambaree & Sjöberg, 2019).

As an intervention that includes an animal in it, AAI will often involve either therapy dogs, trained to assist with daily activities, or visitation animals for less structured enhancement opportunities (Brooks et al., 2018; Foreman et al., 2017; O'Haire et al., 2015). In comparison to companion animals, which are used only for the pleasure of their company, AAI offers goal-oriented and structured interventions that intentionally incorporate animals for improved health and wellness. In the workplace, such support programs have been seen to improve the atmosphere, reduce stress, and boost mood, helping to address issues in those workplaces (Etingen et al., 2020). Whether in a social or assistive capacity, dogs in the workplace offer workers a unique and emergent form of engagement and wellbeing. As a health-promoting resource, data on AAI is nascent, with the tension between the positive functional, communication and social opportunities, being weighed up against socio-economic, legal and organisational challenges (Rambaree & Sjöberg, 2019).

Dogs are synonymous with Australian tradesmen, and the image of 'the dog in the ute' as a well-established trope in the Australian vernacular (Hayes, 2020), While examples of interventions range from the mental health of patients (Koukourikos et al., 2019), the wellbeing of students and staff (Rambaree & Sjöberg, 2019), burnout in healthcare (Etingen et al., 2020), and resilience in Farmers (McNaughton, 2021), to date, little has been done on the use dogs as an intervention in the Australian construction industry.

Whilst dogs need to be well trained and socialised, workers have attested to how a dog "saves your soul and saves your sanity" and have a way of calming us, especially good for those who have stress (Webber, 2011). Whilst there are some perceived barriers to the introduction of therapy dogs into a construction worksite context, such as safety, legal, cultural sensitivities and animal welfare issues, it is evident that AAI could be valuable in tackling mental health in the construction industry, especially though short, focussed interventions that are sensitive to the workplace environment, and incorporate a social element.



Case Study: WAGS & SNAGS

Addressing mental health in the construction sector

Designers: Chelsie Loader, Ben Canham, Runjhun Agarwal, Jasmine Grey

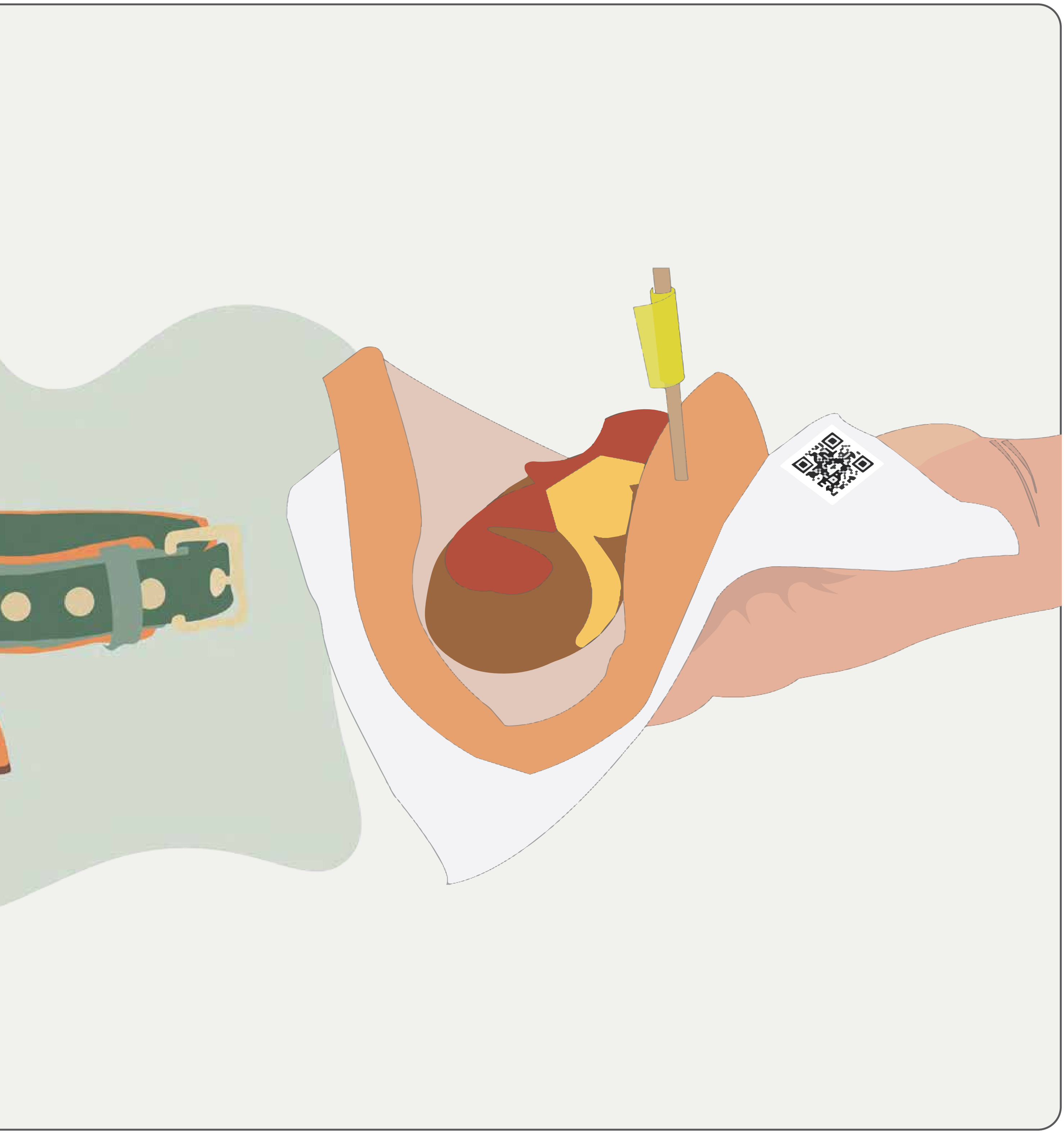


Figure 25: WAGS & SNAGS Graphic

Figure 26: WAGS & SNAGS Graphic Problem Statement

WAGS and SNAGS is a mobile engagement service that aims to raise awareness of mental health and connect vulnerable construction workers to a self-diagnostic toolkit.

Problem Statement

Providing mental health support to aging workers is vital to job satisfaction. With the added stresses of bodily decline or risks of injury, many older workers fear the future. This is especially true with those in the construction industry, where workers are 53 percent more likely to die by suicide than males employed in other industry sectors.

Construction work is physically demanding, and workers are more likely to work longer hours under more difficult conditions than most other industries. In addition, the industry is vulnerable to shifting economic pressures and is one of the first industries to be impacted by changes to the Australian economy. Construction workers are exposed to a number of psychosocial factors that impact mental health including poor job security, low job control and lack of empowerment, excessive job demands, low rewards, recognition and compensation, poor working relationships and workplace bullying and harassment.

For many construction workers, their job provides socialisation, self-worth, social status and identity and a sense of purpose. So, what happens when they can no longer work? In the instance of workers returning from injury or suffering from gradual physical decline as they age, there is a heightened risk of anxiety, low self-worth, and depression, with a strong connection evident between physical and mental health. Older workers who progress into more managerial roles, also find themselves increasingly isolated from the social 'mates' culture that exists amongst the manual labour workforce, but not feel accepted into the office culture. These workplace stressors are likely contributors to poor mental health and suicide in the construction industry.

Poor mental health has afflicted the construction industry for decades. In Australia, it's a stigma that is as silent as it is deadly. Unfortunately, there is limited knowledge about mental health in the construction industry, especially around 'symptomology' and it is apparent that most mental health initiatives in the workplace are reactive, rather than pre-emptive, occurring after problems are apparent in the workplace (affecting performance or safety) or after the worker presents to healthcare professionals. Consequently, mental health often goes undetected in the workplace, and is not always recognised or acknowledged by the individual until it is too late. "93 per cent of construction workers who had committed suicide in the past had never sought professional help" (CEO of Mates in Construction, Brad Parker).

Underpinning this lack of awareness of key triggers and warning signs, is the prevalent 'macho' culture found in the construction industry, where negative attitudes towards help-seeking and stigma against mental ill-health are well documented. Workers are reluctant to show 'weakness' or vulnerability and are not always encouraged or supported to do so.

The self-literacy required to recognise, acknowledge and seek medical intervention is critical in the effective treatment of, and recovery from mental health issues. Unfortunately, the majority of sufferers of mental health disorders (especially males) do not actively seek help. It is thought that this is due to a number of factors, including lack of knowledge of signs and symptoms, ignorance about accessing treatment, embarrassment, shame and workplace stigma, existing prejudices, and an expectation that they may be discriminated against (Mates in Construction Report on Mental Health in the Construction Industry 2017).

It is therefore essential that mental health awareness and de-stigmatisation occurs in the construction industry workplace, as this will play an important role in facilitating workers to seek early medical intervention and treatment. But it is evident that existing initiatives such as mandatory workshops, information lectures and compulsory therapy sessions have proved ineffective.

The ability to for a construction worker to privately self-diagnose away for the workplace and colleagues, could be valuable in the early recognition of symptoms and worker acknowledgement that help is required.

The construction industry is well serviced by excellent mental health support agencies including Beyond Blue, Blue Hats, Mates in Construction etc. These organisations have proved effective in supporting workers who have acknowledged that they have a mental health issue, but despite their efforts, the industry continues to be deficient in mental health self-awareness.

A more pre-emptive intervention is required to raise mental health literacy, and to enable self-evaluation, and prompt timely treatment seeking.

Key Considerations

- raising awareness, encouraging discussion and reducing workplace stigma,
- engagement that voids workplace shame and showing of weakness/vulnerability,
- workplace culture of ultra-masculinity, competitiveness, tough/macho mates,
- achieving worker acknowledgement that they have a problem and prompting action,
- need for self-diagnosis (away from workplace),
- link to existing support agencies (eg. Beyond Blue, Blue Hats, RU OK, Mates in Construction).

Project Outcome

Wags and Snags is a mobile engagement service that aims to raise awareness of mental health and connect vulnerable workers to a self-diagnostic toolkit, without shame of stigma in the workplace. It comprises two interventions; an initial on-site social engagement, which raises awareness and facilitates access to the second part of the service, a website/app where the construction worker can undertake a self-diagnosis process in the privacy of their own home, with spousal or family support as appropriate. The program is specifically designed to support mental health self-awareness and deliver access to services for those who actually need it, without ‘calling out’ individuals, or forcing people to participate.

Engagement Process

Wags and Snags is an on-site engagement which aims to subtly raise awareness of mental health issues and connect with those in need, in a discrete yet effective way. The intention is to draw in workers whilst simultaneously creating an atmosphere that they feel comfortable in.

Lunchtime Barbeque

The mobile sausage sizzle (a nostalgic and non-gendered Australian activity) encourages social grouping and interaction between co-workers, whilst the on-site presence of working dogs (kelpies, blue heelers etc) at the event provides a welcome break from work pressures, alleviates stress and encourages worker engagement with the service. The serviettes dispensed with the sausage have a printed QR code link to the self-diagnosis “Tough Guy Toolkit”, which ensures that all workers will have discreet access to the link without the need to accept a flyer, or directly engage with the service personnel in front of their colleagues.

Figure 27: WAGS & SNAGS Problem Scenario

Figure 28: WAGS & SNAGS Graphic Service Journey Map

On-site Therapy Dogs – Wellbeing Interactions

The second part of the on-site engagement process is the presence of therapy dogs.
Animals in the workplace have been scientifically proven to boost mood, alleviate anxiety and increase sociability. They've been particularly useful in high-stress environments, from high schools to prisons, and have been found to significantly improve mental health when implemented regularly. As working dogs are already entrenched in the culture of the construction industry, they present an ideal and non-stigmatised engagement opportunity.

The dogs can provide mental health and wellbeing support but also facilitate another way for the construction workers to access the Toolkit. The dog's collars contain a Bluetooth chip that will attempt to connect with the workers' phones whilst they are interacting with the dog. If the worker accepts the connection offer from the dog, they will be directed to the Tough Tradie Toolkit. The worker can decide at a later point if they want to proceed further into the website, and undertake the self-diagnosis, but in front of their colleagues they can continue interacting with the dog and their colleagues in an innocuous manner.

The 'Tough Tradie Toolkit'

The self-diagnosis toolkit is at the heart of the Wags and Snags intervention. As many suffering from mental health issues are either unaware of the causal responses or symptomology, it is essential that workers have the opportunity to gain a better understanding and to undertake self-diagnosis in a private or supporting environment, away from the workplace. If a construction worker can be assisted to understand and accept that they may have a mental health problem, then they can be directed to the excellent mental health support systems already in place.

It is in this gap that the Tough Tradie Toolkit has the potential to make a significant impact. Based on mental health diagnostic tools developed by psychologists, and the Beyond Blue K10 checklist, the toolkit asks a series of questions, designed to identify the underlying signs of depression, anxiety and similar issues. Participants are asked questions relating to unexplained tiredness, nervousness, calmness, restlessness, feelings of hopelessness, moods and depression, effort and motivation, spirit and worthlessness. Questions are designed to use common language to 'speak' to the construction worker and to avoid seemingly overly 'clinical or analytical.' Participants respond using a Likert style five-point psychometric response scale, which is used to measure the respondents' agreement with various statements.

At the end of the analysis the participants will be provided with a risk rating with recommendations for further actions, and where necessary, encouraging them to seek professional help and providing links to those services. Care is taken to declare to participants that this is not a clinical medical diagnosis, but a useful awareness and early warning service that medical intervention may be required.

Implementation Strategy

Wags and Snags aims to fill the existing gap between lack of worker awareness and accessing support services. It has a carefully designed implementation strategy to entice construction workers to engage with the service, raising awareness and helping workers understand and accept that they may have a mental health problem. The service will need the support of the construction industry (major employers, industry groups and unions) and will be most effective if delivered in partnership with one of the existing support agencies (e.g. Mates in Construction, Blue Hats, Beyond Blue).

A collaboration with the RSPCA for the provision of therapy dogs, would not only provide meaningful engagement with construction workers, but may also provide that organisation with new openings to find new homes for abandoned dogs, whilst workers suffering from mental health may have opportunities to foster, adopt and care for an animal as part of their rehabilitation.

Review of Potential Impact

The biggest challenge in opening a dialogue about mental health in the construction industry is bypassing the prevalent negative culture relating to help-seeking, poor mental health literacy, the lack of understanding of symptoms, and workplace stigma against mental ill-health. Getting workers to engage in conversations regarding mental health is difficult, and it is even harder to transition a worker to a point of recognition and acknowledgement that they have a problem, and for them to then seek professional help.

The goal of Wags and Snags is to get construction workers to recognise and accept that they may be facing a mental health problem and to do so without shame. Its social engagement approach, when combined with the self-diagnostic Tough Tradie Toolkit, has potential for significant impact on the mental health issues facing the construction industry. By raising awareness, providing the tools for self-analysis and guiding workers towards support services, lives may be saved.

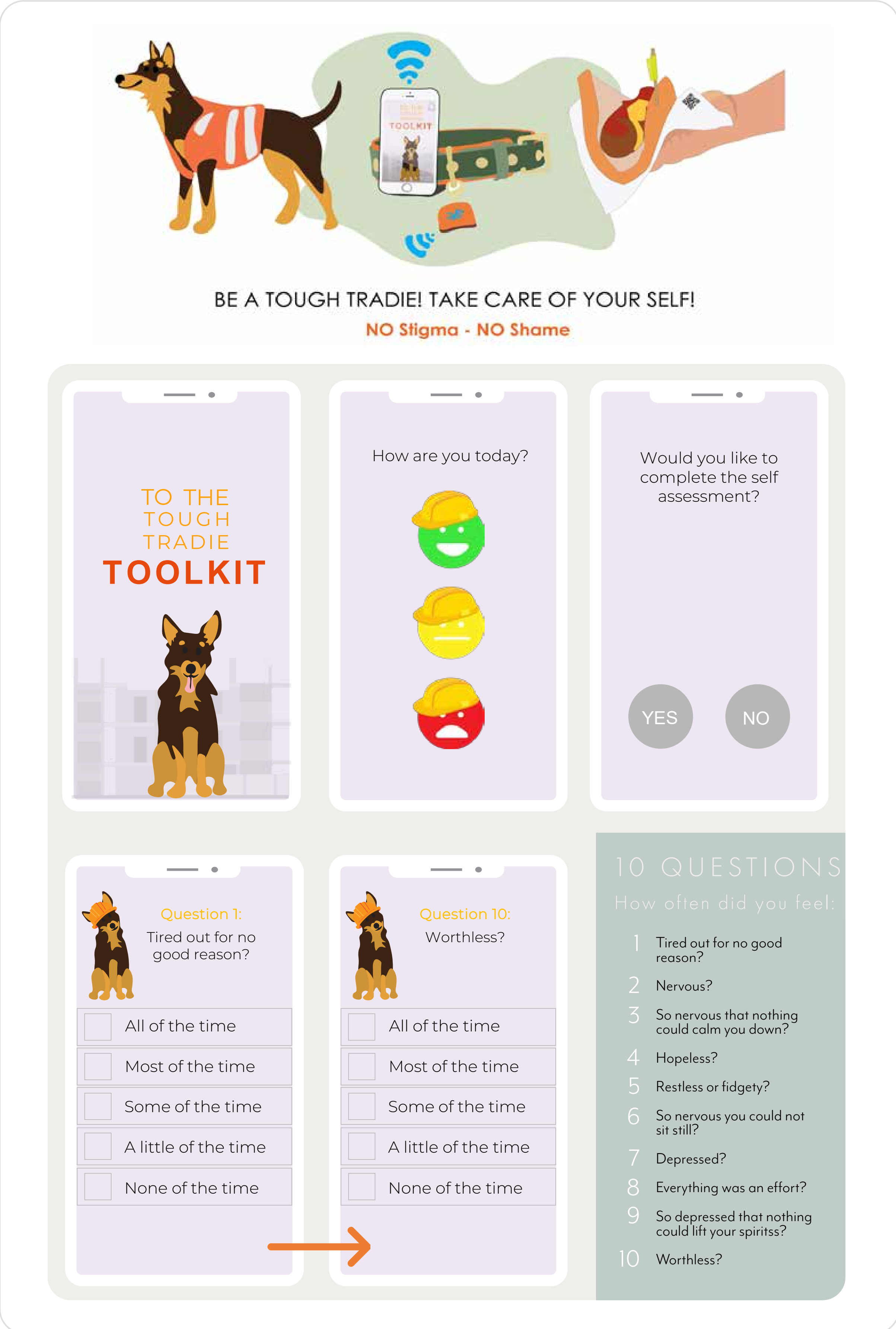


Figure 29: WAGS & SNAGS Digital Interface Overview

5

Reducing Ladder Injuries in the Residential Construction Industry

Reducing Ladder Injuries in the Residential Construction Industry

The residential construction sector is a less controlled and organised workplace than in the commercial construction sector, and resultantly, a more hazardous work environment from a health and safety perspective. Consisting mainly of small firms and highly mobile independent contractors, it is difficult to enforce the level of workplace safety that is found on larger commercial construction sites, especially where a variety of different trades and unskilled labour are working in close proximity. Residential apprentices must deal with greater job strain, less supervision, further workdays lost to injury and pain, and health-related loss of productivity (Dale et al., 2021). The Australian residential construction sector faces two critical matters: (a) new regulation will bring forward distinct changes to the way homes are designed and built, and (b) consistent high rates of injuries and fatal accidents, in a sector typified by fewer safety resources and oversight (Helen Lingard et al., 2017; Nous Group, 2021). One of the identified sources of risk for construction workers in the residential sector is falls, with over half of the fatal falls occurring from structures that are less than 6 metres high (Kaskutas et al., 2013).

In the residential sector, it is common for inexperienced workers to perform risky work at heights before they have been trained in safe work methods (Kaskutas, et al., 2009, Lipscomb, et al., 2008) with evidence that carpenter apprentices were twice as likely to fall at a residential worksite than apprentices working in a carefully controlled commercial construction site (Kaskutas, et al., 2010). This highlights the prevalent safety problems and inadequate worksite training (Hung, et al., 2011) found in the residential construction sector.

In navigating the challenges in this sector, the wellbeing and safety of workers are of key concern for both young and older workers. There is an urgency to develop a highly-skilled workforce for tomorrow, from today's over 200,000 subcontracted unskilled and skilled labour (Kelly, 2014). Compounding the issues for the sector and its workers is the fragmentation of the industry, made up of small enterprises and sole proprietors, and the casualisation of the workforce, making work health and safety difficult to regulate. The inconsistent and insecure nature of their employment undermines workers' confidence, making workers less likely to raise safety concerns, and resulting in consistent under-reporting of incidents, safety risks and injuries (EY, 2018; Sentis, 2018). Preventive and proactive measures remain key to reducing the work health and safety risks, where incidents can result in fatality, or serious life changing injuries.

Within this chapter, we overview the safety dynamics of this sector and the implications for its workers and explore pioneering preventative solutions. In examining worker interaction with environments and equipment, the dangers of ladder use are highlighted, especially for older workers. The case study looks at an innovative approach to supporting the health and safety of ladder users, reducing injuries, and incorporating technologies that may become commonplace across the larger industry.

Residential Construction Work

The residential construction sector has had to follow the 'booms and busts' of the housing market, with consistent growth of the last two decades leading to high demand for workers. In a sector where employment is accessible to both unskilled and skilled labour, the cyclical nature of construction has led to its reliance on flexible subcontracting, resulting in the least unionised sector in the industry (Fidelis Emuze & Smallwood, 2017). These conditions have seen temporary migrant labour become a tenet of the construction site, however these workers are at increased risk of exploitation and poor working conditions, in both legal and unlawful employment (Hedwards et al., 2009). This is combined with what has been called "a blatant disregard for the value of safety by many in the residential construction sector," sees workers, in such demanding working conditions, lack proper policies to support their wellbeing (Helen Lingard et al., 2017).

In cataloguing the health and work outcomes for the residential construction workforce, Ann Marie Dale and her colleagues (2021) offer a comprehensive guide to the Australian context. They suggest that these workers report fewer workplace safety policy breaches, experience a higher frequency of heavy lifting, and are at greater likelihood of reporting musculoskeletal pain. Compared to their commercial sector counterparts, productivity was linked more to their physical health and the demands of the work, rather than the mental demands seen in commercial workers. As Marie Dale and colleagues (2021) go on to summarise:

"Residential construction is typically characterised by fewer safety resources; smaller employers with less formal organisation and project oversight; frequently changing work environments, higher turnover of workers on projects; fewer safety regulations; less training; and small, often scattered, crews with less knowledgeable leaders."

Regarding the characteristics of the workers themselves, residential construction workers are notably younger than all other occupations, reflecting the physical demands, however around 21% of bricklayers and 17% of carpenters are aged 50 and over (Deloitte Access Economics, 2017). The Victorian Skills Commissioner (2021) has documented the skills shortage amongst this workforce, noting the challenges faced in sourcing plasterers, painters and tilers, while there are ample carpenters, electricians, and plumbers. The Commissioner's report comes as workforce licensing is set to be introduced from 2022, requiring workers to develop and maintain robust understandings of contracts, permits and estimating, while technological skills become a necessity.

Safety in the Workplace

Whether moving from one location to another, or being on the same construction site for months on end, residential construction workers face a dynamic environment, comprising of not only hazardous tasks and equipment, but frequently systemic lawlessness and illegal conduct on-site, every day. As part of the Productivity Commission Review into Housing Australians, Graham Wolfe (2016) navigated the erosion of workplace safety regulation and lawful activity over the past two decades, the use of standover tactics and coercive pattern bargaining against vulnerable workers, seeking more productivity and competitiveness in Australia's workplaces. In addressing this context, we look to highlight two major factors which affect construction workers: the under-reporting of incidents on-site, and casualisation of the workforce.

First, the complex issue of under-reporting of work injuries affects all industries, with some estimates that only 4% of work injuries are actually reported (Safety Solutions, 2017), though other research details 25% to 31% of incidents go unreported in Australia (Sentis, 2018). In construction similar rates of under-reporting likely exist, as workers may perceive injuries as either small or 'part of the job', though many also fear negative consequences in injury reporting (Taylor Moore et al., 2013). Notably, both frontline workers and managers under report personal incidents to significant degrees, suggesting that both individual-level and organisational-level under-reporting persists (Probst et al., 2019). The implications of under-reporting are significant, for both industry and individual. Accurate reporting can allow health and safety regulators to be more effective and responsive, and lead to earlier problem identification and remediation within the sector. For the individual, unresolved muscular and physiological problems can significantly impact future quality of life, but where employment is tenuous, workers are often unwilling to disclose issues.

The abundance of non-secure work in the sector directly effects the psychosocial safety climate on-site, moving the onus of responsibility for equipment, financial stability, and health and wellbeing onto the individual. Almost 1 in 4 workers are casual, with around estimates of 26-41% of workers hired on sham contracts as independent contractors rather than as employees (EY, 2018). Amy Zadow of UniSA has detailed how this leads to worker expectation that they will be 'thrown away' and replaced when they wear out, reducing their security and capacity in seeking support or raising issues (Safety Solutions, 2017). For independent contractors often working alone, this is exacerbated by time pressures, inconsistent or non-existent training, and the lack of support from a supervisor or an organisation.

For workplace health and safety to improve, better ways of reporting, and addressing casualisation, are important first steps. Safer processes, such as the use of offsite pre-fabrication, are also beneficial to improve time and cost certainty, predictability and productivity on-site, and to reduce worksite risk. Creating safer workplaces can support the needs of older workers and improve the conditions for their younger counterparts.

Older Workers and Falls

One of the most potentially hazardous tasks in the construction workplace, the use of ladders to access work at height continues to be dangerous and deadly, more so for older workers. This industry records 37% of falls-related fatalities, at a fatality rate four times more The evidence suggest a strong correlation between age and ladder falls, with a concerning fall-related fatality rate for workers over 45 years, whilst in the general community (in the DIY context) 65 to 74 year olds are experiencing the most falls. (The Australian Institute of Health and Welfare, 2013). As ageing affects the worker, balance and skill on a ladder can diminish, making preventative measures critical to ensure safe to supporting longer and safer careers.

Work-related ladder falls, which predominantly involve older workers and generally result in more severe injuries than non-occupational falls, can be best understood through examination of both intrinsic and extrinsic risk factors (Vallmuur et al., 2016).

Intrinsic individual aspects, such as age, experience, and fatigue, play an important role. Whilst older workers may have more experiences of working at height and be more competent ladder users, the ageing process can inhibit decision making performance (Lonsdale, 2011 and reduce cognitive performance with the vestibular (inner ear) and visual systems decreasing in functionality. Reduced blood flow and nerve damage to the inner ear causes dizziness and vertigo, leading to balance issues and reduced confidence and ladder competence (Webb Schoenewald & Bailey, n.d.). This age-related decline in physical and cognitive abilities, not only reduces workplace performance and capability, but is particularly dangerous in the ladder usage context, bringing new vulnerabilities to older workers.

Extrinsic risks such as slippery or uneven surface, obstacles, and weather can also produce unsafe conditions which can led to falls. However, a New Zealand study has found most workers were stationary on the ladder before falling, indicating that overreaching, ladder placement issues, ladder instability will more likely contribute to a fall then than mis-stepping or slipping on rungs (Vallmuur et al., 2016). Whilst there are different levels of ladder experience and competency, across different trade groups, it is also evident that over familiarity can lead to reckless or over-confident behaviours, such as working outside the stability limits of the ladder to avoid time-consuming ladder repositioning. In addition, conducting difficult or awkward tasks, or manoeuvring heavy equipment whilst on a ladder increases the likelihood of a fall.

Whilst workplace safety issues are beginning to be addressed through a combination of Australian Standards, a Code of Practice, legislative measures and the publication of comprehensive workplace guidelines for ladder usage (e.g. WorkSafe Victoria 2013), domestic ladder falls account for a high proportion of all ladder falls (Miu, 2015). In non-occupation, 'Do-it-yourself' (DIY) maintenance around the house, falls make up most of the injuries that lead to hospitalisation (The Australian Institute of Health and Welfare, 2013). The cohort at most risk are men over 50 years who have fallen more than one metre, which has led to 7-day hospital stays (K. Roberts et al., 2020). Hospitalisation is most often due to fractures, more often in the head and neck region, followed by the hip and lower limbs (Australian Institute of Health and Welfare, 2021b). Roberts and colleagues (2020) detail how the long-term implications of these injuries are often more damaging for older people, with a loss of independence, corrosion of social relationships and reduction in psychological wellbeing through sleep disruption and increased pain and anxiety.

Ladder Design and Innovation

The design of ladders follows specific regulation and guidelines, which can be slightly different depending on country of use. Such legislation does generally recommend safer alternatives instead of ladder use (e.g. platforms), however ladders have both flexibility of use and a quick functionality that make them the most appropriate choice, especially in situations with uneven or unprepared surfaces, minimal space and/or where quick repositioning is required. As a result, portable ladders are one of the most commonly used tools for working at heights, despite their inherent stability and safety issues. However, users need to be more vigilant about the risk of falling when working at heights, and in the workplace should implement appropriate fall control measures (WorkSafe Victoria 2013 and ensure supervision to ensure safe practices are followed. If a ladder is necessary, the ladder type, position, securing, abilities of user, and site conditions need to be taken into account (Lonsdale, 2011). However as evidenced by the statistics above, people continue to incorrectly use ladders, incorrectly levelling them, failing to secure them and overreaching, leading to fall incidents.

There has been minimal innovation in ladder design with respect to safety. Whilst design innovation has occurred with regard to materials, folding systems, versatility and functionality, the only safety-related innovations have been the inclusion of tie-off and mounting points, as well as slope compensation devices (Lonsdale, 2011). Workplace health and safety regulators have done significant work in the context of user behaviour on a ladder and risk avoidance; however, the ubiquitous ladder remains mostly unchanged and the manner of (mis)use remains a significant cause for concern.

Wearable sensing technologies have an increasing role to preventing workplace safety incidents. The emergence of low-cost portable sensor devices which are capable of detecting movements and behaviours and predicting and warning of dangerous outcomes, represents a new area of workplace safety innovation. Two recent studies explored fall hazard identification through gait patterns (Yang et al., 2017) and stability (Antwi-Afari & Li, 2018). In the latter study, a wearable insole pressure system was used to capture 'loss of balance events' that may lead to a slip or fall. This work reveals how an individual's speed of movement and foot plantar pressure are associated with unsafe conditions and the increased likelihood of falls. This type of sensing technology could be effectively utilised to monitor the interaction between the worker and ladder to ensure that activities occur within the stability footprint of the ladder, to avoid overbalancing and falls.

Technology integration can be used for either predictive (as above) or responsive responses. In addition to predicting hazardous situations, sensor technology can be utilised to trigger an instantaneous response system, such as the rapid airbag deployment seen in motorcycle protective equipment. in this expanding field, wearable avalanche airbag systems are being used in alpine areas to increase survival rate in the event of an avalanche (Rose, 2015), with some success. However Guo & Goh (2017) note that the wearing of such equipment can provide a false sense of security, which is a particular concern which risk taking behaviours are predominant and may be encouraged by additional protection.

In the context of ladder incidents, the severity of falls could be reduced through supplemental fall protection measures or technology that can absorb the energy of impact (Hsiao et al., 2008), such as those used in motocross or downhill mountain bike sports. Development in extreme sports protection equipment has seen rapid advancement in material technologies that provide low profile impact absorption with minimal restriction of movement. Airbag usage has previously been investigated in a ladder context, with a system that integrates airbag systems into the base of the ladder, to cushion an individual's fall (Balzano, 2012). However, this technology was not adapted for widespread utilisation and opportunities exist for the exploration of personal protective equipment for ladder users.

Case Study: BREAKFALL

Ladder Safety System

Designers: Ben Fiteni, Massimo Fecht, Marcus Lightbody

Figure 30: BREAKFALL Graphic

BreakFall is a ladder accident prevention and protection system aimed at the residential construction industry, with a specific focus on the needs of older workers and infrequent ladder users.

Problem Statement

An ageing workforce paired with a declining manual labour supply has started to reveal long term implications to the commercial viability of industries that require sustained physical activities. As people age, they begin to lose muscular strength, range of movement and dexterity, and may endure pain and reduced mobility resultant from the onset of osteoarthritis. Injury or ageing can also impact the vestibular system, the sensory apparatus of the inner ear that helps the body maintain its postural equilibrium. These physical and sensory deteriorations contribute to the decline of balance, making older workers more vulnerable to fall injuries, with the majority of ladder falls attended by paramedics involving men aged over 50.

The construction industry accounts for 37% of fall-related fatalities, 26% more than any other industry. Falls make up 25% of all construction-related fatalities, but many falls, whilst not fatal, still have life changing and career impacting long-term consequences.

Ladder use is inherently dangerous, but if used responsibly with due care and attention, the risks can be minimised. However, ladder falls continue to be overrepresented in hospital admissions. The most common accidents from ladders occur because of 'over reaching' (working outside the balance footprint of the ladder), inappropriate use or misuse of ladders, poor ladder selection for the task, and failing to adequately secure the footing or the top of the ladder to maintain stability.

Whilst it would be expected that construction professionals would be experienced and competent ladder users, not all construction trades utilise ladders sufficiently to develop safe working practices. In addition, familiarity can lead to overconfidence and unsafe practices, especially when faced with commercial pressures, completion deadlines and poor working and climatic conditions. Adding to the danger, an age-related decline in physical and cognitive abilities could result in an ageing worker's transition from that of a competent ladder user, to someone who may be increasingly vulnerable to a workplace ladder fall.

Ladder falls can have life changing consequences, with common injuries including limb and rib fractures, neck, hip and spinal injuries, head injuries/concussion, internal bleeding, sprains and bruising etc. and can lead to lasting physical impairment and mental health issues.

Ladder users need a feedback system to help identify dangerous situations, especially with regard to ladder instability, and user positioning/ movements outside of the balance footprint of the ladder. However, as it is impossible to prevent all ladder falls, the inclusion of a personal protection system that reduces the injury severity of a fall is also necessary.

Figure 31: BREAKFALL Problem Scenario

Figure 32: BREAKFALL Artifact Outcome Sensor Unit

Key Considerations

A fall prevention and personal protection system for ladder users:

- ladder safety education and awareness,
- identification of hazardous setup and/or user behaviours,
- fall prevention through an effective and timely feedback system,
- personal protection equipment to reduce fall severity,
- easy and fast setup and operation,
- wearability - not restrictive of normal user movement/tasks, comfortable,
- weatherproof, shockproof, rugged, easily cleanable.

Project Outcome

BreakFall aims to prevent ladder falls through a ladder and user position monitoring system with feedback warning, and personal protection for users in the event of a fall. This two-part solution consists of a ladder mounted sensor unit and a wearable safety vest with an integrated airbag protection system to reduce injury severity. The potential to receive instant feedback regarding ladder and user instability will not only prevent falls, but heighten awareness, educating workers and developing safer work practices.

Feedback System – Sensor Unit

The first part of the system is a sensor unit (attached to the top of the ladder) that alerts the user to lack of balance and stability, acting as an automatic early warning system to allow people to realise when they're putting themselves in unsafe situations, with the aim to encourage behaviour change.

The sensor unit interacts with the safety vest (worn by the user) to determine user positioning on the ladder and provides warning signals (auditory and vibratory) to prevent the worker from exceeding the stability threshold of the ladder through dangerous positioning on the ladder (e.g. overreaching, leaning outwards, twisting to work behind, and other destabilising activities). Ultrasonic sensors are incorporated to determine the objects' distance from each other without any physical contact involved. In addition, the sensor stability awareness recognises instability in ladder positioning (e.g. on an uneven or angled surface) during set up and warns the user before ladder usage occurs.

The goal of this design is to create a system that stops preventable injuries and ensures that the user stays safe, recognises their mistakes have serious consequences, and learn from them.

Protection System – Safety Vest

This second part of the system is directly related to personal protection. Whilst the sensor system aims to prevent ladder falls, it is important to recognise that people aren't always going to make the right decision or make that decision quickly enough to avoid an incident. For this reason the BreakFall system has both preventative and protective measures in place to limit workplace injuries.

The safety vest has two functions; the interaction with the sensor unit to determine user positioning on the ladder and personal injury protection. User protection in the event of a fall is through impact protective material (D30) and an integrated airbag.

The vest is padded with D30, a highly durable and impact protective material that protects against straight-on impacts, piercing, and cutting injuries. Whilst its primary function is to lessen the impact of a fall, it is important to recognise that worksites are often cluttered and so provide some protection against sharp objects, or tools and equipment that may occupy the fall zone. D30 is also a light and malleable material that allows for good moveability of the user so it should have a very minimal impact on a worker's ability to perform their job efficiently and effectively.

The integration of the airbag unit will offer substantial protection to the head and neck in the unfortunate event of a ladder fall. This significantly reduces the risk of life changing injuries and death. Using an inbuilt accelerometer in the vest to register the extreme and/or sudden movement or positional change associated with falling, the airbag will deploy just before impact with the ground. As the airbag deployment does not require communication with the feedback loop system the safety vest can be used independently of the ladder, which is an advantage if working above the ladder (e.g. on a roof). The vest is modular and the airbag unit can easily be replaced after each deployment.

Education and Awareness

The BreakFall system has the potential to interact with a phone-based app to monitor and record user behaviour during the workday. The app will show the user how many times they breached the safe operating zone, providing access to a backlog of past sessions through the calendar, and issuing the user with a weekly safety score that they can track over time.

Employers who purchase multiple units will be given the option to opt into a yearly subscription service which collates the safety data from all their workers with more robust statistics and data analysis. Having access to data analysis to determine what time of day are workers being least safe, how many safe operating zone breaches over time, or what ladder type's workers had more safety incidents, etc. could be used effectively to implement specialised training and safer workplace practice.

Figure 33: BREAKFALL Artifact Outcome Safety Harness

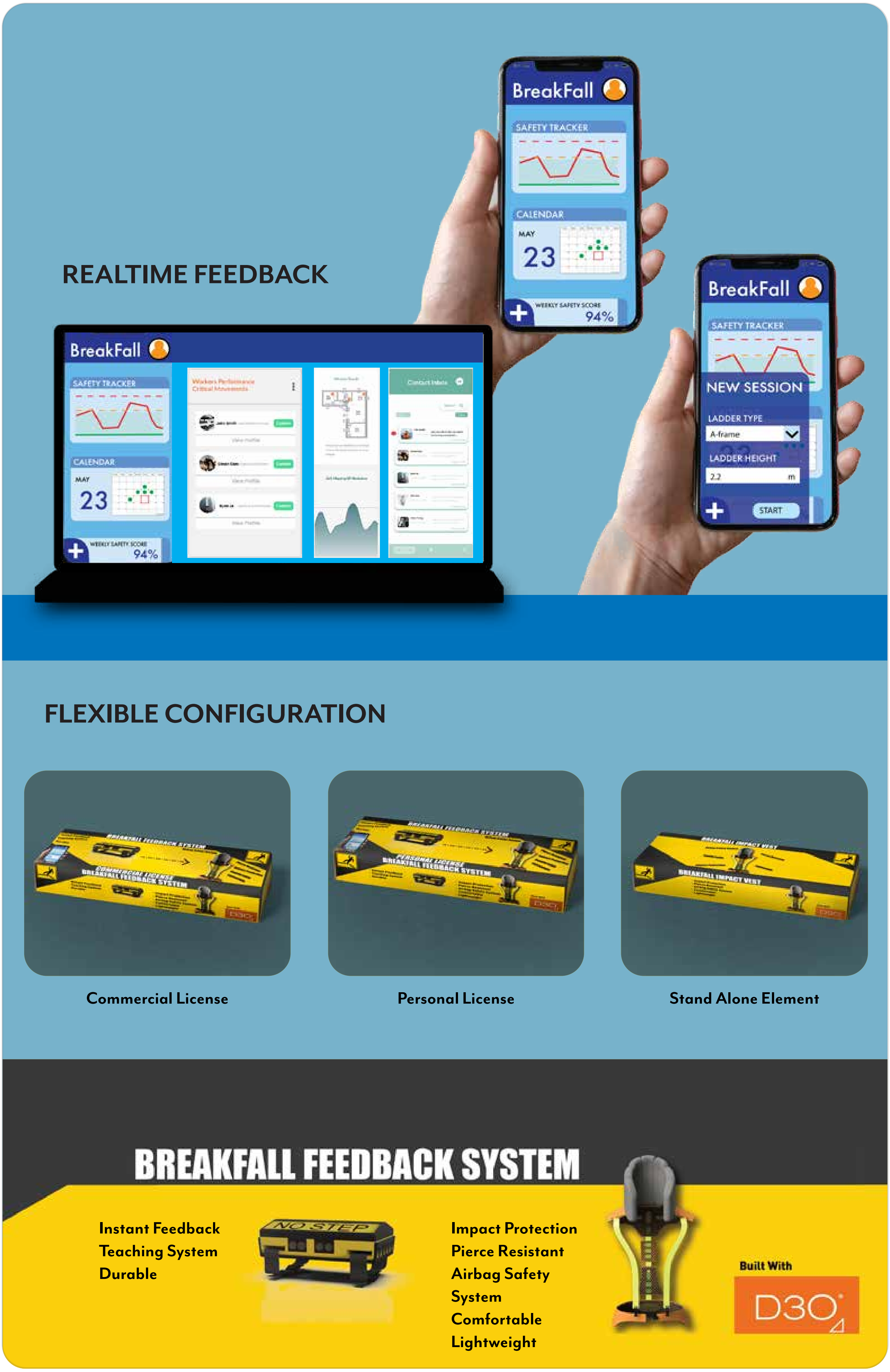


Figure 34: BREAKFALL Digital Outcome and Implementation Options

Implementation Strategy

The BreakFall system can be purchased either as the complete system of detection and protection, or just the safety protective vest with an integrated airbag. It is anticipated that novice operators may gravitate towards the full system, whilst those who are highly experienced and ladder competent, may choose to initially purchase just the safety vest.

It is important to recognise that residential construction worksites are not as heavily regulated as large commercial sites and often utilise independent contractors who are under significant time pressures. It has been identified that these workers over-confidence and macho or 'she'll be right' attitudes can lead to poor judgment and/or risk assessment. These attitudes can be significant barriers to the implementation of new safety systems and behaviours. Uptake of the BreakFall system will depend on comfort, wearability, affordability and the workers sense of vulnerability, however influencing networks e.g. wives and partners, employers, insurance agencies may drive early sales.

It is suggested that an initial partnership with major tool / ladder brands and major trade retailers and promotion through trade organisations would drive early adoption and acceptance, however partnering with unions and safety regulators to lobby for broad implementation as part of employer issued personal protection equipment (PPE) may also be effective.

Review of Potential Impact

BreakFall's ladder accident prevention and protection system is an effective solution for aiding an aging workforce and limiting the chance of injuries in both the residential construction industry and the DIY home renovation domain.

This product not only protects the user from life changing injury in the event of a ladder fall, but actively prevents falls by alerting the user to potential safety issues in real time. This capability should help educate users in ladder safety and encourage safer ladder usage behaviours. The BreakFall system will support and protect all ladder users, and provide additional user confidence and security, especially for older workers, who may be suffering from deterioration of balance due to changes in the vestibular system as they age.

It has the potential to lead to safer work practices and drive behaviour change through its monitoring and data analysis functionality, and become standard PPE for construction workers.

6

Reducing Vibration for Ageing Agricultural Workers

Reducing Vibration for Ageing Agricultural Workers

Agricultural workers must manage the issues that come with hard physical work, exposure to extreme climatic conditions, isolation and long workdays, which are compounded by gradual side effects of both the ageing process and work-related muscular-skeletal disorders. However, farmers typically spend very little time dealing with the long-term implications of their health and wellbeing. Health statistics indicate that farmers are half as likely to visit a general practitioner or a mental health professional, than those employed in non-agricultural professions (Brew et al., 2016).

Farming is an intensely physical profession, it requires a high level of strength, and it has awkward postures and movements, high repetitions and high muscle loads. Agricultural machinery and vehicles now assist with a lot of the physical work, and consequently, farmers spend more time sitting down, than walking. A considerable amount of the working day is spent either in tractors, operating machinery or exposed to the risks of working with dangerous equipment. An ongoing, indirect, and invisible danger in using such vehicles and tools is exposure to vibration, noise, and other unintended consequences of using of the vehicle in rough terrain. Research on whole-body vibration (WBV) has shown that there are considerable health risks, associated with exposure to vibrations from tractors, especially over extended periods, causing spinal problems and exposing bodily organs to damaging resonations. However, the risks of whole-body vibration for long-term health are yet not a priority when choosing a budget friendly tractor or agricultural equipment (Cutini et al., 2017).

The agricultural workforce is ageing, with the average age of farmers 17 years older than the Australian workforce average. Consequently, farmers are exposed to the physical demands and health impacting factors of their workplace for much longer than in other professions. As long-term exposure to whole-body vibration over prolonged periods will only exacerbate impacts on worker health, it is essential that action is taken to not only protect older farmers, but to ensure that younger workers are not exposed to harmful WBVs that may impact long-term health and career longevity.

This chapter investigates the hazards to which agricultural workers are exposed throughout their careers, with a specific focus on the impact of vibration exposure during tractor usage. In tractor operation, farmers are often required to undertake upper body twisting motions to monitor operations and equipment performance; partially rotating in the seat to look over their shoulders behind the tractor. These repetitive and awkward movement patterns and poor postures increase the likelihood of muscular-skeletal injuries, but more importantly magnify the potential impact of vibration as the spine is exposed to external forces whilst in an unnaturally twisted orientation.

Forming an understanding of the potential health issues due to long-term exposure to the agricultural equipment can pose operators, we identify the need for cost-effective and adaptive interventions that can be introduced quickly into the agricultural environment. In addressing the issue of vibration and compromised seating in low-end tractors, we explore the development of a retrofit solution that offers agricultural workers an option to reduce WBV-related health issues, prolonging their time in the workforce and ensuring greater quality of life in later years.

Ageing on the Farm

As an industry that captures a high portion of older workers in Australia, agriculture is a hazardous industry that sees frequent tractor mishaps and machinery-related injuries (Vryhof et al., 2019). Approximately 60 percent of deaths from work-related injuries in agriculture occur in those 55 years or older, and older workers who do survive will take longer to recover and return to work (Nilsson, 2016). Farmers work long hours, have physical work, and often live in remote areas, preferring to manage themselves rather than access support (Brew et al., 2016). In Australia, this industry has the second-highest fatality rate, and with a mean age of 53 years, is a notably fast-paced ageing workforce (Monaghan et al., 2017).

Agricultural workers rely on their vision, hearing, memory, and decision-making abilities to perform often complex and repetitive daily tasks. The natural ageing process alongside disability or disease can see a degradation in these capabilities over time and lead to an increased chance of injuries (Voaklander et al., 2012). While older farmers do acknowledge these workplace risks related to ageing, most suggest they rely on their perceptions of common sense and experience to work safely (Caffaro et al., 2018). Due to these factors, being considered an 'older farmer' in Australia is not considered such as barrier as in other industries, with Noeline Monaghan and colleagues (2017) indicating that farmers often continue working up to 75 years of age.

The risks posed by working on the farm are worsened by the ageing process, which in turn is exacerbated by exposure to agricultural equipment over a lifetime. As one of the quickest ageing sectors in Australia, both these long-term effects and the heightened risks for older workers, need to be explored and addressed. A specific area highlighted in research is how the operation of farm tractors is inherently dangerous for workers, notably children and older adults (Marlenga et al., 2017; Monaghan et al., 2017). As one of the most important pieces of agricultural equipment on the farm, tractors form a key workplace where risks and hazards are most apparent for farmers (Gao et al., 2021).

The Tractor Workplace

Alongside the functional aspects of operating a tractor, the driver's health, safety, and comfort should be of utmost importance. In terms of risk exposure, there are two prominent areas of concern: farmer behaviours and machinery design (Caffaro et al., 2019). This can be seen in undertaking unsafe behaviours, for example, while getting in and out of a tractor, or maintaining poor driving posture, both of which can lead to musculoskeletal disorders. Yet when choosing such equipment, farmers will prioritise reliability, performance and cost-effectiveness before cons idering machinery access and safety (Renius, 2020). Adopting safety equipment and systems, such as rollover protective structures and seat belts, has been seen to reduce fatalities in the sector (Rondelli et al., 2018). However, they have not influenced the fatality rates for older Australian farmers over the past two decades, which remains steady (Monaghan et al., 2017). Australia lacks a national tractor safety standard, and safety is further eroded by low-end imports (Saunders, 2010). Even today, imports are not subject to the rigours of motor vehicles, putting operators at risk (Jacks, 2020).

While the rollover protective structures mentioned above have been retrofitted to tractors and quad bikes (WorkSafe Victoria, 2018), practical efforts to reduce less pronounced and more gradual risks aren't evident. Notably, while evidence has proven exposure to tractor ride vibration can cause or worsen significant health disorders, many tractors do not have adequate vibration protection for operators, and long-term impacts continue to affect farmworkers (Cutini et al., 2016; Gao et al., 2021; Prasad et al., 1995).

Whole-Body Vibration Syndrome

Whole-body vibration (WBV) is vibration transmitted to the whole body by the surface supporting it, for example through a seat or the floor of a vehicle. In a tractor, uneven terrain, unmade fields and rutted roads, are common contributors to whole-body vibration, as are mechanical resonations caused by the tractor's engine, driveline and ancillary equipment. During tractor operation, vibrations are transferred through the vehicle and the seat into the farmer's pelvis and lumbar spinal area (Druley 2019).

Repeated exposure to whole body vibration impacts the spinal discs and cause discomfort, ongoing health disorders (e.g. MSD) and aggravate pre-existing conditions. The effects of vibration are complex, but it is known that the impact of vibration and how it travels through the body is influenced by posture and is greater when experienced in a seated position.

"Any sort of equipment where an operator is in a seated position, has the potential to impart mechanical vibration that could be problematic," Nathan Fethke, Associate Professor of Occupational and Environmental Health, University of Iowa.

The longer a worker is exposed to WBV, the greater the risk of long-term health effects and musculoskeletal disorders. Whilst the most reported impact is lower back pain, long-term and prolonged exposure to WBV may also cause neck and shoulder pain, fatigue, herniated discs, and early degeneration of the spine (Safe Work Australia 2020). In addition, WBV may contribute to digestive problems, impairment of balance and vision, and cardiovascular, respiratory, neurological and metabolic changes. It is also evident that exposure to both noise and vibration simultaneously, whilst exacerbating musculoskeletal problems, also causes fatigue that will impact operator performance, and may also lead to workplace incidents.

A study by Safe Work Australia (2020) has identified that working posture and age are key factors in determining the impact of WBV. That research specifically identified prolonged sitting in constrained or poor postures, frequent twisting of the spine and adopting twisted head postures as activities likely to exacerbate muscular-skeletal disorders – all of these common to tractor operation.

Vibration induced health conditions progress slowly and may not be apparent to the worker until significant damage has occurred. Initially it starts as pain which, in a tough agricultural industry with high levels of physical activity, may not be directly attributed to tractor operation. As vibration exposure continues, the pain may develop into an injury or disease, with the longer a worker is exposed to vibrations, the greater the risk of the onset of health effects and muscular disorders.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Exposure to Tractor Noise & Vibration

The long-term effects of working on the farm can be attributed to accidents and resulting injuries and daily exposure to dangerous working conditions. Damage from these conditions to hearing, vision, or other parts of the body, can be caused by prolonged and cumulative effects over many years (Depczynski et al., 2005). The study of high levels of exposure to excessive noise, vibration and ultraviolet rays by farmers is well-documented (Smit-Kroner & Brumby, 2015; Vryhof et al., 2019), but how they are addressed practically is often not so clear.

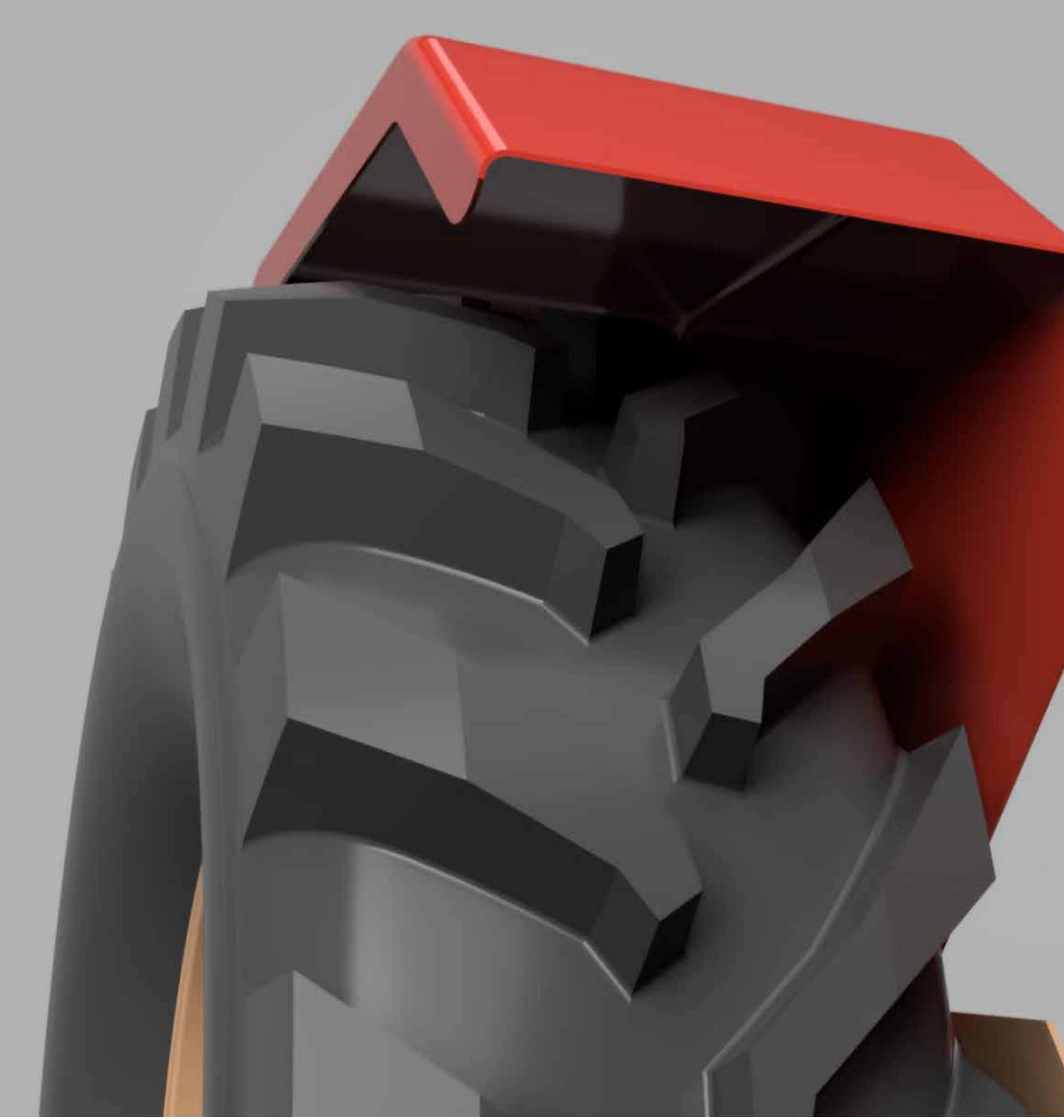
As such an issue, extreme noise frequencies caused by agricultural equipment can induce minor discomfort to long-term hearing loss, affecting workers' health and efficiency (Aybek et al., 2010). The primary source of noise for tractor operators is the vehicle engine, which emits frequent and often intense sounds from the muffler (Jahanbakhshi et al., 2020). Research indicates that the acceptable noise threshold increases with time in the seat, with older workers likely to have more diminished hearing functionality than others due to long-term exposure to noisy environments (Khadatkar & Mehta, 2018). Options for reducing sound pollution are either insulated cabins or worn ear protection. However, farmer ambivalence and unsafe behaviours, combined with operational needs, may make these options less viable (Behroozi Lar et al., 2012).

Alongside noise exposure, whole-body vibration is a major concern. Exposure to constant and uncomfortable vibration levels while driving, is exacerbated by compromised working conditions or unsafe behaviours. These involve uncomfortable postures, inappropriate seats, or frequent handling operations (Cutini et al., 2017). As vibration is generally transmitted via the seat, backrest, and touchpoints on the vehicle, solutions are often passive anti-vibration systems such as suspension seats which isolate vibration (Figure 4). However, while a seat system can reduce vibration through offsetting the movement of the driver to the tractor, they can reduce visibility and complicate actions in the cabin, leading to awkward postures and positions, and long-term, unsafe behaviours (Aisyah Adam et al., 2019).

Because this vibration originates from tractor attachments, weight distribution, power delivery, and interactions with soil, alternative anti-vibration solutions are complex and expensive to retrofit (Brunetti et al., 2021). Modern tractors will generally come pre-fitted with the necessary suspension systems for the front axle and cab, which amongst other features, can make upgrading a costly exercise. Whilst high end tractors and agricultural equipment may also have air-suspended seating, however older tractors, or lesser-known brands do not offer anti-vibration measures, with examples of farmers fitting cushions rather than face the cost of a high-quality active seat (Cvetanovic et al., 2017).

It is evident that an affordable retrofit solution is required to protect tractor operators from the health impact of whole-body vibration. Such a solution will need to be flexible and adaptable to many different installation contexts and accommodate the distinct operator movements required in agricultural procedures.

Figure 35: Massey Ferguson 1800E and 2800E Series compact tractors



Case Study: Spider V1

Vibration Dampening Tractor Seat System

Designers: Grace Henschke, Sid Pearn, Riley McComb

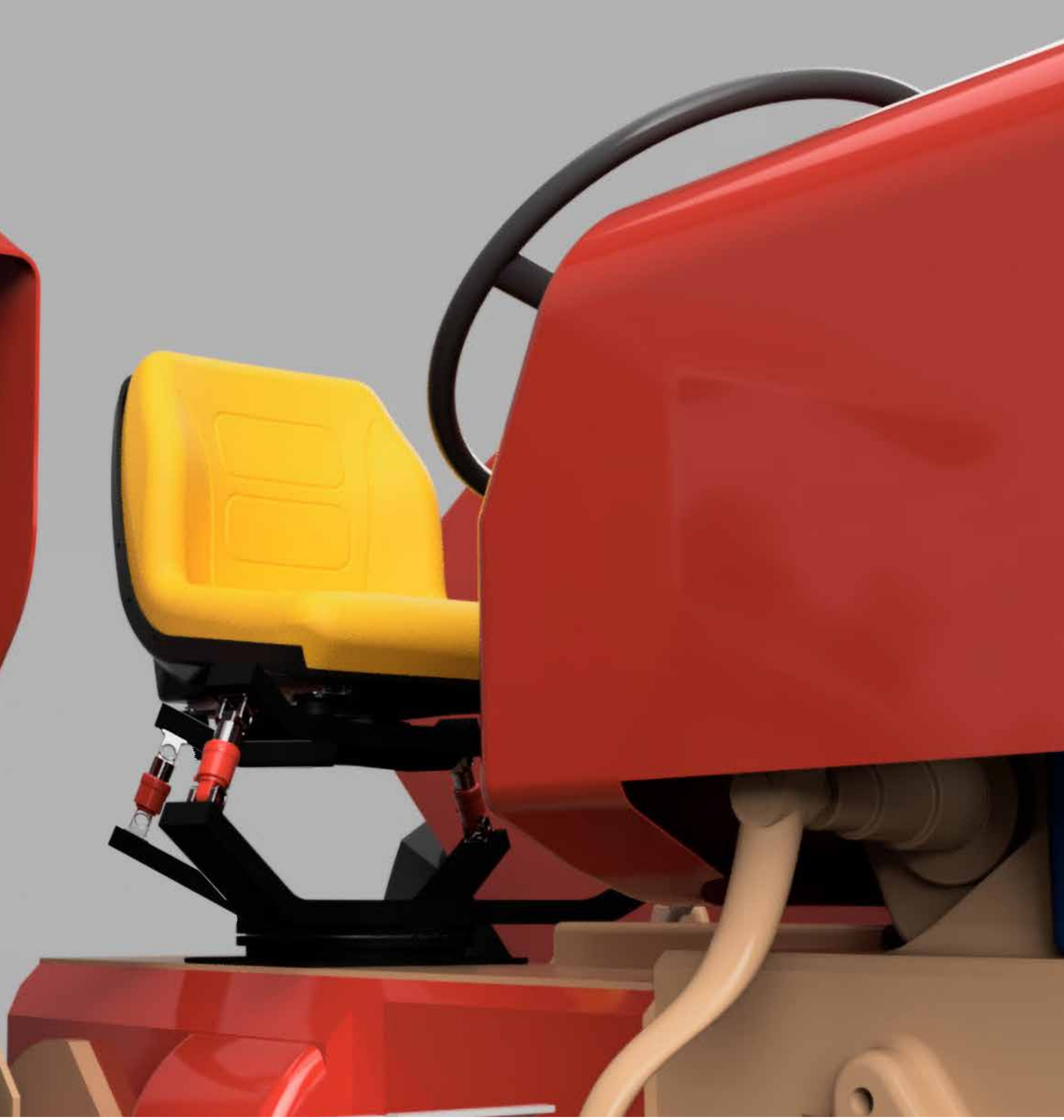


Figure 36: SURGE SPIDER Graphic

The Spider V1 is a seat base for tractors and other light machinery that specifically targets the dampening of machinery and activity-based vibrations that impact farmers' health, whilst allowing rotation to reduce twisting forces on the upper body.

Problem Statement

An ageing workforce and a dwindling itinerate manual labour supply have long term implications to the commercial viability of industries that require sustained physical activities. Labour recruitment challenges currently facing the agricultural industry have resulted in farmers working much longer, with the 2017 census finding that the average age of an Australian farmer is 56 years (Vidot, 2017). This is 17 years older than the average age of the Australian workforce.

Not only are these farmers losing muscular strength, range of movement and dexterity as they age, but they are also more vulnerable to muscular-skeletal issues. Farmers using small utility and specialty tractors undertake repetitive, restricted, or awkward movements and are exposed for long periods to a range of different vibrations. This combination of whole-body vibration exposure and repetitive strain can cause debilitating injuries to farmers as they age. Most tractors don't sufficiently dampen vibrations, and this can lead to extreme discomfort (e.g. muscle pains, muscle cramps and numbness) and lead to life changing degradation of the spinal column, and other significant health issues. (Safe Work Australia, 2020), (NHS, 2018).

In a tractor cab there are multiple sources and different types of vibration. Some vibration comes from the engine and drivetrain, as well as the operation of various sub systems, whilst other vibration is chassis derived, triggered by external sources such as the terrain that the tractor is transitioning. Farmers are typically exposed to whole-body vibration trauma through the seat, floor and steering wheel of the tractor. The health risk from vibration for operators or drivers increases with the intensity and duration of vibration exposure, combined with forced sitting posture and heavy physical work. In agriculture, farmers are exposed to prolonged periods of driving, with vibrations exacerbated by rough terrain and poor seated posture.

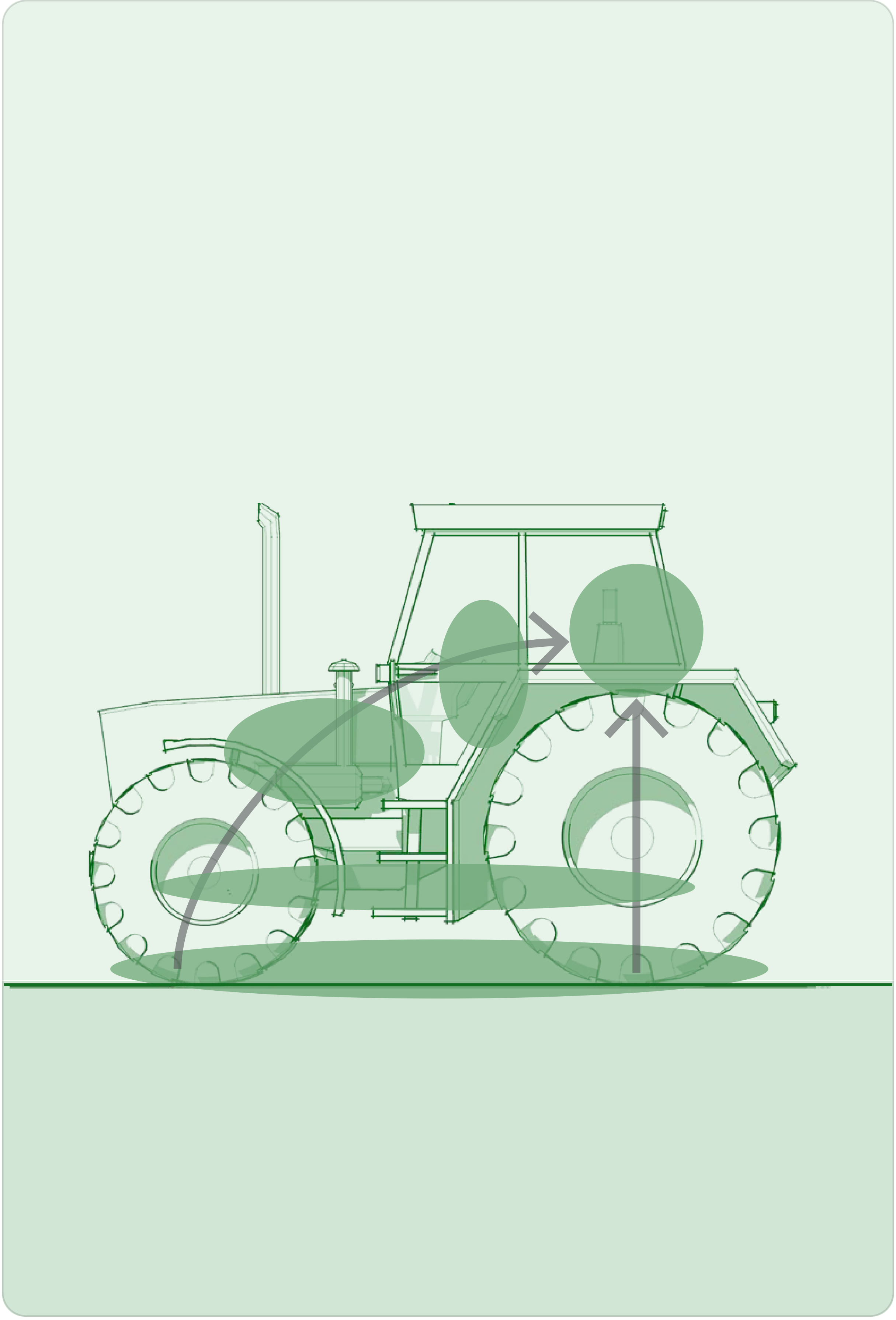
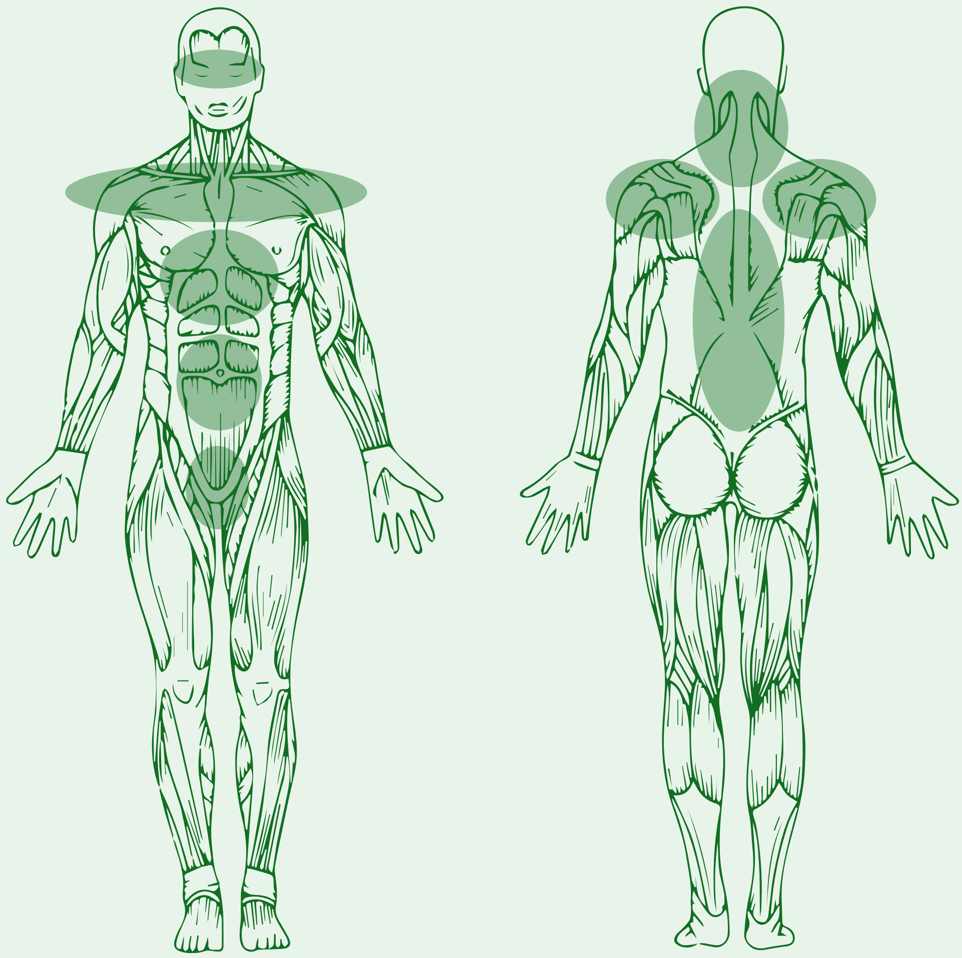


Figure 37: SURGE SPIDER Sources/Paths of Vibration



56
The average age of a farmer in Australia

2.3
The average number of health conditions suffered by farmers over 50

21%
The percentage of ageing farmers that were injured in the past year. 50% of these were related to farm work

85,681
The number of agricultiral business across Australia

Figure 38: SURGE SPIDER Key Areas of Vibration Trauma

Vibration and Posture

Prolonged exposure to vibrational frequencies of any range can have long term effects on the body. Safe Work Australia (2000) has identified Whole-Body Vibration (WBV) as a matter of concern. Exposure to Whole-Body Vibration can be from a series of repetitive vibrations or irregular sharp impacts such as shocks and jolts.

Vibration effects are dependent on the posture and anatomy of an individual (the geometry of the person will determine the path that the vibration travels) however the most pronounced long-term effect of whole-body vibration is damage to the spine. The spinal region most frequently affected is the lumbar area, where spinal deformation, herniated spinal discs, lumbago, and sciatica can develop as a result of mechanical overload. Organ systems, such as peripheral and autonomic nervous, vestibular, vascular, digestive and female reproductive systems are also liable to become affected, and sufferers can experience impairment of vision, hearing and balance.

One of the consequences of tractor driving in agricultural contexts is the need to regularly monitor what is happening behind the tractor, to check equipment operation and monitor progress. As tractor seats are typically fixed in position, this necessitates frequent twisting of the upper body to look over the shoulder. These repetitive actions, completed whilst the spine is exposed to vibrational forces, can lead to repetitive strain injuries and exacerbate the onset of whole-body vibration syndrome.

Key Considerations

- combat whole-body vibration exposure in tractors
- effective dampening of drivetrain and terrain derived vibrations across all frequencies,
- enabling and supporting better movement (twisting and turning) in tractors to prevent repetitive strain injuries and impact of vibration during awkward postures/movements,
- raising awareness in agriculture communities of the dangers of vibration exposure,
- affordable, adaptable, customisable solution,
- universal mounting system with retrofit potential,
- local engagement and implementation strategy.

Project Outcome

The SPIDER V1 aims to significantly reduce health impacting whole-body vibration, by dampening vibration exposure through the tractor seat. It is specifically targeted at farmers and is a universal seat fitting that can be mounted directly under existing tractor seats. It utilises hydraulic struts to dampen major/large vibrations and sharp impacts and rubber vibration dampers to diminish smaller harmonic vibrations.

Vibration Dampening

The existing tractor seat is remounted into a suspended position within an array of hydraulic shock absorbers, placed at 30° angles in each corner to optimise shock and vibration absorption from all angles. This system will allow the seat to effectively 'float' within the mounting frame, isolating the farmer from terrain derived impact shocks and drivetrain, chassis and ancillary equipment derived vibrations. This system is supported by an additional rubber mount dampening system situated at the base to absorb small frequency vibrations.

Fabrication

The Spider seat mount system is designed to be locally manufactured in metal fabrication workshops within local farming communities. It is important that the suspension system is simple to fabricate and repair locally and that it can be easily customised or modified to suit a specific installation or an individual farmer's needs. For this reason, the frame is made from mild steel with simple bends and welds that can be easily replicated in a range of tubular or flat bar materials in most workshops, with only rudimentary fabrication equipment.

Mounting

The Spider v1 utilises a universal mounting system that allows it to be retrofitted to most tractors, using the existing seat mounting system. However, it has been designed specifically to be also easily adaptable and customisable for different installation contexts.

Seat Rotation

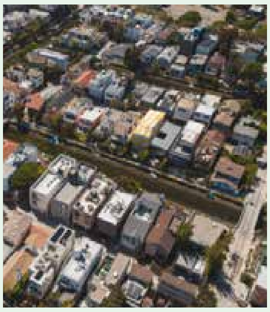
The other function of the Spider V1 is to allow for some left and right rotation (adjustable) to reduce upper body and neck twisting when the farmer is monitoring activity behind the tractor. Whilst rotation of 90 to 180 degrees would be advantageous and eliminate twisting completely, it would be hazardous for the driver to be in an extremely rotated position whilst the tractor is moving forward. However, even a relatively small rotation of the seat (e.g. 30- 45°) can significantly reduce the amount of upper body twisting and neck strain whilst maintaining full operational control of the tractor.

Figure 39: SURGE SPIDER Artifact Outcome

1.

Present SPIDER V1 at field days & release local advertisements

Surge Design and Worksafe Victoria present early prototypes (and provide education on vibration exposure and RSI) to farmers and communities. This is aided by funding from support organisations such as the CWA.



2.

Licence SPIDER V1 out to local fabricators

Fabricators from local towns are licenced to reproduce our design with the option to customise based on client needs. Fabricators take full responsibility for quality and reliability.

3.

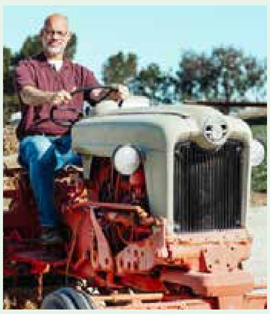
First prototypes are ordered & manufactured

Farmers who want to try SPIDER V1 can contact Surge Design who will connect them with their local participating fabricator to trial the standard SPIDER V1 model.

4.

Farmers trial SPIDER V1 & give feedback

Each fabriccator will have standard SPIDER V1 models to lease on trial. Following the trial farmers can consult with their fabricator to produce an appropriately customised model-based on their needs.



5.

Farmers purchase SPIDER V1 from their local fabricator

The farmer will reach an agreement with their fabricator and purchase their SPIDER V1. Royalties from the purchase will be provided to Surge Design and WorkSafe Victoria

Figure 40: SURGE SPIDER Graphic Implementation Stratergy

Implementation Strategy

Word of mouth and local endorsement are powerful tools in rural communities.
The farmer mentality means that sometimes they'll work until it is physically impossible to do. Whilst this shows great resilience, it can lead to extensive injury. It is therefore important for farmers to understand the potential health risks resulting from prolonged vibration exposure, and for local farming communities to embrace the problem and own the solution.

The first step of the Spider v1 implementation plan is to raise awareness in farming communities of the health hazards associated with vibration exposure in tractor usage. Influencing networks such as the Country Women's Association (CWA), ABC Television's Landline and Country Hour programs, locally based equipment suppliers, and product demonstrations at Agricultural Field Days will be important to ensure that the information is trusted and taken seriously.

The deployment model is underpinned by extensive local involvement. After a program of events aimed at generating awareness of the risks of vibration exposure, the product will be introduced to the local farming community through trusted agricultural equipment suppliers and will be available for 30-day obligation free trials.

The design will be licenced to local fabricators who will be responsible for prototyping, testing and manufacture of the product. The design allows for adaption to individual farmer's needs as well as to the available materials, and fabrication expertise and equipment. This ensures local control at all times, and the ability for customisation, modification and further development to occur in a manner that empowers the local community and its businesses.

Review of Potential Impact

The awareness campaign, the Spider v1 tractor anti-vibration seat mounting, and its implementation strategy have great potential to positively impact health and wellbeing in local farming communities, as well as invigorate local industry.

At present, there is insufficient community awareness of the risks associated with whole-body vibration exposure and farmers are working harder and longer due to the shortage of itinerate workers. This product will help to slow long-term spinal degradation in younger agricultural workers and extend the effective working life of older farmers.

The product licensing model puts the control of the solution into the hands of local communities and businesses, allowing them to be proactive in lessening the impact of whole-body vibration syndrome.

Conclusion

Conclusion

This research has sought to examine safety across the Australian industrial landscape, identify and understand the needs of older workers, and respond with targeted design interventions that enable an ageing workforce to maintain good health and continue to make valuable contributions. Capturing sentiments across multiple industry sectors, the research has realised insights on the impact of ageing on various workers, their employers, industries, and communities.

It is forecasted that future workforces will consist of fewer and older workers, many of whom will experience safeness and wellbeing issues in the workplace. A significant risk, which impacts the capacity of older workers, is an ongoing and misguided perception that ageing reduces usefulness and potential. This ageism bias is prevalent across many industry sectors, and upheld by managers, colleagues, and in an example of self-stigmatisation, even by older workers themselves.

The resulting case studies described in this report responded to how this negative and deficit-based narrative forms a powerful barrier to ongoing employment. They did so by exploring innovative worker safety measures, centring on improving workability as key to turning the challenges of an ageing workforce into opportunities.

While briefly highlighted across this report, workability plays a prominent role in engaging an ageing workforce and enabling it. Based on how we successfully manage work tasks – our competence, health, and values – workability is more than just key performance indicators that determine efficiency; it is increasingly a gauge of the quality of working life. Intervening to support and promote workability has been a feature across all case studies examined in this report. They have adapted the work environment, the organisation or working conditions to reduce work-related stress or physical demands. Through this, these targeted efforts have supported worker safety within the context of workplace hazards and the employee's long-term wellbeing.

Safeness for an ageing workforce begins with considering how worker workability is linked to their wellbeing through vocation and functional ability. Vocation, the type of work you feel you are suited to do, is often reflected in workers' functional ability in their roles: their intrinsic capacity, external environmental characteristics, and the interactions between these factors. In the workforce, such personal and environmental interactions reflect the tensions between our individual ageing processes, the characteristic of the industries we work within, and our broader expectations and aspiration in later life.

In summarising this report, we focus upon these tensions and how they will frame the future of the Australian workforce: individualised ageing and industry-specific interventions. Throughout this report, both speak to safeness as an underlying concept, while the case studies have interrogated workers' daily lives and workplace engagement. Further expanding upon this, we explore an agenda that positions safeness as an integral concern for the workplace and a platform through which employers and employees can work towards enabling an ageing workforce.

Individualised Ageing

Forming a key feature within the literature discussed throughout the report, we evidenced a salience to how an individual's ageing processes were a critical aspect of their quality of later life. Many of the issues encountered in the workplace, in injuries, illness, or chronic conditions, affect individuals differently and are processed in various ways. This reflects how personalised the ageing process is, as the combination of genetic and environmental factors inform what problems an individual faces and how they navigate them. As an emerging insight into enabling an ageing workforce, we considered how an individualised approach to ageing might improve safety in the workplace.

This question responds to a human-centred approach to design, where we directly engage with the complexity and individualised problems. As a critical aspect of the design process, human-centredness requires research into users' lives to inform the interventions we create for them. This approach was apparent across the case studies compiled in this report, which took a human-centred approach to worker safety, particularly those engaging with the manufacturing and health sectors. These case studies centred on responses to individual workers' physical and mental wellbeing, such as Airlift, which considered the long-term issues posed to nurses working alone, and PosCor, which passively monitored worker actions to produce curated prevention and rehabilitation. Overall, these examples considered individualised ageing through a human-centred lens, engaging with older workers' specific contexts and issues rather than assuming their capabilities or barriers.

Such case studies also demonstrate the duality of preventative and reactive safety measures in the workplace, reflecting the need to both plan out the risks for older workers, and respond effectively to unforeseen dangers. Nationwide campaigns and initiatives that engage with worker advocacy, often led by unions and similar political organisations, primarily target broad employer practices and advocate for systemic changes. However, the unique context of an ageing workforce will require such macro efforts to be balanced with individual-scale measures. A combination of reactive and proactive safety innovations is necessary for managing workplace health and safety, provoking conversations that address existing issues facing ageing and older workers, and preparing for future scenarios.

Many of the designs proposed in the studio component also addressed an important service-driven aspect of design - tailoring solutions to individual needs rather than institutionalised assumptions. The PosCor proposal transitions the physiotherapy sector from reactive to pre-emptive action, with BreakFall showcasing the capability of digital futures to realise safer and healthier workplaces. Such safety-centred services reflect broader trends in older workers for increased flexibility, more options, and further training and development to remain involved in the workplace for longer. Systems that can realise this level of individualised support and curation of services will become critical ventures in supporting safety and wellbeing in a rapidly ageing workforce.

Industry-specific Interventions

Alongside centring on person-level safety towards supporting healthy ageing, it is also important to engage with the macro trends that each sector's literature review has considered. As each worker navigates their own path through their career and into later life, their journey is cut through specific industries with unique characteristics. These traits are most apparent in the workplaces, where workers undertake specific tasks, engage with an established culture, and explore particular career trajectories. Contextualising a worker's personal ageing within the issues, complexities and qualities of their industry is an essential step towards intervening proactively in the lives and safety of workers more broadly.

As each chapter backgrounded the unique safety and wellbeing issues for older workers within specific industry contexts, the attributes and unique characteristics of these industries became evident. Each sector produces unique physical dangers and health risks due to the nature of the occupation as well as the cultures, regulations, and workplace behaviours. For example, when considering the everyday activities of older health care workers, the lack of colleague support and resources, and high physical intensity when working in a patient's home, had considerable impact, contributing to workers' physical and cognitive burnout.

The complex and often obscured nature of physical deterioration over time, and mental health decline, continue to be vulnerabilities to which workers are exposed, and become barriers to employment for many older workers. The aforementioned healthcare workers' burnout is not unique to their sector, as we documented how construction workers also deal with such issues throughout their careers. However, the tensions between personal health and environmental factors such as a macho work culture have seen mental stressors as a particular concern in the construction sector. In both industries, safety measures that identify and respond to causal factors can result in more effective proactive measures, for example in the case study WAGS & SNAGS, which leveraged social and cultural norms to engage workers with mental health topics.

Similar to the prevalence of specific mental health issues, physical health across industries was also located in a particular form: work-related musculoskeletal disorders (WMSDs). Across Healthcare, Manufacturing, Construction and Agriculture, avoidable chronic issues connected to WMSDs are still creating a barrier to ongoing work and quality of later life. This was most prominent in manufacturing and construction, where workers age physically quicker than their peers, encountering physical disorders earlier due to risky or harmful behaviours. It was also a concern in the healthcare sector, where a primarily female workforce is often required to perform potentially harmful patient transfers. Risky behaviours are an already well-established feature of safety design, engineering and policy, where we have traditionally eliminated or mediated the danger at the source. An ageing workforce complicates existing frameworks by requiring us to consider health issues that are not immediately apparent, but emerge over prolonged periods of employment.

An Agenda for Safeness

If we seek to support both individualised ageing and industry-specific interventions, the tensions that form from balancing personal and environmental factors need to be addressed. This forms an agenda to promote safety and wellbeing for our ageing workforce in how designers, engineers, policymakers, and employers incorporate safeness strategies into their work.

Towards the first part of this agenda for safeness, we have detailed six case studies that employed a 'safeness by design' approach to older workers' safety and wellbeing of older workers. These indicated the value and benefit of drawing on these strategies to enable an ageing workforce. Foremost is an effort to identify and frame problems within a more local and accessible context. We must contextualise the individual within their workplace to support their safety from a better viewpoint. In then working quickly and broadly across multiple contexts with a social and community focus, designing for safety takes on a more expansive view of the workplace and considers the characteristics of the external environments that workers navigate. Finally, in evidencing capability to enable early engagement in future design cycles, we see the need to draw in the designers, engineers, policymakers, and employers and rationalise and advocate for workers in enhancing health and safety in their workplaces.

An ageing Australian workforce poses unique challenges; enabling older workers means forming strategies that place their health, safety, and dignity at the core, and promote workplace capability and employment longevity. This report has detailed how worker barriers and industry characteristics can limit older workers, and how younger workers can develop long-term impairments through poor workplace design and poor movement behaviours. In responding, we developed design interventions that can support workability and lead to healthy ageing across our workforce. In detailing an agenda for safeness, we impress the importance of considering how each worker ages differently and how their workplace, in the tasks, culture and opportunities it offers, can support their health and safety into the future.

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