Government Office for Science

Foresight

Workplace infrastructure

Future of ageing: evidence review

Foresight, Government Office for Science

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Professor Peter Buckle

Helen Hamlyn Centre for Design, Royal College of Art, London

March 2015

This review has been commissioned as part of the UK government's Foresight Future of Ageing project. The views expressed do not represent policy of any government or organisation.

Contents

Executive summary

This Evidence Review considers changes to workplace infrastructure and environment that will enable large numbers of people to successfully remain in the workforce for longer and to consider how this will evolve in 2025 and 2040. It focuses on the literature related to the built environment and technology infrastructure factors that play a part in enabling extended working lives. Specifically it considers the barriers that ageing workers face within a variety of workplaces, business sectors and organisational structures. Research literature, related materials and expert input have formed the basis for this review. Resources did not allow a full systemic review to be undertaken. Most of the infrastructure design initiatives identified have not been subject to robust evaluation.

Key findings:

- Older workers are considered valuable employees because of their knowledge, skills and experience.
- Managing an ageing workforce requires additional training to maximise the potential and contribution of older workers. Older workers will need appropriate motivation to retain them in employment.
- Programmes are required to enable managers to gain these skills; such programmes are available in other EU countries.
- Physical and psychological work demands on older workers frequently exacerbate existing conditions or lead to ill health.
- Improved design of work systems, including equipment and the organisation of work, should make use of the existing extensive knowledge base of the needs and capacities of older workers.
- Risk assessment of work for over 65s lacks a sound evidence base. Current guidance has predominantly been drawn from a younger working population. This is especially evident for risks arising from physical demands at work.
- Evaluation of the impact (benefits) of workplace interventions and designs for older workers is needed. This evidence should be based on appropriately designed trials.
- Designers of infrastructures (including technology) should consider co-design/participatory approaches as essential when considering older workers.
- Work system interventions based on one workplace factor alone are unlikely to be sufficient to demonstrate a significant effect. This is because work is a complex sociotechnical system with interrelated dependencies.
- Sector-specific policy is needed as the requirements appear to vary significantly across industrial work sectors. This is particularly noticeable where technology is advancing rapidly or where physical work demands remain high.
- The modelling of the workforce for 2025 and 2040 is generally poor. Until this is addressed, assessing the needs of older workers and prioritising resources will remain speculative.

1. Introduction

Today's workplaces must accommodate an ever-widening demographic age range. This necessity arises from generational longevity and the increasing burden that this places on pensions and related welfare and benefits. This need has coincided with a period of financial austerity within the UK that has led to increased pressures on most industrial sectors.

A significant literature is emerging regarding the role that older members of the workforce might play in the future. This Foresight initiative is capturing this evidence and working with experts to predict those changes that will arise as a result of an ageing demographic, and to use this knowledge to enhance changes and develop new ways of thinking that will benefit industry and individuals.

This review considers changes to the infrastructure of the workplace and the environment that may enable a larger number of people to successfully and productively remain in the workforce beyond traditional retirement ages. It also addresses the potential for enabling people to remain in employment while at the same time enduring common health ailments that affect an older demographic.

2. Workplace infrastructure

Understanding what is meant by the 'infrastructure' of the workplace varies according to the perspective taken. An architect may see it as the physical and the environmental space, a technologist may see it as the IT systems, while a sociologist may consider it to be the social networks and affordances given to opportunities for social interactions.

The professional discipline that deals with many of these perspectives (e.g. psychological, physiological and sociological) is ergonomic/human factors. This review will consider all research findings within the context of ergonomics/human factors but will provide a specific focus on the physical infrastructure and environment of work and workplaces.

An ergonomics approach is necessary as each element in a work system interacts with others in complex ways. These interactions affect the performance, behaviour and well-being of those working within it. To consider any one element in isolation is unlikely to be appropriate.

A useful model illustrating this perspective is shown in Figure 1.

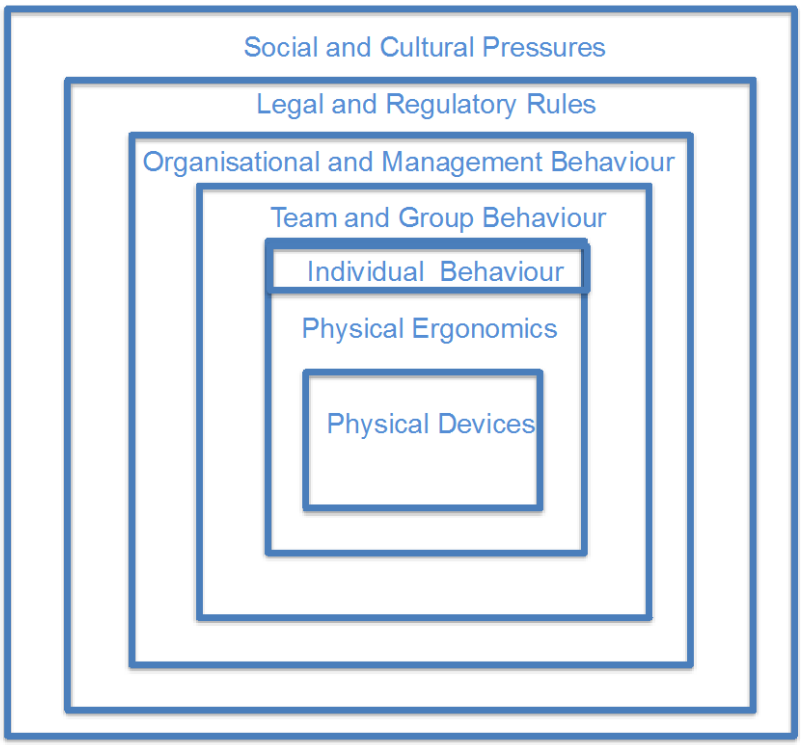

Figure 1: Ergonomics model (after Moray, 2000)

This model has been adapted from that first presented by Moray (2000). It is helpful because it readily identifies the complexity and potential interactions between many components within the system that might impact on the behaviour and well-being of the worker. For example, any dimension of the physical ergonomics of the workplace (e.g. lighting, sound levels) may interact with other workplace factors (e.g. teamworking) in ways that may differ according to individual characteristics. For example, an older worker with impaired hearing may need to be physically closer to hear what team colleagues are saying when in a noisy environment than in a quieter workplace. Failure to provide such an environment may compromise performance or safety and may also prove to be a

stressful environment in which to work. Indirectly it may lead to covert exclusion of older members of the workforce from such teams.

Interactions between these workplace system components are ubiquitous and a central feature of the discipline of ergonomics/human factors is to seek to understand these and design systems to minimise their adverse impact.

3. Methods

The agreed terms for this Evidence Review were:

- To consider what are the changes to workplace infrastructure and environment that will enable large numbers of people to successfully remain in the workforce for longer and to consider how this will evolve in 2025 and 2040.
- That the review should focus on the literature related to the built environment and technology infrastructure factors that play a part in enabling extended working lives.
- To consider the barriers that ageing workers face and how they can be overcome within certain timeframes.
- To consider a variety of workplaces, business sectors and organisational structures.

To enable this to happen this review has:

- Undertaken a review of the literature (research, policy and practice, including grey literature where readily available) to (i) describe the relevant historical drivers for change (past 25 years), and (ii) describe what is known about the current situation.
- Included literature that seeks to forecast future scenarios, within the parameters set out in the project brief.
- Identified and reviewed design-based initiatives that are seeking to address these challenges.
- Engaged with the design community with respect to 'future look' research.

Academic research literature has been searched through the following databases: Web of Science MEDLINE, PsycINFO, AMED, BNI, CINAHL, EMBASE, Health Business Elite and HMIC. Grey literature has been identified through desk-based research and through connections with professional bodies, academic authorities, voluntary and charitable organisations dealing with older workers, and international experts where appropriate.

The quantity/quality of evidence has been evaluated using traditional academic approaches, with peer-reviewed articles (e.g. journals, conferences) being given priority. However, the literature surrounding this topic is extensive and often of limited quality when critically examined. The time and resources available have limited the extent to which materials could be reviewed. Therefore, this is neither an exhaustive nor a systematic review of the conventional nature. Critical academic judgement has been used regarding the inclusion/exclusion of materials. This has applied in particular to the grey literature and other materials, notably in the design domain. Design literature was sourced through the Royal College of Art e-journal collection. The author believes that what has been presented is a fair representation of the current position relating to this broad topic.

4. Future demographics

2015: Predicting long-term changes in the workforce composition is generally acknowledged to be extremely difficult. While the statistical demographics of the whole population may be forecast with a reasonable degree of accuracy, the same is not true of the world of work. Changes in technology, globalisation of workforces, regional variations and international economic trends interact in a complex manner (Sinclair *et al*., 2013). Most of those that have attempted this challenge have restricted themselves to workforce changes over the next 10 years (i.e. to 2015).

In 2011, Age UK (Brooks *et al*., 2011) modelled the projected number of older workers in the UK and estimated their possible employment status. They found that there are likely to be over 1.5 million additional workers aged 50–64 by 2025 (Figure 2). Fifty per cent of older workers will have to work for at least 6 years past their State Pension Age (SPA) to maintain the same standard of living in retirement. This may increase further depending on longevity. Flynn (2014) indicates that most of the 1.5 million job growth over the next decade will be in work that is now female dominated (UK Commission for Employment and Skills, 2011), and that we will see further significant rises in older women's employment.

Projections are for a net increase of 3 million women aged 50–59 in the workforce, with an increase in the older male workforce of less than 1.9 million.

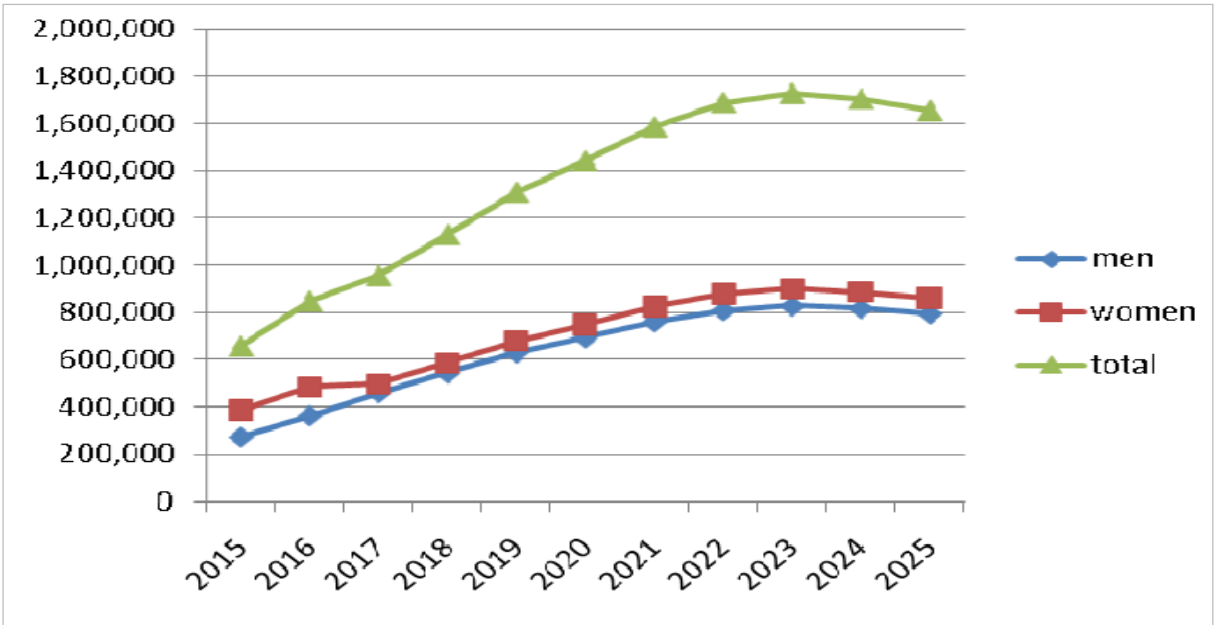

Figure 2: Total numbers of additional workers aged 50 to SPA 2015–25

2040: Speculation regarding the shape and nature of the workforce in 2040, and hence the needs of older workers with respect to infrastructure and technology, is clearly problematic. The nature of world trade, changes in technology and shifting labour forces generate endless scenarios.

What is more predictable is the shape of the ageing demographic and the costs to our society. According to accountants PWC, the 2013 Autumn Statement announced that someone in their 40s currently will not receive their state pension until they are aged 68; that someone starting work now will have to wait to age 72, and that a child born today is unlikely to receive their state pension until they reach 75. Figure 3 highlights these

forecasts and also demonstrates how the ageing demographic is likely to impact on the type of workforce needed to care for this shifting demographic. Thus the shape of the workforce may be partially determined by the demographic that will show increases in need for long-term care, health professionals and technology and infrastructure that protects and nurtures this ageing population.

Others, such as the Employers' Organisation (2004), have suggested that the percentage of disabled people in the workforce will increase as well. Thus infrastructure and technology will also need to embrace such changes. It is important that the ageing workforce and those with disabilities are both considered in new designs. An inclusive design approach is advocated as being one proven method for ensuring that this can happen. Mayhew (2000) has forecast that the number of people with disabilities will grow substantially, but will level out in developed countries by 2050 (earlier for all but the oldest age groups), while the number of people with disabilities in all age groups will continue to grow in less developed countries.

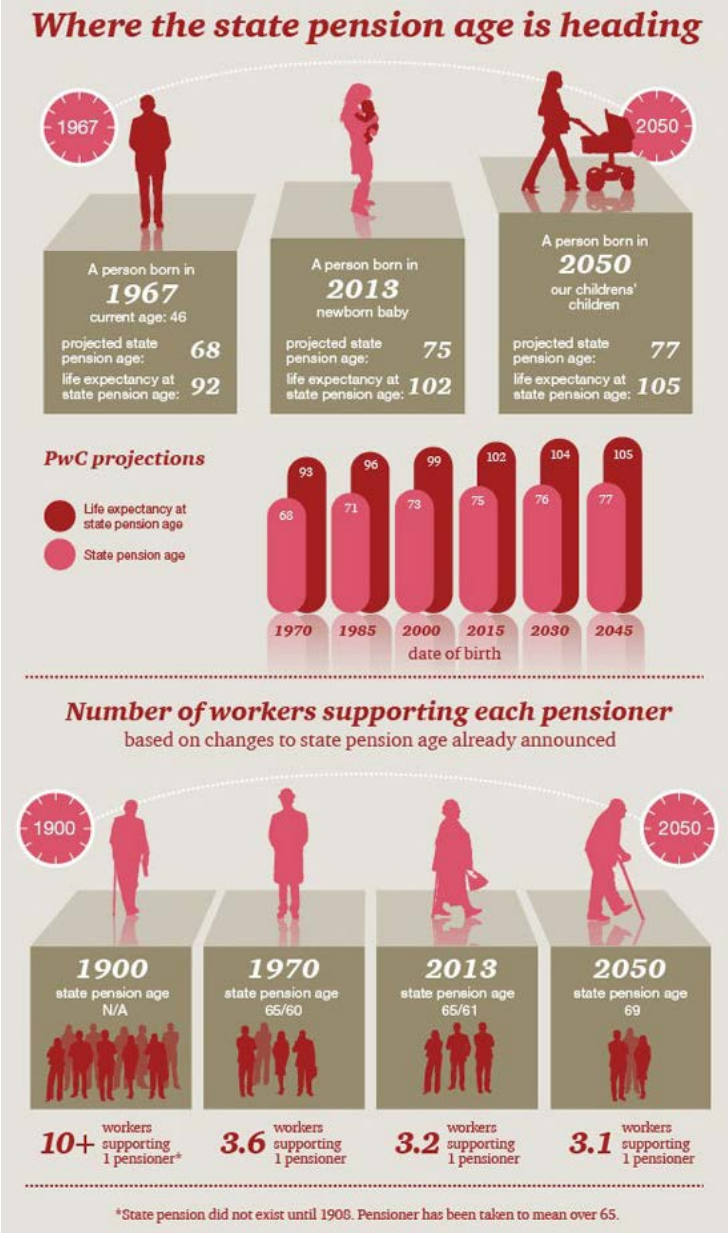

Figure 3: SPA predictions (PWC, 2014)

5. The drivers determining infrastructure and technological needs

5.1 Changing complexity of the demographics in an ageing workforce

The workforce is not homogenous and as a result there will be different needs for many groups. For example, as reported earlier, older females are more likely to be found in administrative roles than in transport and construction. Also, most of the job growth over the next decade will be in work that is currently female dominated, much of this associated with health and social care needs. Prioritising investment in the ageing workforce requires attention to such factors.

5.2 Ageing and individual changes

Age inevitably brings about an increased prevalence of physical change that can result in impaired workplace functioning. For example, deterioration of visual acuity and functioning in low light levels may begin in the mid-40s. Hearing loss is common in those over 60, making conversations and instructions harder to distinguish from background noise. Aerobic and cardiovascular functions decline with age, and recovery time following exertion increases. Musculoskeletal changes lead to reductions in muscle and grip strength, posture and balance (Parliamentary Office of Science and Technology, 2011).

These changes start to form the basis for those that take an inclusive design approach to the design of the physical workspace. This approach has been available to designers and others for some time but could be applied across the design world to benefit many more users (Coleman *et al*., 2007; Myerson, 2010; see also Cambridge University's www.inclusivedesigntoolkit.com/betterdesign2/).

Cognitive capacities may also change (Parliamentary Office of Science and Technology, 2011). Cognitive capacities such as working memory, adaptability to new tasks and problem-solving speed deteriorate after peaking in the 20s. The research regarding these changes has often been carried out under laboratory conditions with traditional experiments. Thus, although such changes may be significant, it is less clear what their impact may be in today's complex work systems. For example, older workers may adopt strategies that offset the need for very rapid responses under normal operating conditions. Therefore, it may only be under exceptional conditions that decrements in working memory or response time are evident. Even then, they may not be critical to successful and safe task completion.

However, ageing may bring other benefits. For example, verbal fluency, general knowledge and vocabulary do not seem to decline and may improve if exercised through work.

Much of the data and other evidence underpinning both physical and psychological changes have been derived from laboratory-based studies. Their validity when transferred to real work settings is likely to change. For example, speed error trade-off under laboratory conditions is unlikely to reflect the complex decision-making required in the modern workplace. Those with some form of chronic health condition or mobility issues are more likely to reside in less physical jobs. Sluiter (2006), in a major review of this topic, concludes that a body of evidence exists that can provide us with estimates of the rates of

ageing in specific systems within the body and of specific capacities. However, she also points out that the extent to which such indices correlate with workability is not available. This is an area where work design specialists must ensure better and safer work systems for older workers in the future. In any event, further research is required to help assess those jobs or tasks where the older worker may be at greater risk with respect to their own well-being or where they increase the risk to others in the system. Current guidance has little to support objective risk assessment of older workers, particularly those who must or choose to work beyond the age of 65.

Buckle *et al*. (2008a) reported that older workers were aware of changes in their physical and cognitive capacity, and felt that provision should be made for this. Current knowledge from laboratory-based findings on age-related changes probably does have relevance to the real world of work, and the implications of this need to be recognised by equipment and workplace designers. Examples of physical issues for older workers were particularly evident in the social care sectors. The provision of equipment to reduce manual handling loads is important. Older workers saw training as being most effective when undertaken in the appropriate setting, i.e. in the context in which it is used. In one sector studied (the cleaning workforce), the recent introduction and use of lightweight plastic vacuum cleaners and improved cleaning agents made a substantial difference to older cleaners, including lowering the risk of developing musculoskeletal disorders. The importance of such simple physical design changes should be recognised and shared.

The data reported here show that workers are aware of reduced and changed physical abilities, frequently described as becoming physically tired more quickly and generally slowing down at work. Sluiter (2006) identifies physical factors of potential importance in an ageing workforce. Physical exertion during work is a regular feature of many manual jobs and tasks. Age-related decline in measures such as cardiorespiratory fitness have been estimated and marked changes occur as age increases past 40. Some studies have also described similar age-related decline in functional reserve capacities of the heart and skeletal muscle (Kasch *et al*., 1995; Goldspink, 2005).

Nunez (2010) reports on the effect of age on health problems that affect paid work. Problems with the heart, blood and circulation, arms and hands, and legs and feet were strongly related to age. Women's health-related ability to participate in work was less affected by age, but they suffered particular problems with arms and hands, skin conditions, allergies and depression. Interestingly the study analyses the non-linear effects of unit increases in age. This may identify the ages at which ageing intensifies its effects on occupational health. Such findings should inform future design of work systems for an ageing demographic.

5.3 Age and obesity

Obesity is a significant problem in our current population and is the subject of much public health attention. The workplace is an area where improved design might help workers of all ages to address the challenge that obesity brings (Buckle and Buckle, 2011). However, there is little objective evidence of how design might help in this effort. Sitting behaviour and obesity have long been associated in 'lay thinking', but recent studies show that this idea may not hold true. Pulsford *et al*. (2013) report data based on a prospective cohort of office workers which show that sitting time was not associated with obesity during the study period. Even where 'prior obesity' was considered, it was solely associated with time spent watching TV per week, but not other types of sitting. The time period for study was 1997 to 2004, and it may be that work-related sitting times have increased over the last decade, but it is an interesting finding nonetheless. Based on current evidence, therefore,

reducing sitting time at work may not be as important a factor as is commonly held. Nevertheless, increasing obesity does alter job demands and worker capacity and this will impact on older members of the workforce disproportionately (Cavuoto and Nussbaum, 2014).

5.4 Workability of older workers

The 'workability' of older members of the workforce has been an area of significant research in Finland for many years (e.g. Ilmarinen *et al*., 2005). This research has led to a better understanding of how the changing physical and psychological factors may relate to ability within work systems. Many of these dimensions improve with age and hence provide ample opportunities to design work systems that reinforce and play to the strengths of older members of the workforce. Capturing these in design processes is a hugely important component of successful change.

Capturing these changes and their implications should also involve the workforce themselves. Co-design or participatory design is a very well-established method for enhanced user-centred design and evaluation of systems but is still too often ignored by organisations when commissioning new buildings, equipment and technology.

5.5 Management of an older workforce

The CIPD (www.cipd.co.uk) has developed a resource to aid with management of the changing workforce demographic. Age management (Ilmarinen *et al*., 2005; Ilmarinen, 2007) uses the concept of work ability. This was first constructed and defined in 1981 in a study of ageing employees. The conceptual definition was, "How good is the worker at present, in the near future, and how able is he or she to do his or her work with respect to the work demands, health and mental resources?" To measure the work ability, a method called the Work Ability Index (WAI) was developed and its validity tested by clinical examinations and follow-up studies.

This concept has now been translated into management styles and training. In some European countries this has been seen as beneficial to aiding the ageing working demographic and influencing work system design. By raising managerial awareness of the challenges an ageing workforce faces, there is a greater opportunity to then influence infrastructure and technology needs. That said, there is little evidence that this approach has been embraced by management in the UK. This omission seems strange and warrants further investigation. Any lack of awareness from management may minimise the likelihood of the need to create better environments for older workers and to invest in appropriate technology and infrastructure.

5.6 Support from unions

Unions are finding the challenges of dealing with an ageing workforce an area of potential contradiction. Flynn *et al*. (2013) have considered this within a European context and reflect the need to promote workplace policies that extend working life with the challenge of protecting routes to early retirement. Such conflicts may not always be in the best interests of changing the infrastructure within the work system. He recognises that: "Unions also need to use their organisational strength to push employers to revisit how they manage work in later life with a view towards promoting healthier and higher quality workplaces for older workers."

5.7 The role of small and medium enterprises

The CIPD (2014) has considered the role of small and medium enterprises (SMEs) and the ageing workforce. In a survey of approximately 600 SMEs they found good recognition of the skills that workers of different ages bring to small businesses. In particular, that an "age diverse workforce benefits a business with not only improved knowledge sharing, but that it also brings better problem-solving skills and a more enhanced customer service". Despite this they considered that small businesses could do more to attract, recruit and support workers of diverse ages. Very importantly, training older employees was seen as a good return on investment.

5.8 Self-employment

According to Brooks *et al*. (2011) the 50+ cohort has, at present, the highest rates of self-employment among all age groups. This trend seems likely to continue. Thus a strong focus on how self-employment might benefit older workers if better infrastructure can be provided is now required.

5.9 Changing nature of work and technological impact

Gratton (2011, 2014) describes the effect of 'hollowing out of work', where middle-skilled jobs are replaced by technology, leaving either low-end or high-end skills. This makes predicting the size of work sectors difficult, other than to note that older workers may be successful if they fall into the high-skill category but may be excluded from the low-skill end, as that is likely to be more physically demanding. Older workers will need to consider and then compete for jobs requiring human creativity and social intelligence, as these will not be replaced by technology (at least not in the near future). Frey and Berger (2014) report that up to 47% of US workers could be replaced by computer-driven technologies over the coming decades. The implications for older members of the workforce are likely to be significant.

The number of self-employed among the over-65s has increased by 140% since 2000 (Dellot, 2014). While this may provide freedom and autonomy for some, it also brings other pressures. The lack of organisational structure and support services may prove a challenge for older workers should health or other issues arise. For some the additional income may be a pension 'top up', but for many others this income is essential. It is very unclear how such changes will affect those who must work many years beyond the old SPA with chronic health issues, or how the workplace will accommodate this. The infrastructure needs have yet to be determined.

Schone (2009) considers how work practices and new technology impact on older/younger workforce members in Norway. Interestingly, they found a lack of evidence of age-biased effects of new technology and new work practices. This suggests that, in Norway at least, the labour market is fairly robust regarding technological- and organisational-induced changes in the labour market. Schone highlights union involvement and strong employment protection which may mean that, in response to technological or organisational change, retraining of workers already employed by the firm is the most realistic solution for employers. Coupling changes to new technology infrastructure with appropriate training may be a powerful way forward for employers to retain and fully use the experience of the older workforce.

Bertschek and Meyer (2010) provide evidence on whether the IT-enabled innovative activity of firms is affected by the age structure of the workforce. They report that the probability of realising process innovations is positively related to the IT intensity of the firms studied. Their report demonstrates that IT-specific training for older workers is conducive to the probability of such process innovation. They therefore suggest that older workers do not in general impede innovation capabilities, only those where older workers lack the appropriate IT skills. The implications for IT and equipment infrastructure would therefore seem to be that investing in the training of older members of the workforce will be both essential and worthwhile.

The same authors (Bertschek and Meyer, 2009) have previously reported empirical evidence on whether the IT-enabled labour productivity of firms is affected by the age structure of the workforce. They found workers older than 49 were not significantly less productive than prime age workers between 30 and 49. Older workers using a computer were more productive than older non-computer users and the percentage of older workers is not significantly related to productivity.

All of these studies would suggest that older workers can be soundly engaged in new technology or other innovative service and manufacturing infrastructures, providing employers value their skill/knowledge sets and afford them appropriate training.

It seems unlikely that the necessary decisions to secure new infrastructure will arise unless there is much greater awareness of both the need and the potential for such changes. Given the relatively limited evidence for quantified benefits there is now a need to invest and evaluative new ideas. For this to happen there will need to be conviction from ‘thought leaders’ in aspiring and innovative industries – it is recommended that such leaders are identified and engaged.

Buckle *et al*. (2008a) found that older workers recognise and, for the most part, accept their changing relationship with the world of work. This finding came from a qualitative study of 60 workers from four different sectors: retail, service sector (cleaning), manufacturing and social care, located across the UK. However, often those interviewed were not satisfied with the ways in which their experience and commitment was being recognised by others, nor by the support that they received from management.

While they generally accepted that their physical abilities, to some extent their cognitive skills, and in some cases patience, declined, they felt that these losses were compensated by knowledge and experience accumulated over a lifetime of work.

Buckle *et al*. (2008b) found many reasons for older workers to continue working. A main reason was financial, a finding endorsed by many others. However, work also provided a structure to life and important social networks. Reasons given for wanting to stop working included the negative attitudes of management, difficulties of communicating with senior management, and health-related issues. Long-term exposure to hazards such as heavy physical work, shift work, heat, dust and noise were cited as health-related issues. Regular health checks, provided by some firms, were viewed positively.

Workforces generally combine older and younger workers to form teams or co-functioning groups. Older workers may become reliant on younger workers to undertake more physically demanding tasks. This has been observed to lead to a culture where younger workers may believe they ‘carry’ older workers who earn more than they do, and older workers may believe that younger workers are unreliable and less skilled. With increasing numbers of older workers, this may be an important issue for work planning and allocation,

especially as there is the potential for serious intergenerational conflicts in the workplace. To some extent these problems can be overcome by better infrastructure such as equipment, designed to reduce the physical demands for those who undertake heavy manual tasks. Similarly, enhanced workplace design could support those in office-based roles (Buckle *et al*., 2008b).

This type of change would enable older workers to undertake a fuller range of tasks and help to ensure that younger workers are not subject to the work-induced health-related disorders that have affected today's older workers. New approaches to the allocation of work, especially the scheduling of shift work, would benefit all workers, not just older workers. Interestingly, many of the themes that emerged in this research (see Figure 4) do not reflect a need for changes in physical infrastructure. This may be because those interviewed did not see the possibility of these things changing. However, they do reflect issues relating to the physical load of work.

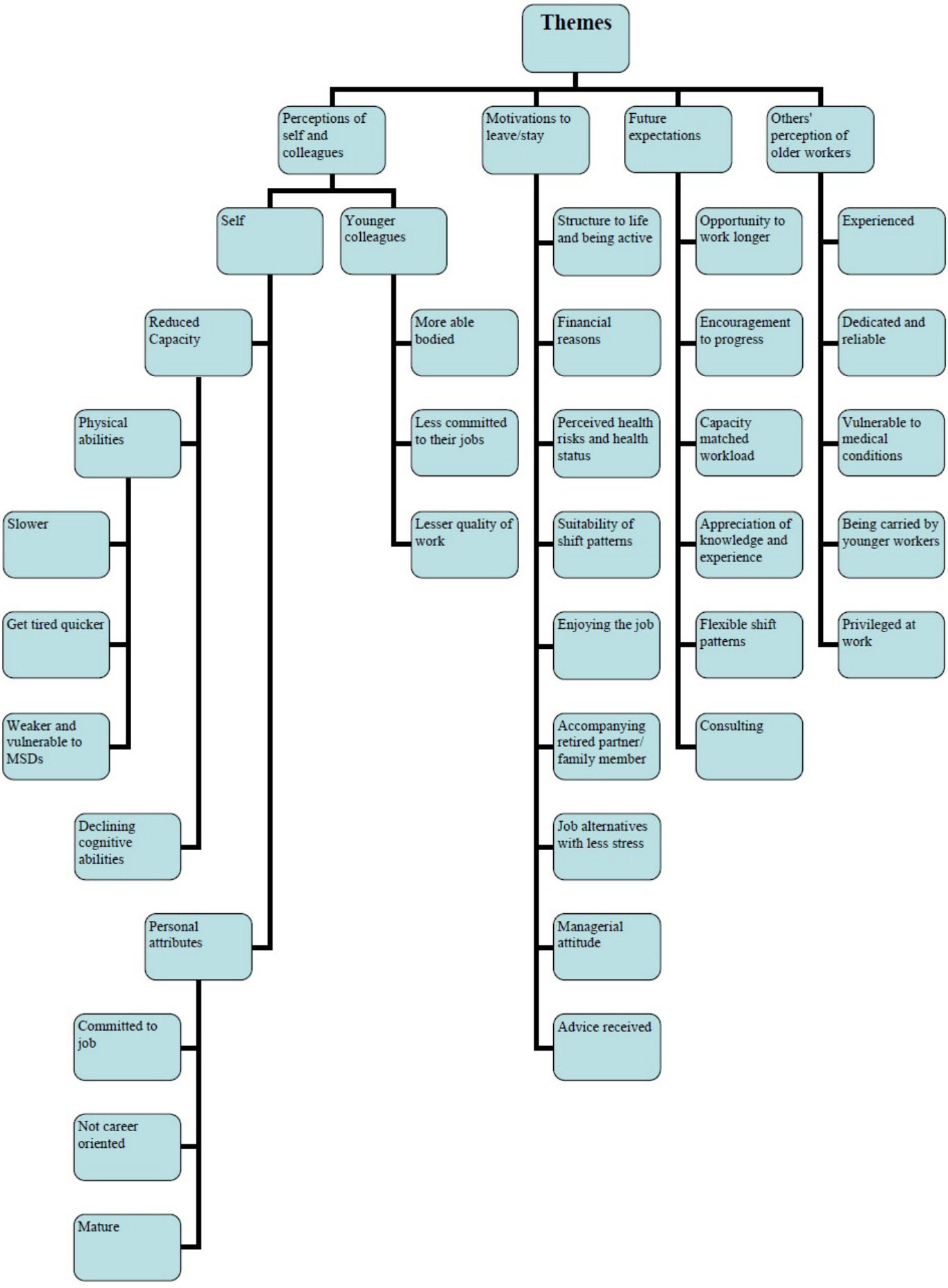

Figure 4: Themes from the study on ageing workers (Buckle *et al*., 2008b)

6. Industrial sectors and ageing

6.1 Trends across sectors

The distribution of the workforce across sectors is hugely diverse. Age is one factor among many that determines this spread. However, understanding these differences is important in predicting how and where the older workforce will be in the future. The Department for Work and Pensions (DWP) has undertaken a number of studies that can help with this. Table 1 shows the age group breakdown across the sectors.

Table 1: Numbers and proportions of workers by age group in nine sectors (Weyman *et al*., 2012)

Sector	Number of people (000s)					Percentages				
	18-24	25-49	50-64	65-69	18-69	18-24	28-49	50-64	66-69	18-69
Total population	*5,810*	*21,554*	*11,355*	*3,234*	*41,953*	*14%*	*51%*	*27%*	*8%*	*100%*
All employees	*3,081*	*14,992*	*6,031*	*401*	*24,505*	*13%*	*61%*	*25%*	*2%*	*100%*
Finance	*148*	*965*	*204*	*10*	*1,328*	*11%*	*73%*	*15%*	*1%*	*100%*
Construction	*177*	*762*	*312*	*21*	*1,273*	*14%*	*60%*	*25%*	*2%*	*100%*
Manufacturing	*219*	*1,623*	*749*	*38*	*26,828*	*8%*	*62%*	*28%*	*1%*	*100%*
Public Admins	*41*	*911*	*382*	*15*	*1,349*	*3%*	*68%*	*28%*	*1%*	*100%*
Health & Social care	*299*	*2,138*	*1,035*	*56*	*3,529*	*8%*	*61%*	*29%*	*2%*	*100%*
Hospitality	*443*	*700*	*175*	*17*	*1,335*	*33%*	*52%*	*13%*	*1%*	*100%*
Retail	*790*	*1,914*	*750*	*59*	*3,513*	*22%*	*54%*	*21%*	*2%*	*100%*
Education	*180*	*1,738*	*842*	*50*	*2,810*	*6%*	*62%*	*30%*	*2%*	*100%*
Transport	*70*	*636*	*308*	*21*	*1,035*	*7%*	*61%*	*30%*	*2%*	*100%*
Other sectors	*715*	*3,604*	*1,274*	*114*	*5,706*	*13%*	*63%*	*22%*	*2%*	*100%*
All workers (employees and self-employed people)	*3,258*	*17,227*	*7,443*	*614*	*28,543*	*11%*	*60%*	*26%*	*2%*	*100%*
Finance	*150*	*1043*	*267*	*18*	*1,478*	*10%*	*71%*	*18%*	*1%*	*100%*
Construction	*228*	*1,286*	*565*	*38*	*2,117*	*11%*	*61%*	*27%*	*2%*	*100%*
Manufacturing	*222*	*1,705*	*814*	*51*	*2,793*	*8%*	*61%*	*29%*	*2%*	*100%*
Public Admins	*41*	*921*	*391*	*19*	*1,371*	*3%*	*67%*	*28%*	*1%*	*100%*
Health & Social care	*304*	*2,288*	*1,135*	*67*	*3,795*	*8%*	*60%*	*30%*	*2%*	*100%*
Hospitality	*446*	*783*	*235*	*28*	*1,493*	*30%*	*52%*	*16%*	*2%*	*100%*
Retail	*807*	*2,119*	*892*	*82*	*3,900*	*21%*	*54%*	*23%*	*2%*	*100%*
Education	*192*	*1,830*	*917*	*61*	*3,000*	*6%*	*61%*	*31%*	*2%*	*100%*
Transport	*75*	*782*	*393*	*37*	*1,287*	*6%*	*61%*	*31%*	*3%*	*100%*
Other sectors	*792*	*4,470*	*1,834*	*213*	*7,309*	*11%*	*61%*	*25%*	*3%*	*100%*

6.2 Sectors for case studies

This variation has led to the need to identify a number of sectors for further review and to afford insights that may have wider implications. The criteria for selection have been

based on demographic trends, projections and consultation with experts to arrive at a professional judgement. The sectors selected are: manufacturing, health and social care, retail, construction and office/knowledge work.

6.2.1 Manufacturing

Despite the importance of manufacturing there has been little research into the impact of an ageing workforce or how infrastructure needs might have to change to accommodate this shifting demographic. The 'extending working life sector' initiative analysis (Weyman *et al*., 2012) has shown that almost a third of this workforce is aged over 50, representing at least 1.3 million workers. Almost half of these would prefer shorter hours than at present. While the reasons for this are not stated it is probable that the physical demands of such jobs are a significant factor. One recent review (Stedmon *et al*., 2012) has considered this sector in more depth. They have found that the general physical changes in the older workforce could be offset by increased mechanisation and automation. There is, however, a potential trade-off in such scenarios. This is because an increase in mechanisation and automation may result in higher cognitive and other psychological demands (e.g. isolation) on the workforce. The literature surrounding cognitive changes with age is harder to interpret and act upon as there is much individual variation and the changes may be subtle. Perceived 'workability' may be important in this regard, as demonstrated by a recent study (McGonagle *et al*., 2014), which found that job demands, along with health and sense of control, were most strongly related to work ability perceptions when perceived work ability was measured in a follow-up study of manufacturing workers.

Some organisations and manufacturing plants have started to address this challenge and it is important that others follow.

For example, BMW introduced 'Today for Tomorrow' to create a more age-diverse workforce (Anderson, 2013; see also BMW Group Age/Experience website, www.bmwgroup.com/e/0_0_www_bmwgroup_com/verantwortung/diversity_inclusion/erfahrung.html). This has included the implementation of over 70 small changes that improved the efficiency of an experimental production line (e.g. magnifying glasses, stretching station, wooden floors, and ergonomically designed standing chairs). Many of the changes came about as a result of employee input using a participatory or co-design approach. This initiative also plays to the strengths of older workers and in particular how they have "more patience and skill that comes from experience", and the extent to which an age-diverse workforce is "motivated, competent and highly effective" (https://hbr.org/2009/03/bmw-and-the-older-worker).

Others (e.g. Ng and Law, 2014) have found that older workers across a range of sectors use various strategies to adapt to a change in resources. These strategies help them cope and maintain their functioning in the workplace. These results were based on semi-structured interviews with 32 women and men aged between 55 and 64 in the healthcare and manufacturing industries, at both blue- and white-collar and professional occupational levels.

Databases now exist demonstrating how organisations are tackling the ageing workforce issue (e.g. the European Foundation for the Improvement of Living and Working Conditions [Eurofound]). However, the majority of the cases focus on redeployment and flexible working practices rather than more substantive infrastructure changes. A motor vehicle components manufacturer (see Eurofund, www.eurofound.europa.eu) specialising in agricultural and heavy goods vehicles has introduced changes to improve lighting in the

plant, through the introduction of high-quality low lighting. Another change was to ensure that every element of the workstation on the production line was at the same physical level. This reduced the physical demands on workers. This led to the removal of 74 forklift trucks from the plant, and their replacement with three low-level flatbed tow trucks to allow for easier movement of the manufactured items. Others (Fritzsche *et al*., 2014), when considering car manufacturing, showed that age was related to prolonged absenteeism and more mistakes in work planning, but not to overall performance, but that both ergonomics work design and mixed team composition may compensate age-related productivity risks in quality.

Landau *et al*. (2008) report a case study at 256 workstations on an assembly line for cars. The age of the assembly workers influenced the choice of workplace, with older workers being found mainly in jobs with a 'very favourable' expert rating compared with younger workers. They concluded that age and job strain were *not* independent. Despite these preferences older workers still complained of musculoskeletal symptoms, regardless of the lower demands imposed by their jobs. Head, neck and shoulder symptoms also occurred more frequently in older workers working under unfavourable conditions. These and similar studies all point to the need to design infrastructure and equipment to minimise the physical loads on older workers.

In some instances the drivers for change are coming from those providing companies with equipment. For example, customers of Atlas Copco Tools AB are starting to worry about the ageing of their assembly workers (Johannsson, 2011). Improvements to tool design, while feasible, are not considered to be the biggest problem. Rather, it is the awkward body postures, monotonous movements, heavy lifting and the high pace of work that are of greater concern. Awkward body postures, and the high pace of work and monotonous movements, present work system challenges that may need to be addressed through improved infrastructure and a more considered introduction of new technology. Technology often increases the pace and monotony of an assembly line, whereas a line that has a longer average unit production time may be preferable for older workers.

The American Society of Safety Engineers (see www.asse.org) suggests companies take various steps (see Table 2) to increase workplace safety for an ageing workforce.

Infrastructure initiatives in any sector would benefit from the use of a checklist such as this. It is suggested that a checklist/audit tool to aid architects and other designers regarding these issues is made widely available.

Table 2: Increase workplace safety for an ageing workforce (source: American Society of Safety Engineers, ASSE)

Increase workplace safety for an ageing workforce
• Improve illumination, add colour contrast. • Eliminate heavy lifts, elevated work from ladders and long reaches. • Design work floors and platforms with smooth and solid decking while still allowing some cushioning. • Reduce static standing time. • Remove clutter from control panels and computer screens and use large video displays. • Reduce noise levels. • Install chain actuators for valve hand wheels, damper levers or other similar control devices – this brings the control manipulation to ground level – helps reduce falls. • Install skid-resistant material for flooring and especially for stair treads – helps reduce falls. • Install shallow-angle stairways in place of ladders when space permits and where any daily elevated access is needed to complete a task – helps reduce falls. • Utilise hands-free volume-adjustable telephone equipment. • Increase task rotation, which will reduce the strain of repetitive motion. • Lower sound system pitches, such as on alarm systems, as they tend to be easier to hear. • Lengthen time requirements between steps in a task. • Increase the time allowed for making decisions. • Consider necessary reaction time when assigning older workers to tasks. • Provide opportunities for practice and time to develop task familiarity.

6.2.2 Construction

The 'extending working life sector' initiative analysis (Weyman *et al*., 2012) has shown that approximately 25% of this workforce is aged over 50, representing at least 600,000 workers.

Hengel *et al*. (2012) have found that in a large population of Dutch construction workers (*n* = 5803), older workers were more often able, but less willing, to continue working in their current profession until the age of 65. Construction workers were defined as painters, plumbers, welders, fitters, electricians, assemblers, repairmen, mechanics, bricklayers or carpenters. They concluded that not only physical job demands but also psychosocial job characteristics play a significant role in both the ability and willingness to continue working until the age of 65 in this sector. Interestingly, they did not seek to collect information regarding post-65 year old employment. From a health perspective they also showed that preventing musculoskeletal complaints might support the ability and willingness to continue working (see Figure 5). From a psychological well-being perspective they found that preventing emotional exhaustion is also relevant for the ability to continue working. Others (Jebens *et al*., 2014) have focused predominantly on the physiological changes in older construction workers and have concluded that the older workers are more exposed to overload than their younger colleagues because physiological capacity and muscle strength were lower in the older cohort. Boosting fitness in this group was seen as one

ameliorative measure. Providing adequate opportunity to do this might be part of a broader infrastructure strategy (e.g. gym membership, better facilities to encourage alternative forms of commuting such as cycling or walking, and improved nutritional provision).

Eaves *et al*. (2014) have undertaken in-depth interviews with construction workers aged from 18 to over 50. They were from a small maintenance facility, a medium-sized domestic new-build company and a large civil engineering company. Many of those interviewed were suffering with aches and pains, which many considered to be related to their job. Many of those located in the maintenance facility had moved from harsher, faster-paced industrial work to 'slower' maintenance work in an attempt to reduce health problems.

They encountered a range of low-cost ideas for change that showed a good level of knowledge, creativity and experience of the industry. These findings suggest that the use of a participatory (co-design) approach to enhance the design of the workplace is appropriate. Workplace environment and equipment can therefore influence the suitability of work within the construction industry (Williams *et al*., 2011). This in turn is likely to improve work ability (Ilmarinen, 2007). Such an approach has the added advantage of potentially improving the quality of working life for both younger and older workers.

McNair and Flynn (2006) have generated guidance for employers as to how best to manage an ageing construction workforce. In particular they have examined issues regarding such factors as using physical strength or length of experience or service as a selection criterion in the context of age discrimination. They have also briefly considered the need for reasonable adjustment to working practices under the then Disability Discrimination Act (note: since replaced by the Equality Act, 2010).

Figure 5: Paving slab handling device (source: TNO, Netherlands)

6.2.3 Nursing and care services

There is an extensive literature on the work demands of nursing personnel. Much of this focuses on the psychological and physical burden of their work. Thus, Stichler (2013) has reviewed the research data relating to the ageing nursing workforce. She has found that older nurses struggle with the heavy workloads, both physical and physiological. A recent review has found that long shift work (e.g. 12 hours) exacerbated age-related health and led to chronic fatigue and lack of sleep. Further research is required to evaluate the efficacy of changing such infrastructure conditions, in particular the need to consider how the physical load on nurses may be reduced through better physical infrastructure and especially equipment.

However, many of the issues encountered by nursing staff apply equally to care home workers. As the care sector is part of the health and social care sector, which will see a massive increase in demand over the next 30 years, it is a priority that the physical demands on workers within this sector are addressed. Failure to do so is likely to exclude many of the potentially skilled older workforces. Such a failure will not only have implications for the employability of older workers, but will also lead to increased numbers of older nursing and care staff with injuries. The evidence surrounding the prevalence of back pain and other musculoskeletal disorders continues to cause problems for workers, employers and patients. The cost of treating such injuries is also substantive. This is well recognised and is likely to become a barrier to those who might otherwise wish to stay in the sector/profession. For example, a recent Danish longitudinal study (Sejbaek *et al*., 2012) of 2444 eldercare workers found that physical strain of work and organisational approach/attitude were the most significant factors in determining early retirement intention.

The technology and equipment required to remove or reduce physical strain and load on nursing and care workers does exist (e.g. Figures 6 to 8). However we are still short of evidence that evaluates its efficacy in controlled trials for *older* staff. Such evidence is required prior to substantive investment in this aspect of infrastructure.

In another recent initiative in a care setting, it was found that the residents themselves might be of greater assistance in terms of reducing the physical demands on staff. For example, those helping with the open kitchens were encouraged to actively participate in the cooking process, thereby promoting independence and engagement while simultaneously reducing the physical strain on staff. More advice on better design of these facilities can be found at the Better Care Homes website (www.bettercarehomes.org).

Figure 6: Example of overhead tracking to reduce physical load on care staff

Figure 7: Hospital equipment to reduce physical loading on health and care staff

Figure 8: Hoists to reduce physical loading on health and care staff

6.2.4 Office-based knowledge workers and mobile workers

Sharples and Buckle (2015) have discussed the extent to which the work–life boundary is blurring. Nowhere is this more evident than among knowledge workers. Systems that enable remote working, distributed work systems and global working hours are now commonplace. The fuller social implications of this are still emerging. Interestingly, however, it is clear that for some sectors, social and economic factors are combining to enable networks to emerge that maintain physical connections between members of the workforce when it may have been predicted that 'remote working' would have been satisfactory. The emergent design community in the East End of London provides a recent example of this phenomenon, as do the biomedical sectors and 'big data' analytic companies that are co-locating in other parts of major cities. It may be helpful to understand how such physical co-locations are seen by older workers (i.e. as benefits or threats), as they may become significant new trends in urban industrial regeneration. The potential for enhancing these new initiatives to enable older workers to maintain their productivity may be considerable and at a time when such regeneration seems to be prevalent it is clearly an opportunity that should be seized. A study of 'if' and 'how' these communities are reaching out to older workers would provide important and welcome insights. These could be used to inform other initiatives where older workers might otherwise be excluded.

Myerson (2010) has argued that aspects of age-related physical and cognitive decline are partly a function of the working environment. Further, he suggests that workplace modifications can compensate for many changes and impairments associated with age.

While this may be intuitively obvious (e.g. better lighting, larger screen fonts, more adjustable furniture), there is little documented on how important such changes are, how great a change they might make to the performance of older workers, how desirable they are seen as by older workers, and how much they may influence the decisions of older workers with regard to staying in the workforce for longer. All of these factors, plus the potential 'return on investment' for an organisation, need further study.

An early, small study of US office administrators (Kupritz, 2001) found that age diversity does not appear to influence the overall types of design items, attributes and privacy features perceived to impact on work. It seems probable that good design for older workforce members is therefore likely to be good design for all. Thus the benefits of better design are likely to be universal and not necessarily limited to one demographic group.

The 'Welcoming Workplace' research initiative (Myerson, 2008) considered how office space might be designed for an ageing workforce. The study considered the guidance that might be required to accommodate changes in vision, hearing, physical ergonomics, cognition, and health and well-being likely to be important in an ageing workforce.

While there is an extremely limited evidence base assessing the actual *impact* of interventions in office design, there are a number of guidelines that can be presented and followed.

These are based on the changing needs and requirements of an older workforce. Much of this hinges on the need for flexible and adaptive workspace. In order to achieve good communication and enable innovative work communities it is important that the environment reflects the needs of older workers (Myerson, 2008).

In particular, there appears to be a need to have areas where tasks requiring analytical skills and concentration (i.e. the solo aspect of knowledge work) can be readily undertaken

by older workers. Myerson (2008, 2014) identifies that the need to provide space for contemplation and recuperation is also important. Examples of office space to provide such facilities are shown in Figures 9 to 12, taken from the Welcoming Workplace report (Myerson, 2008).

It is strongly recommended that evaluations of the efficacy of such changes be undertaken for older workforce members. Without such evidence it is hard to see why many organisations would follow this guidance. Recent studies of open-plan offices (Bodin Danielsson *et al*., 2014) found differences in the rate of sick leave between office types, depending on the number of people sharing workspace and the opportunity to exert personal control. Gender differences were also apparent, but age was not tested as a variable. The cumulative evidence suggests that traditional open-plan offices are less good for employee health and, given the needs of older workers, this may have a more pronounced effect on their performance and well-being than younger workers. This is because, according to DeCroon *et al*. (2005), working in open workplaces probably increases cognitive workload and worsens interpersonal relations; close distance between workstations intensifies cognitive workload and reduces privacy; and desk sharing improves communication.

Figure 9: Welcoming Workplace: guidance for architects and developers (see http://hhc.rca.ac.uk/welcomingworkplace/)

Figure 10: Welcoming Workplace: guidance for architects and developers

Figure 11: Welcoming Workplace: guidance for architects and developers

Figure 12: Welcoming Workplace: guidance for architects and developers

A recent report on flexible working in the public sector in Northern Ireland (Northern Ireland Assembly, 2014) reached the view that the focus should not be on homeworking but rather on selecting the appropriate remote working options and technologies. These might include options that suit a given job or team environment in meeting business needs:

- working from hub/satellite offices;
- working in virtual teams;
- using mobile devices;
- sharing office space.

They also recommend a coordinated extension of the work hub/satellite office network across the NI public sector. This would “enable a greater number and range of public servants to work remotely as applicable, with a view to realising the associated benefits, not least the work–life balance, environmental and economic benefits from reduced travel time.” Such an approach may well benefit older workers and enhance retention past the traditional retirement age. However, there is little objective evidence to back up such a supposition. Similarly, the suggestion of video conferencing rather than face-to-face meetings is presented yet there is little information that shows how effective such IT approaches to meetings are or how older workers perceive them.

The British Council of Offices (CABE, 2006) provides an interesting report into the impact of office design on business performance. The report states that “work environments designed for linear transaction processes are less appropriate than those that support knowledge transfer and connect communities of people and autonomous workers” and that “the implications of linking office design with business performance are so profound that innovation is as important in the conduct of research as in the ways that offices are developed, designed and managed”. The implications of this for an older workforce require prospective, evaluative research.

BT has investigated ‘flexi-working’, which may have important implications for an ageing workforce in this sector. The company states that two important factors have enabled it to introduce flexibility throughout the company: (i) the development of technology that means that individual workers can carry out their jobs at home or on the move, (ii) the establishment of trust in working relationships

(http://eurofound.europa.eu/observatories/eurwork/case-studies/attractive-workplace-for-all/bt-uk-towards-a-balanced-flexibility). Flexible working at BT entails a range of different practices including:

- compressed time – working the same hours but over fewer days, perhaps with some short and some long days;
- job sharing;
- accrual of hours (time banking) – building up hours to be taken off at particular times such as school holidays;
- annualised hours;
- flexitime;
- teleworking from home;
- limited working – special arrangements such as term-time working;
- time out – paid or unpaid leave of up to 2 years for education, personal development or recreation;
- freedom to work: employees agree to work to achieve set outcomes on the basis of quality assessments and in specific timescales, but with no set work pattern or location.

Each of these practices needs to be evaluated for 'desirability' by older members of the workforce. Equally, the infrastructure and technological requirements to support this need to be identified.

Sharit *et al*. (2009) consider older workers as teleworkers across a variety of US companies. The results presented a mixed picture regarding employability of older workers as teleworkers, and suggested that less experienced managers would be more resistant to hiring older people as teleworkers. This is despite the fact that research has shown that older people are willing to (and capable of) learning new technologies given adequate training and support. Training managers in 'age management' must be an integral part of any strategic plan to enhance the employment of older workers in this sector.

6.2.5 Retail

The International Labour Organization (ILO) highlighted in 2011 (ILO, 2011) that measures need to be taken to make the retail sector more attractive to older workers. Within a European context they considered that these measures needed to be developed and implemented by retail social partners in cooperation with policy-makers. They pointed to good practices that already exist in some public and private sector organisations. They identified areas such as training; development and promotion; flexible working practices; and ergonomics and job design as being topics that should be addressed.

Despite some well-publicised examples of the retail sector recognising the benefits of older workers (e.g. B&Q DIY/home stores) there is a remarkable paucity of research on the needs of older workers with regard to physical infrastructure or technology needs. This is strange given the importance of this sector.

In the UK, statistics from the labour force (see Table 3) show the size and importance of the retail workforce (e.g. sales and customer service occupations) and especially the numbers of older employees in this sector.

Table 3: UK retail occupations by age (source: UK labour force survey 2009)

Occupation	16-24	25-49	50+	Total
Managers and senior officials	42,858	336,255	129,693	508,806
Professional occupations	4,008	45,858	10,022	59,887
Associate professional and technical	20,653	78,525	26,017	125,195
Administrative and secretarial	35,666	76,620	38,837	151,123
Skilled trade occupations	15,425	54,330	28,460	98,215
Personal service occupations	775	3,045	723	4,543
Sales and customer service occupations	604,076	523,186	281,167	1,408,429
Process plants and machine operatives	11,778	50,607	34,343	96,728
Elementary occupations	130,327	138,259	77,196	345,781
Other	158	446	0	603
Total	**865,722**	**1,307,131**	**626,457**	**2,799,309**

Source: UK Labour Force Survey (annualised), 2009, as presented in Skillsmart Retail Analysis: The age of retail, op. cit.

The ILO (2011) states that: “Employment in physically demanding jobs or in jobs with difficult working conditions is a major cause of early labour-market exit among older workers. Physically demanding jobs include general physical activities, handling and moving objects, spending significant time standing, or having any highly physically demanding work. It may also include cramped workspaces, labour outdoors or exposure to contaminants, hazardous equipment or distracting or uncomfortable noise. While the retail working environment is considered generally less physically taxing than most, a number of the preceding elements are prevalent in that environment.”

Despite the authority of the ILO there is little objective research on the extent of these issues and the potential benefits of redesigning the physical infrastructure to accommodate the ageing demographic in the retail sector. However, among other physical characteristics, the future design of the physical infrastructure in retail settings will need to consider postural demands. Sitting and standing at work can form a large component of the working day in retail. While these postural demands have been considered by a number of authors, there has been little attention paid to the older worker and there is virtually no guidance for those past the traditional retirement age of 65. There is good scientific and epidemiological literature describing the potential health effects on the general working population related to both sitting and standing work postures. The literature does not discriminate well regarding the needs of older workers. However, we have a good understanding of both the pathology of these health effects and of their likelihood of occurrence among groups of people exposed to risk. The health effects considered include:

- *Chronic venous insufficiency:* These disorders affect the lower extremities and result from ineffective functioning of venous valves. The result is often oedema (or swelling through pooling of fluid) in the lower leg. Over time this can result in varicose veins. These may have pain associated with them, or more serious complications.
- *Musculoskeletal pain:* There are a number of studies that have considered the relationship between prolonged standing and musculoskeletal pain. Macfarlane *et al*. (1997) found that standing for more than 2 hours was associated with an increased risk of low back pain in workers (odds ratio 1.8 for men and 1.6 for women). This may also be interpreted as an 80% increase in risk for men and 60%

increase in risk for women. In another study, Messing and Kilbom (2001) found that 70% of workers who stood all day at work complained of low back pain at the end of the working day and 50% reported pain in their feet. A key coping strategy is the changing of posture, including sitting to standing and vice versa. Given that up to 30% of employees are likely to be suffering from some musculoskeletal pain at any one time, the provision of a physical environment and equipment that enables frequent postural changes would seem to be appropriate.

It is also evident from other research (see Tissot *et al*., 2005) that prolonged sitting may also carry increased risk for some disorders. Some studies have found that prolonged sitting increases the risk of low-back disorders, although others have failed to detect such a relationship. The evidence, as reviewed by others, is often considered inconclusive. This may be, in part, because such studies do not often take into account the tasks being performed when seated. Other research has shown that prolonged sitting may also lead to swelling of the lower extremities and foot discomfort. More recently, prolonged sitting has been associated with deep vein thrombosis (DVT) in those undertaking long-haul air travel.

The overview of health effects associated with prolonged standing shows that while absolute levels of risk are hard to establish, the biomechanical, physiological and epidemiological studies suggest increased risk for those working in jobs involving prolonged standing. There is some evidence that prolonged sitting can also carry increased risk for some musculoskeletal disorders (e.g. back pain) and that some aspects of biomechanical load (e.g. at the shoulder) may be reduced for some operators working at the retail checkout area if they stood. It is also evident that some dimensions of reach (the so-called reach envelope) are greater when standing (Sengupta and Das, 2000) than sitting. However, some caution must be attached to drawing health consequences from such findings as it may be that reaching further results in lifting loads further from the body, thus increasing the moment and the resultant biomechanical forces on, for example, the shoulder or spine.

Either standing or sitting *exclusively* may carry increased risk for a number of health issues. It would therefore seem prudent, based on current science, to avoid both prolonged standing and prolonged sitting by encouraging all workers to consider alternating between the two on a regular basis.

The ILO (2011) highlights the need to:

- eliminate heavy lifting or violent twisting movements; and
- provide beneficial lighting and seating.

It also suggests that for ageing workers experiencing physical decline, workplace modifications should be possible (e.g. changes in lighting levels to compensate for poor eyesight, changes to workstations to reduce bending and reaching). The need for participatory, inclusive design approaches is evident (see Figures 13 and 14).

Environmental studies of temperature have been carried out. Interestingly, Penzkofer *et al*. (2103) did not find age to be a significant factor in determining subjectively assessed stress and strain working in cold retail environments (chill and cold store). However, order-picking work in the cold, regardless of age, led to frequent complaints, especially in the upper part of the body, which were felt to be ‘quite strong’. Curiously, although physiological disadvantages are known with regards to heat generation for older workers, the cold sensations more frequently occurred in the younger order pickers. This may be due to some acclimatisation to the extreme cold.

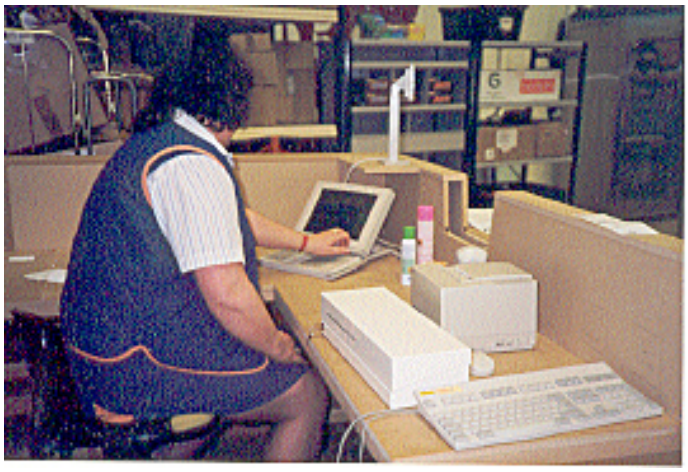

Figure 13: Participatory design in retail – fuel station checkout design showing user input during design development

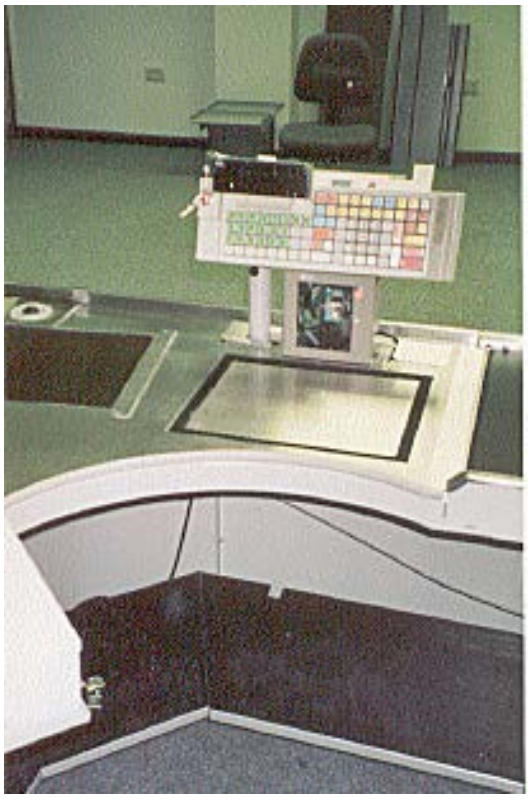

Figure 14: Participatory design in supermarket checkout design (note footrests and curved surfaces to provide easy reaches and comfortable seated work)

7. The future

7.1 Can we prioritise positive improvements based on the current evidence?

At one level the evidence base is poor, hence our ability to prioritise those infrastructure changes that may be desirable is limited. This challenge is exacerbated as the value of any such changes has rarely been assessed. Quite why such interventions are rarely assessed is hard to establish. It is probable, however, that difficulty in securing the necessary resources is a significant factor. The resources required are not simply financial. Undertaking effective evaluations of these multi-factor complex interventions poses many methodological challenges. Complexity (Craig *et al*., 2008) can be considered to comprise such elements as number of groups or organisational levels targeted by the intervention, number and variability of outcomes, number of interacting components within the intervention group and the control group, etc. In some domains, e.g. medicine, social change, public health (see Craig *et al*., 2008), these have been well documented. It seems probable that the explanation for the relative dearth of such evaluative studies encountered in this review lies with the lack of knowledge as to how to do these studies and, potentially, with a failure for the sector to recognise their importance and demand them.

It is also evident that sound and well-established methods for enhancing design are widely available and well accepted (e.g. co-design, participatory design) and a greater emphasis on how such approaches could be used in all sectors should be prioritised (see Wilson and Corlett, 2005; Myerson *et al*., 2010; Myerson, 2014).

7.2 Would changes in workplace infrastructure and environment act as incentives to remaining in the workforce? Are there examples/role models?

The current evidence has largely been restricted to organisational and administrative incentives and changes, for example shorter working hours, more flexible working times and changes in access to pension funds. While these are to be applauded, the evidence regarding the potential impact of enhancing training and technology for older workers while reducing physical and psychological strain seems, at best, patchy and for some sectors almost entirely absent. While some role models exist (e.g. BMW, B&Q), there is little to suggest that this approach is widely taken up by other large organisations. SMEs may be more embracing of this approach but there is little hard evidence to demonstrate its efficacy.

7.3 What would the likely short- and longer-term benefits of such changes be?

Sharpe (2011) comments on the relationship between ageing, health and productivity. The comments consider a number of papers and provide support for efforts to boost the employment rate of older persons, especially those aged 55–69. This, it is argued, will benefit both those working and society more generally, as it will increase tax revenues. However such benefits may be reduced significantly if the workplace itself increases the likelihood of workers developing health problems, especially if these are of a chronic

nature (e.g. musculoskeletal). This review has not found estimates of how such changes might impact on the socioeconomic costs of extending work life. A long-term 'future look' to inform the design of workplace infrastructure (e.g. technology) and environment based on the modelling of what might happen if work systems are not adapted is required (but is beyond the scope of this review).

7.4 What might the impact be on the well-being and stress of the older worker?

Bryson *et al*. (2014) have provided a recent government review on the relationship between worker well-being and work performance. Subjective well-being in the context of work is influenced by a number of factors, both personal and work-related. These are shown in Figure 15.

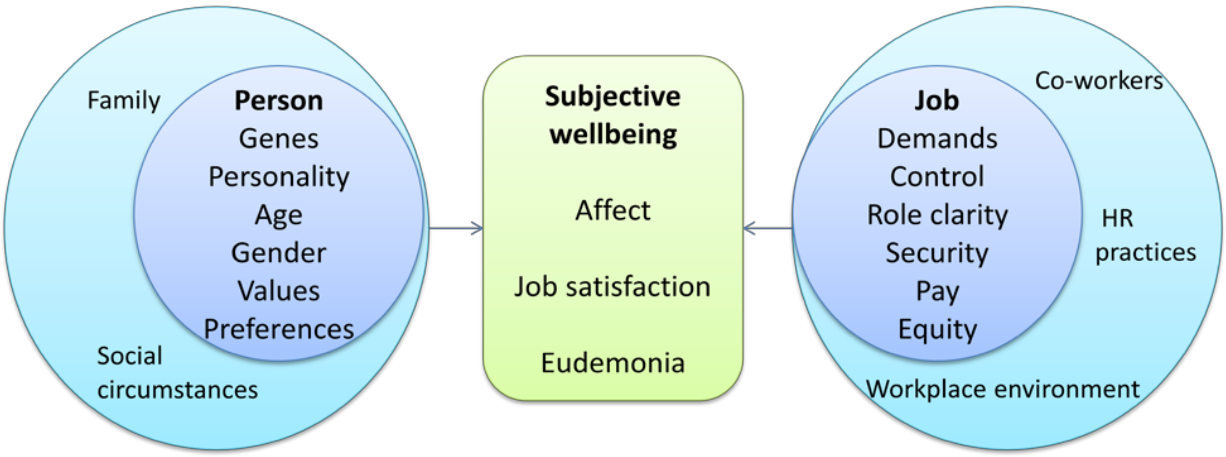

Figure 15: Subjective well-being and related factors

Their extensive review has found that subjective well-being tends to be higher when employees have (Bryson *et al*., 2014):

1. Autonomy over how they do their job and a measure of control in relation to the broader organisation, e.g. participation in decision-making.
2. Variety in their work.
3. Clarity over what is expected of them, including feedback on performance, e.g. via appraisals.
4. Opportunities to use and develop their skills, e.g. via the provision of training.
5. Supportive supervision.
6. Positive interpersonal contact with both managers and co-workers, but also with customers or the general public (where the job requires it).
7. A perception of fairness in the workplace, both in terms of how the employee is treated themselves but also how their co-workers are treated, with disciplinary and grievance procedures being one way for employers to address this.
8. Higher pay, although this relationship depends not only on the absolute level of pay but how this compares with pay of other workers.
9. Physical security, including the safety of work practices, the adequacy of equipment and the pleasantness of the work environment.
10. A sense of job security and clear career prospects.

11. A perception of significance, both in terms of the significance that the job has for the worker, and the perceived value of the job to society.

Factors such as work environment are included in this review but all factors listed are likely to interact and the relative contribution of each is therefore difficult to isolate within any given research study.

Age and subjective well-being has not been separately considered in this review. However, earlier studies have demonstrated that job satisfaction may be higher in older employees but much of the evidence available pre-dates the information technology society of 2015 and is therefore of only limited use in predicting future trends, i.e. 2025/2040.

Stress in the context of older workers has also been the subject of much research, some closely linked to the well-being agenda.

A review of current evidence by Griffiths *et al*. (2013) shows that while older workers report less stress and psychological ill health than workers in mid working life the relationship is potentially biased by a number of study factors. These include the problem of the healthy work effect and issues around how health is 'framed' by workers of different ages. It is known, however, that stress is often associated with early retirement. It has been well established from a large number of research studies that stress among older workers is related to the physical aspects of work, time pressures, shift work, lack of autonomy and flexibility in working arrangements, and inappropriate or poor line management and organisational culture. This is reflected in the main causes of stress (Sedlatschek, 2014), which are reported to general practitioners as: workload pressures (including scheduling, shift work and other organisational factors); interpersonal relationships (including difficulties with superiors and bullying or harassment); and changes at work (including reduction of resource or staff and additional responsibilities).

Age management emerges as an important factor in enhancing the likelihood of older workers staying in work. Longitudinal studies in Finland have consistently shown that management style and behaviour are strong predictors of who will remain in the workforce. Interestingly, leisure time physical activities also emerge as a predictor. It may be that maintaining physical and psychological health is a matter for both work and leisure infrastructures. These might be enhanced through better workplace provision for, and encouragement of, exercise and leisure. Sedlatschek (2014) reports an opinion poll (European Agency for Safety and Health at Work, 2013) which shows that while the UK is doing better than many EU countries, with two-thirds of workers (65%) saying that work-related stress is controlled well at their workplace, half of the UK participants believe that older workers (aged 60 and over) are less able to adapt to changes at work than other workers. She further reports that across Europe, 4 in 10 workers believed that older workers tend to suffer more from work-related stress than other workers. Management will need to be well informed to tackle such beliefs and recognise the skills and experience of the older worker.

7.5 Where do we need more evidence?

There appears to be remarkably limited evidence from appropriately designed intervention studies that changing the infrastructure will enhance the well-being, the performance or increase the working life of older workers. This seems to hold true across most sectors

considered in this review. It seems surprising that such a potentially productive area of investigation has not been the subject of better studies.

The robust evaluation of such interventions is therefore required. Particularly welcomed would be interventions based on co-design projects that engage directly with the needs of older members of the workforce.

Currently the design of, for example, office environments has little post-occupancy evaluation to support their stated goals of enhanced workspaces. More specifically this review has found a dearth of studies that have embraced this evaluation with specific focus on the ageing workforce.

In some areas, for example workplace injuries and illness, the research is more substantive. In one review, Silverstein (2008) found that older workers have more serious, but less frequent, workplace injuries and illnesses than younger ones. He also identified that there is evidence that many of these problems can be prevented and their consequences reduced by anticipating the physical and cognitive changes of age. Other areas of research (e.g. considering the performance of older workers at work) might utilise the methods used by health researchers to better quantify the impact of any infrastructure or technological intervention.

The principles required to improve infrastructure *must* include the need to make and test adjustments in the infrastructure that includes the physical work environment, the psychosocial work environment, worker skills, work organisation and age management. This review has demonstrated the connectivity between these factors. It seems likely that *all* of these must be addressed and that attention to the physical infrastructure or technology infrastructure alone will not be sufficient for tomorrow's ageing workforce, whether that be in 10 or 25 years' time.

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Web resources

Age UK

www.ageuk.org.uk/professional-resources-home/knowledge-hub-evidence-statistics/debates-on-ageing/digital-technology/

Aging Workforce News

www.agingworkforcenews.com

Better Care Homes

www.bettercarehomes.org

Chartered Institute of Personnel and Development (CIPD)

www.cipd.co.uk

Eurofund (European Foundation for the Improvement of Living and Working Conditions)

(i) Health and well-being case studies:

http://eurofound.europa.eu/observatories/eurwork/case-studies/ageing-workforce/denso-manufacturing-united-kingdom-health-and-well-being

(ii) Ageing workforce case studies:

http://eurofound.europa.eu/observatories/eurwork/case-studies/ageing-workforce

Government of Canada: Age-Friendly Workplaces: Promoting older worker participation

www.seniors.gc.ca/eng/working/fptf/promoting.shtml

Inclusive Design Toolkit (Cambridge University)

www.inclusivedesigntoolkit.com/betterdesign2/

Office National Statistics (ONS) Older Workers 2012

www.ons.gov.uk/ons/rel/lmac/older-workers-in-the-labour-market/2012/video-summary.html

PWC Sate Pension age predictions

www.pwc.co.uk/pensions/issues/state-pension-age-predictions.jhtml

TNO

(i) Healthy working:

www.tno.nl/nl/aandachtsgebieden/gezond-leven/prevention-work-health/innovaties-voor-gezond-en-veilig-werken/

(ii) Roof panel vacuum lifter

www.youtube.com/watch?v=2QPJ0zJjn4c&feature=youtu.be

(iii) Tools to encourage movement and changes of posture

http://tools.nisb.nl/beweegmomentjes.html

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GS/15/4