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School of Mechanical Engineering

Master of Science in Mechanical Engineering

Master of Science Thesis

Employment of Ageing Workforce and the effect of Smart Manufacturing, Industry 4.0 and Decision Support Systems

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Erman Olcay Akay and Semih Salih Karataş

Table of Contents

List of Figures

List of Tables

Abstract

A significant demographic change has taken place around the globe during the last decades. There is a remarkable increase in life expectancy such that in 2020 the life expectancy for both sexes was 72.3 years, which is expected to become 76.8 years in 2050 (UnitedNations, 2020). As this aging phenomenon has major impacts on both society and economy, it also poses an important challenge: the proportion of the older people is gradually growing in the workforce while the younger people are diminishing. There is also the factor of 5% growth rate of overall workforce compared to the 55% growth rate of +65 aged workers which indicates that by 2024 we will face with older workers than younger ones. This has led to the ageing workforce in organizations. However, most of the organizations are not aware of this issue fully. Therefore it has been a critical concern to develop adjustments, policies and take safety measures in order to create a safe and healthy environment for older workers while maintaining their productivity and paying attention to their needs in the concept of Occupational Safety and Health. The main purpose of this thesis is to raise an awareness of ageing workforce associated with the role of employers and organizations, the effect of industry 4.0 and new technologies on the employment of ageing workforce.

Keywords: ageing workforce, occupational safety and health, industry 4.0, smart manufacturing, ergonomics

Introduction

The median age of the total population in 2020 is 30.9 while it is predicted that in 2050 the median age will become 36.2 in the world (UnitedNations, 2020). Ageing workforce is a direct implication of the ageing population phenomenon. World health organization defines older adults as 65+ aged individuals (Farivar, Abouzahra, & Ghasemaghaei, 2020) but as working-class 55+ aged people are considered older workers (Silverstein, 2008). Although the older workers have some advantages over younger workers in case of skills, experience, and dedication to work and age related intellectual, they are at risk regarding the health problems, long term sickness absence and also showing decline in physical strength and cognitive processing. These declines negatively change the tolerance of older people to certain environments, physical loads, and learning, reacting, attention capacities. Understanding the differences between older and younger workers needs is crucial to find methods and technologies that may be helpful for older workers to maintain high performance. Those factors directly affect the operational performance of the worker, which in turn may introduce a reduction in productivity and higher costs for the organization.

Those aspects indicated the importance and the need for the Occupational Safety and Health which is science of anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment according to the International Occupational Hygiene Association. The higher experience and lower capabilities that older people have may affect the injury rates and severity of the injuries. Nature of the injury is important to adjust the work environment to meet the needs of older employees.

Knowing the intention of older people to work longer and their contribution, the organizations has to take into account the sustainable development and sustainable employment of ageing workforce. The workplace innovation play a crucial role here, which can defined as the implementation of new and combined interventions or measures in the fields of work organization, human resource management and supportive technologies (Pot, 2011). The workers should be provided with safe working environments where they are assigned tasks according to their work ability index and where they work with satisfaction and emotion. It is also essential that the organizations and the employers are willing to hear and evaluate the needs of ageing workforce, introduce training programs, introduce safety measures and adjustments, provide assistive technologies to help older workers to cope with work better.

Last decade, it has been witnessed that there is a transition from traditional manufacturing to automation and modern smart technologies with the fourth industrial revolution in which smart manufacturing systems will combine digital production, network communications, computer technologies and automation (Piatkowski, 2020). The workforce is going to be replaced by robots, artificial intelligence by automation of work activities. Those new technologies are going to expect new requirements from workers in case of knowledge and skill. This situation is forcing the organizations implement these new technologies corresponding to secure human resources, and also employees to adopt lifelong learning and improve their skills to stay relevant with their jobs. The role of ageing workforce in Industry 4.0 is going to be crucial for their future employment.

This thesis aims to deepen our understanding on the concept of ageing workforce, the role of organization on the sustainable development of ageing workforce with OSH and the future place of ageing workforce in Industry 4.0 and digitalization.

Based on these objectives, the main research questions of this thesis are:

1. Why employment and continuation to work of ageing workforce is needed?

2. What are the declined capabilities of the ageing workforce?

3. What are the methods to reduce the effects of declined capabilities?

4. What are the future expectations from older workers due to forth industrial revolution?

5. What is the role of Industry 4.0, Smart working and digitalization on ageing workforce?

Methodology

The objective of this thesis is to investigate and find solutions for employment and continuity of ageing workforce with the help of decision support systems (DSS), industry 4.0 and smart manufacturing. The existing literature must be examined scientifically in order to draw more general conclusion about the topic by using the individual studies. The best way is to use systematic literature review, which is, "a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest." (Kitchenham, 2004)This method is best suited to understand the relation of ageing workforce and the assisting technologies. To keep the review scientific and reliable three principles must be ensured systematic, transparent, and reproducible (Tranfield, Denyer, & Smart, 2003).

There are five stages for conducting a systematic review according to Kitchenham;

1. Identification of research
2. Selection of primary studies
3. Study quality assessment
4. Data extraction & monitoring
5. Data synthesis

Reporting the review follows after completing the five stages.

Guiding questions

1. Why employment and continuation to work of ageing workforce is needed?

2. What are the declined capabilities of the ageing workforce?

3. What are the methods to reduce the effects of declined capabilities?

4. What are the future expectations from older workers due to fourth industrial revolution?

5. What is the role of Industry 4.0, Smart working and digitalization on ageing workforce?

Stage 1: Identification of research

In this thesis Scopus is used as online search engine for the systematic literature review, it is an easy access and largest online database for scientific articles, books and journals.

Keyword selection is the most crucial part to reach all the available data that are relevant with the topic. It's been decided to conduct one single research query to include the all the combinations of keywords. When the keyword combinations divided in separate query search it's been seen that the relevancy of the documents diminish since the topic becomes too broad. The two main keywords are "ageing" and "workforce"; it is set that in all of the papers these words are included. These two keywords are broad inside their own group and only using these two would limit the review. To not exclude or miss useful information these two keywords are branched inside each other. Branching the "ageing" included four different keywords, (1)"aging", (2)"ageing", (3)"old*" and (4)"disabl*".

The keyword “disabled” is added to the list because with the initial review showed that some of the assisting technologies that are helpful for disabled workers might be also helpful for aged workers since with age the physical and cognitive measures decline. The branching of “workforce” included six new keywords, (1)”worker*”, (2)”workforce”, (3)”personnel”, (4)”manpower”, (5)”employ*”, (6)”human”. Inside the group these keywords are connected with Boolean search operator “OR” showing the papers that include at least one of the keywords. The keyword groups connected with “AND” in order to have at least one keyword from each group. The keywords that included the

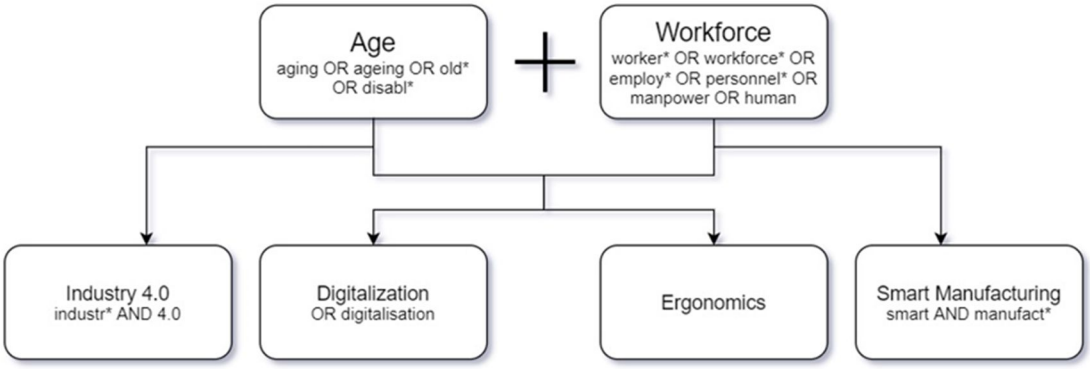

Figure 1 Figure that shows the relation of research keywords

assistive technologies interested were added to the query by “AND” and “OR” in between each other to ensure at least one of them are included. These keywords are, “industry 4.0”, “digitalisation”, “digitalization”, “age-product”, “ergonomic”, “smart manufacturing”. The figure below shows the interaction of the keywords.

The search query was formed by the combination of the keywords to complete the process. The total search query was:

TITLE-ABS-KEY(aging OR ageing OR old OR disabl*) AND ((industr* AND 4.0) OR digitalisation OR ergonomic* OR age-product* OR digitalization OR (smart AND manufact*)) AND (worker* OR workforce OR employ* OR personnel OR manpower OR human)*

The initial research from Scopus resulted in +18000 papers. These papers are considered for the preliminary phase of the review.

Stage 2: Selection of primary studies

In the previous section Scopus found all the papers that the keyword combinations are present but not all the papers are related with the topic. To find the related papers inclusion and exclusion criteria are used. Two inclusion steps used and one exclusion step.

Initial inclusion:

- Studies must be directly related to the topic “Ageing Workforce” (applied in step 1)
- Studies must include at least one of the related topic “Industry 4.0”, “Digitalization”, “Ergonomics”, “Smart Manufacturing” (applied in step 1)

- Studies must be available in full text and free
- Studies language must be English
- There is no limitation on publication year
- The studies type must be Journals, Articles and Reviews.

Inclusion of subject areas interested:

- Psychology
- Business, Management and Accounting
- Engineering
- Economics, Econometrics and Finance
- Decision Sciences
- Social Sciences
- Health Professions

After the two steps of inclusion the amount of studies reduced from +18000 to 6404 papers in total. After the inclusion steps the exclusion step followed. The keywords that are not related with the topic were excluded

Exclusion of keywords:

- Child
- clinical article
- traffic accident
- sex difference
- sex factors
- preschool child
- children
- school child

After the only exclusion step the amounts of papers reduced from 6404 to 5223. This was still a high amount of papers. While doing the abstract screening we noticed that after the initial 200 pages the abstracts become much less relevant so we limited our research to the initial 200 pages for abstract screening.

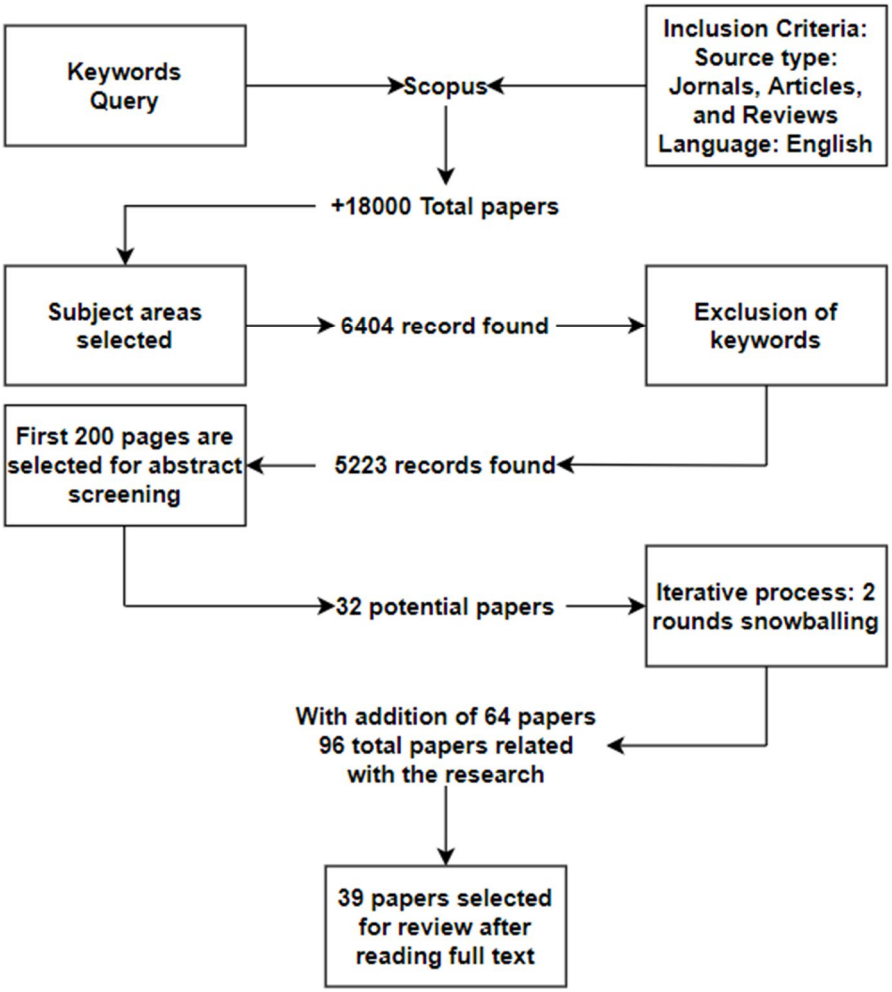

Figure 2 Process flow of the systematic literature review

The systematic literature review process conducted in 5 steps. The first step was the keyword identification and first inclusion criteria. Papers that are English, type that articles, journals and reviews, that are full text and free are selected and resulted in +18000 papers.

In the second step the second inclusion criteria applied including only the subject areas, “Psychology ”, “Business, Management and Accounting”, “Engineering”, “Economics, Econometrics and Finance”, “Decision Sciences”, “Social Sciences”, “Health Professions” which resulted in 6404 papers.

In the third step the exclusion of keywords that are not related with the topic applied. The keywords eliminated are, child, clinical article, traffic accident, sex difference, sex factors, preschool child, child, children, school child. The number of papers reduced to 5223.

The fourth step was abstract screening. We noticed that the abstracts after the initial 200 pages of the research become significantly unrelated so we limited the research to the initial 200 pages. The abstracts of the papers in the initial 200 pages screened and resulted in 32 related papers for iterative process.

	Framework Element	Explanation
Descriptive information	Source	Scopus
	Keyword combinations	For tracking relationship between studies and keyword combinations
	Authors	Descriptive information for citation
	Title	Descriptive information for citation
	Abstract	Inclusion/Exclusion criteria
	Document Type	Descriptive information for citation
	Source title	Descriptive information for citation
	Year	Descriptive information for citation

Table 1 Framework descriptive information

The last step is the iterative process which is snowballing. 64 papers were found that referred or cited the 32 papers that was found in the fourth step and are related with the topic. This makes 96 total papers for full text reading. After reading full text of 96 papers repetitive and unavailable articles are eliminated leaving 39 papers were identified as core papers of this thesis. Additionally demographics from United Nations website are used to give quantitative data about world population. Two articles outside of the research are used to understand procedures of methodology; these are (Tranfield, Denyer, & Smart, 2003) and (Kitchenham, 2004).

Stage 3: Study quality assessment

The review must include only scientifically valid studies, thus they must be ensured. Inclusion and exclusion criteria ensured that the studies are relevant with the topic of the thesis and only scientific articles, journals and reviews are included. Then abstract screening made sure that the papers are relevant and valid. The studies will be deeply analyzed in the later stages.

Stage 4: Data extraction & monitoring

The thesis conducts a single-step, analyzing the studies and answering the whole guiding questions. Hence, a single framework was developed in order to keep data for the one-step approach: Final Review Framework.

Final Review Framework

This analysis aims to define the key concepts of studies in order to provide a broad insight into the aging workforce, meanwhile focusing on the role of industry 4.0, smart manufacturing, digitalization in aging workforce and also how the assistive technologies may help/compensate the aging workforce. It spans descriptive information about each study: source, keyword combinations, authors, tittle, abstract, document type, source title, etc. Besides the descriptive information, it includes information related to research methodology, theoretical/empirical, qualitative/

quantitative, data gathering method, project scope, Ageing Workforce topic, Industry 4.0, Smart Manufacturing, and Digitalization, guiding questions and so on.

Methodology	Research Methodology	Case study
	Theoretical/Empirical	Study type
	Qualitative/ Quantitative	Data type
	Data gathering method	Literature review
	Literature review	Did study follow literature review?
	Literature review area	On which area was literature review conducted?
	Document analysis	Which documents were used for data gathering
Overview	Ageing Workforce Topic	As they are defined on the framework
	Project sector	Production Sector
	Project Scope	
	Case overview	General description of case

Table 2 Framework

Findings

Descriptive Analysis of the Studies

After the inclusion and exclusion criteria, 96 papers are determined for reviewing the full text. After full text reviews 40 papers and website is selected in the purpose of extracting data. In this part, some descriptive analysis is performed for overview of literature in terms of publications year, research method and subtopics.

1 Publications by research methods

As indicated below in the Table 3, two types of research methodologies were applied in research papers related to ageing workforce: literature review and survey. There is a close trend in preference of survey and literature review concerning the ageing workforce. Table 3 shows the types of research methodologies sorted by year it is published.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
L	1	0	0	0	0	0	0	1	0	0	2	0	1	1	0	0	2	1	0	0	2	1	0	0	0	5
S	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	2	1	1	0	1	3	0	2	9

Table 3 Research Methodologies

L: Literature Review (42.5%) S: Survey (57.5%)

The Figure 3 indicated below provides visual perspective for the distribution of research methodologies into the years.

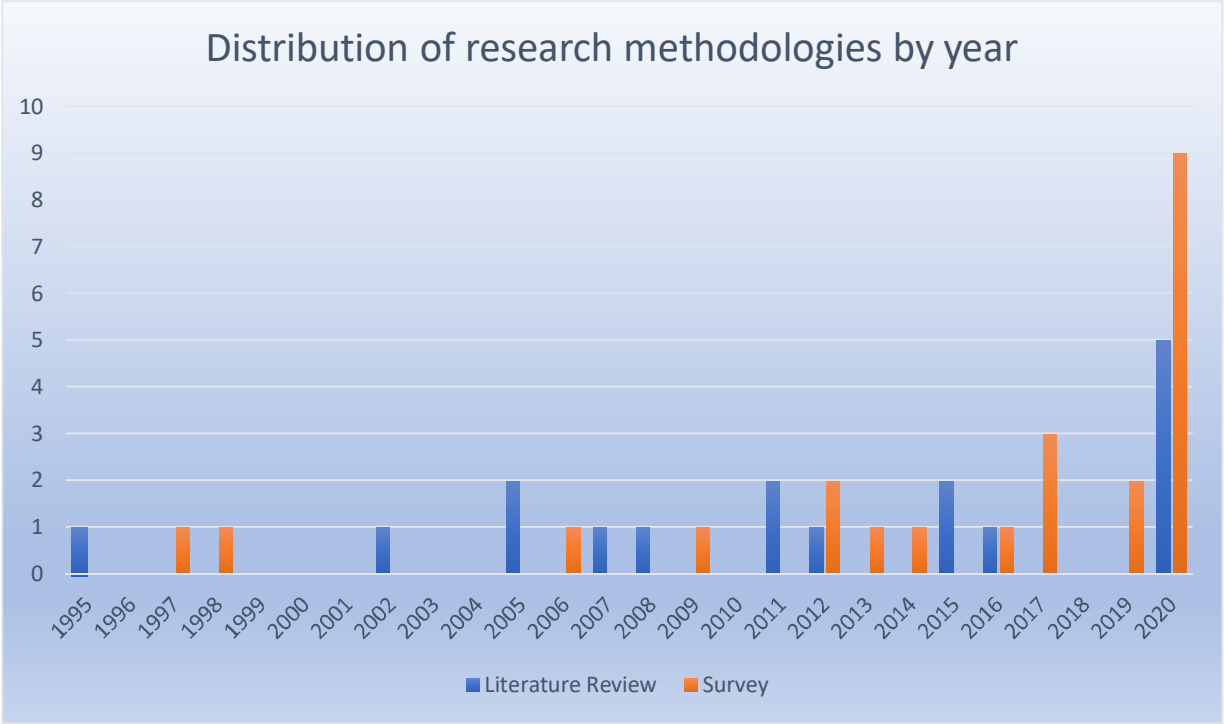

Figure 3 Distribution of research methodologies by year

2 Publications by journal title

The distributions of the number of articles corresponding to journal title are represented in Table 4. 40 articles are used from 31 different journals. The most common journal is Safety Science with 4 articles. It is followed by Applied Ergonomics and Ergonomics.

	Journal	Number of Articles
1	Safety Science	4
2	Applied Ergonomics	3
5	Ergonomics	3
3	Scandinavian Journal of Work, Environment & Health	2
4	Journal of Occupational Rehabilitation	2
6	World Congress on Safety and Health at Work	1
7	Work, Aging and Retirement	1
8	The 'new' older worker	1
9	The International Journal of Human Resource Management	1
10	Technology in Society	1
11	sustainability	1
12	Springer Science+Business Media	1
13	PROCEEDINGS of the HUMAN FACTORS and ERGONOMICS SOCIETY 56th ANNUAL MEETING	1
14	Policy and Practice in Health and Safety	1
15	Occupational Medicine	1
16	National Institutes Of Health	1
17	Management commitment and occupational health	1
18	Journal of Occupational Health Psychology	1
19	International Journal of Productivity and Performance Management	1
20	International Journal of Production Research	1
21	International Journal of Organisational Behaviour	1
22	International Journal of Information Management	1
23	International Congress Series	1
24	Human Resource Management Review	1
25	European Journal of Ageing	1
26	Engineering Science and Technology, an International Journal	1
27	Department of Economic and Social Affairs Population Dynamics	1
28	Corporate Environmental Strategy	1
29	Australasian Journal of Educational Technology	1
30	American Psychologist	1
31	AMERICAN JOURNAL OF INDUSTRIAL MEDICINE	1
	Total	40

Table 4 publications by journal

3 Publications by year

An overview of distribution of journals, articles and reviews are represented in the Figure 4 below. The studies are distributed in the period between 1995 and 2020. It is quite obvious that there is a significant increase in the number of publications in the last year, corresponding to almost 50 percent of studies. This proves that the significance of ageing workforce has expanded in the recent years and the ageing workforce is a growing research area.

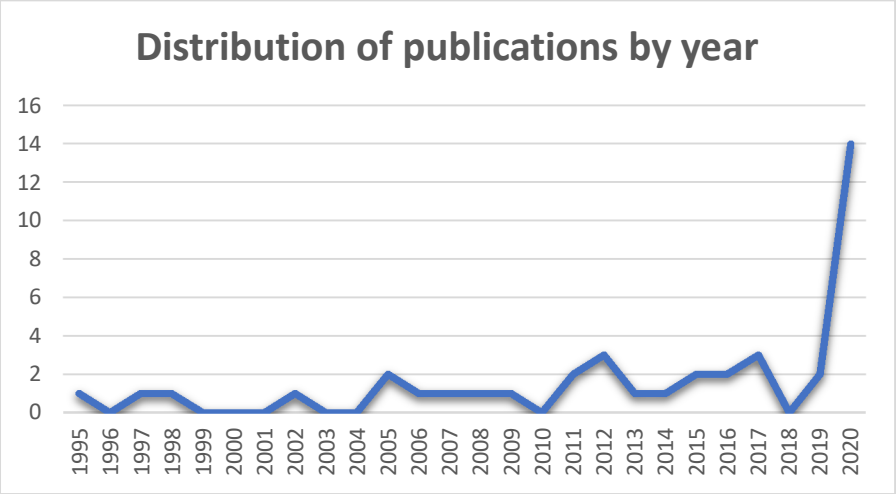

Figure 4 Distribution of publications by year

4 Publications by ageing workforce topic

Those 40 studies, each focuses on a different aspect of ageing workforce, such that some emphasizes the importance of occupational health and safety at the workplace, some mentions the importance of organization and management to deal with ageing workforce or some papers mention the need of new assistive technologies to support ageing workforce. Those aspects are labelled as subtopics. As indicated in the Figure 4, the occupational health and safety has the biggest share, which is %26 of the publications. It is followed by sustainable employment and organization and management.

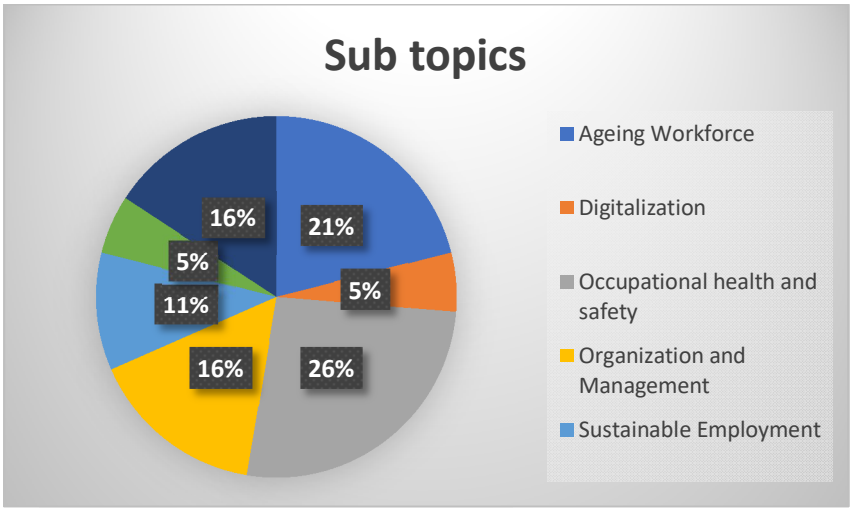

Figure 5 Distribution of subtopics

Ageing workforce

According to the two conferences done by The Center for Research and Education on Aging and Technology Enhancement, in the future the number of older workers will increase as well as their will to continue working. Some sources consider 'older workers' who are 65 years old or older but the labor market participation declines after age 50 (Di Pasquale, Miranda, & Neumann, 2020). There are two main reasons for that; first is the ageing population in the world, second is the older workers want to work longer. The trend of early retirement in the 20th century has reversed and older people plan to work longer (Silverstein, 2008). Ageing population is one of the reasons that more older workforce is expected. 'Ageing workers' are referred to people whom are 30 years old or older because the age related declines start (Di Pasquale, Miranda, & Neumann, 2020).

Ageing population

Aging population is one of the reasons that in the future there will be older workers. According to United Nations (UnitedNations, 2020), the median age of the total population in 2020 is 30.9 while it is predicted that in 2050 the median age will become 36.2 in the world. In 2020 to 2050 the population aged 65+ increases from 727.6 million to 1548.9 million. This corresponds to 9.3% in 2020 to 15.9% in 2050.

In Europe the population is even older compared to the world. The 65+ aged population in 2020 is 142.9 million which becomes 200 million in 2050. In 2020 19.1% of the population are aged 65+ and it becomes 28.1% in 2050 which is triple the amount of people aged 15-24.

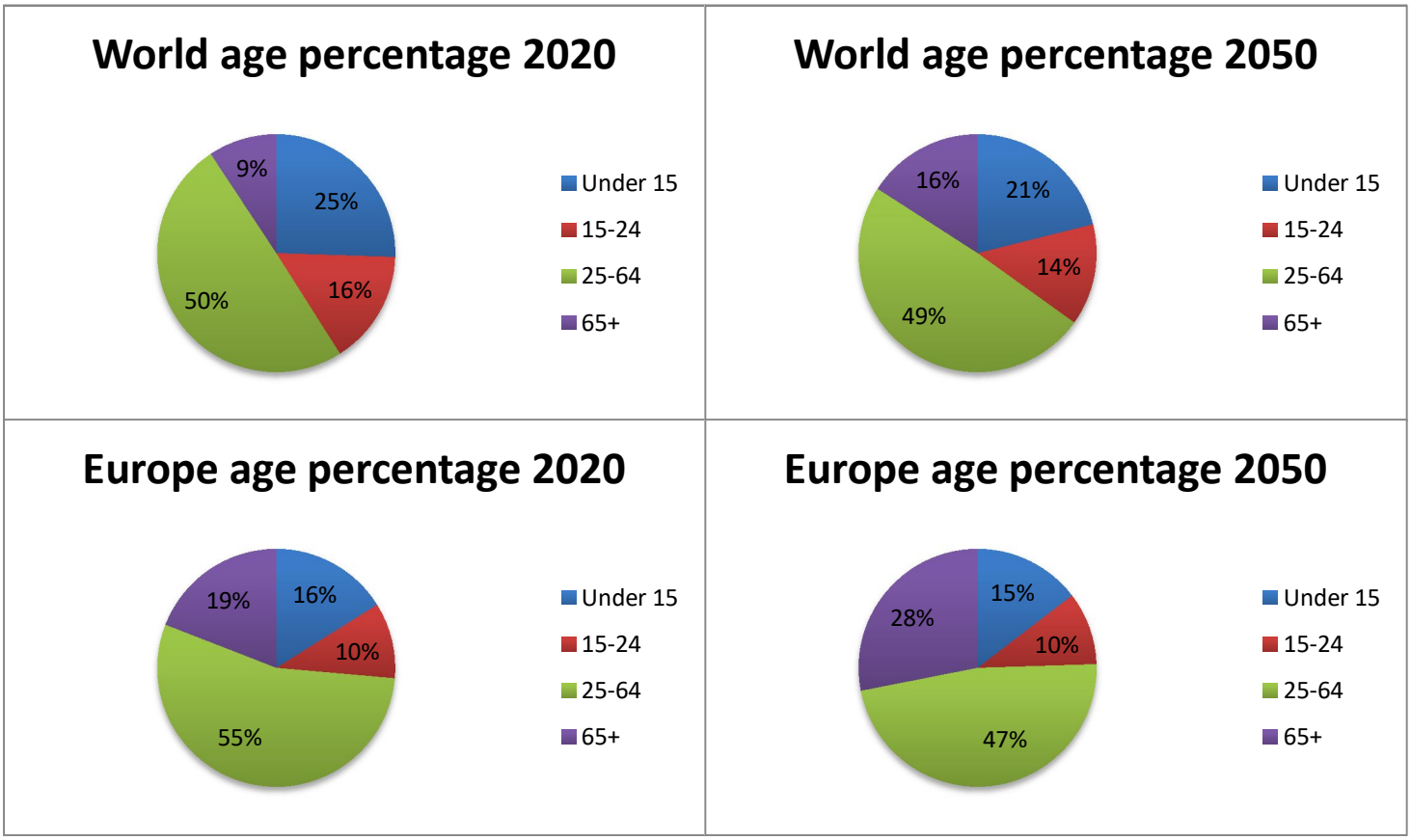

Figure 6 Graphs that shows percentages of age (UnitedNations, 2020)

In U.S.A. the number of people aged 65 and older expected to increase from 52 million in 2018 to 95 million in 2060 (Sharit, 2020). Not only the percentage of the older adults increase but they are also healthier, and living and working longer (Brenda & Katherine, 2020).

In the world also life expectancy increases. In 2020 the life expectancy for both sexes is 72.3 years, In 2050 life expectancy will increase to 76.8 (UnitedNations, 2020).

Why people want to work longer

1 Financial reasons

Many U.S. workers wants to continue working due to financial reasons caused by the changes made in corporate's retirement plans (Sharit, 2020). Many workers can't even get their social security. The main factors effecting older workers to continue working are level of education, financial preparation for retirement and employment sector (Richard & Durand, 2020). Increased life expectancy is another reason old workers are healthy enough to continue working and more willing to sustain and support other members in their families compared to earlier times. Healthier older workers tend to continue work while workers with health problems plan on retirement. However, some older workers reported that working makes them distracted from the chronic pain and benefits

them in a way to control it (Richard & Durand, 2020). Even though older workers want to continue to work, they are involuntarily retired in many European countries (Vandenberghe, Rigo, & Waltenberg, 2012). Employees mostly after age 55, being denied to continue to work by organizations doesn't want to retain them or employ (Patrickson & Ranzijn, 2005). Half of the retirements in Major European countries such as Germany, Portugal Hungary are not by choice. Just because they want to work longer doesn't mean the organizations willing the same. Even though governments encourage employees and employers to continue working after age 65 many of them are not willing because it might be of benefit (Patrickson & Ranzijn, 2005). Although almost every 3 out of 4 older workers prefer to retire by lowering the work time gradually rather than instant retirement (Silverstein, 2008). Increasing number of older worker population can make organizations more open for older employments.

2 Social interaction

The social and intellectual stimulation provided by the jobs make the older workers hesitate retiring, continue in the jobs that become their identity makes people feel relevant despite their older age. "Engaging in intellectual, physical, and social activities can prevent cognitive decline over relatively short periods of time (e.g., 1 or 2 years) and lead to meaningful improvements in cognitive functioning at different points of the adult life span, including old age" (Zacher, 2015). (Richard & Durand, 2020) stated that the main reason for older workers delay their retirement are maintaining daily routines and financial benefits. Involvement in production and social interactions makes people feel importance which is healthier for their mental and physical wellbeing. Intellectually stimulating activities may slow down the cognitive declines that come with age (Zacher, 2015). Social interactions at workplace seems an important factor that older people likes about their lives (Richard & Durand, 2020). It is a way for them to get out of the house and interact with other people and form relationships that will also give them joy in their personal lives.

3 Self-fulfillment

Most people desire to be needed and appreciated by others for their skills or knowledge. For older people this is even more important because they can be appreciated for the experience of years. Continue working and being part of a team fulfills the need of self-fulfillment, being useful to others and the society (Richard & Durand, 2020).

Older workers seem to find mid grounds that they can work part time to spend more time with their families and less time working that would be too much physical work for their age (Sharit, 2020). The education and skill level of the workers plays a big role for them to maintain their job or employ in new ones. Even though the future jobs for older people are more likely to not be physically demanding there are possibilities to employ in industrial work. There are various light industrial jobs that requires less energy and musculoskeletal demands are not exceed older workers abilities. Some of the high demand jobs are automotive assembly, consumer electronic manufacturing, and food production.

Changes in capabilities of older people

Even though older workers are the most experienced and skilled workers they are also the most vulnerable ones. When organizations do not understand the needs of older workers and does not provide required equipment, training programs and policies, they will face the consequence of loss in productivity, quality and safety (Silverstein, 2008). The declines in motor, cognitive and perceptual capabilities may lead to human based errors that reduce productivity and quality (Di Pasquale, Miranda, & Neumann, 2020). Human errors are considered when the physical and mental capabilities of a person fail to achieve expected results which cause and undesired consequence. People aged 50 or older between 1/3 and 2/3 of them have at least one diagnosed disease mainly musculoskeletal or cardiovascular (Di Pasquale, Miranda, & Neumann, 2020).

Even if it is inevitable to reverse the changes that come with age, these changes don't always cause inability to work. According to the research made by (Seitsamo & Klockars, 1997), 4534 test subjects with average age 50 selected to observe the health changes in 11 years. Beginning of the research 37% had a self-reported musculoskeletal disorder and 17% had a self-reported cardiovascular disease at baseline. After 11 years, subjects with musculoskeletal disorders rose to 51% and cardiovascular diseases to 31%. Even though the health problems occurrence increased with years pass, only 45% of the subjects retired while the others continue to work. 20% of them continued with their same job when the experiment started. So these chronic health problems are not severe enough to cause older people to retire.

Physical changes

Some of the capability changes are normal with ageing which separate the older people from younger ones. As we age our body changes, with age the amount of brain cells and muscle tissue reduces. A person reaches its maximum body strength between age 20-30 and start declining after and much quicker after 50 (Silverstein, 2008) & (Di Pasquale, Miranda, & Neumann, 2020). There are all kinds of declines comes with age such as bone density, pulmonary oxygen uptake, exercise capacity, visual acuity, resistance to heat and cold stress, and many other physiologic functions. In 16 years Finnish workers with average age 51 had 20% decline in mean physical capacity mainly because of the trunk muscle strength and loss of spine flexibility (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). After the age 30, mainly the physical capabilities decline.

1 Thermoregulation

Thermal strain in older people is greater compared to younger people while working under heat conditions (Di Pasquale, Miranda, & Neumann, 2020). The reason behind this is the body sweat rate and body heat content are correlated with age. Older people also have difficulties to maintain their core heat while working in cold environments.

2 Cardiorespiratory

Ventilation and maximal cardiac output capacities are declined with age. Maximum heart rate is the most effected from age. Every decade the aerobic capacity drops 5-15% between age 30 to 70 (Di Pasquale, Miranda, & Neumann, 2020). VO_2 max is the maximum rate of oxygen consumption

measured during incremental exercise. Every decade there is a 10% decline in VO_2 max but this is dependent on activity level of the person. If the person is active and exercises regularly the decline effects may be reduced.

3 Muscular strength

People generally keep their static and dynamic muscle strength until they are 45 years old but it starts to decline 5% every decade thereafter (Di Pasquale, Miranda, & Neumann, 2020). There is a 10% handgrip strength which is 0.5-1% every year and 30-45% shoulder muscle strength which is 1.5-2% every year decline in older people compared to younger people. The average muscle capacity of an older person is 10-25% reduced at age 65, this depends on the activity level of the person in their leisure time.

Cognitive changes

The cognitive changes among older people are more complicated. Spatial abilities, processing complex inputs, problem solving declines with age (Silverstein, 2008). Psychologists divide cognitive processes into two; "fluid" functions which is processing input at the time of performance associated with reasoning ability and "crystallized" functions which depends on previous experiences and retrieving them when needed (Silverstein, 2008) & (Taylor & Bisson, 2020). When fluid functions decline it reduces attention and cognitive resources a person uses to solve problems or perform tasks. This heavily affects the ability to learn new skills and information, quick response, novel problem-solving, sustained attention, and extensive memory (Beier, Torres, Fisher, & Wallace, 2019). While fluid function reduces with age the crystallized functions improve due to experience and education, it is attained by workers in long period of time. Crystallized intelligence improves that work behavior by improving the information that workers learn on the job, such as policies and procedures for work, well-learned word processing programs such as Microsoft Word, vocabulary associated with a particular profession, or safety procedures for a job (Taylor & Bisson, 2020). Tests to measure crystallized and fluid intelligence shows that among younger adults with average age 35, there is a strong correlation between both crystallized and fluid tests. However among older adults with average age 65 these test results are different than each other. Fluid intelligence starts to decline in adulthood and gains speed to decline after age 55 while crystallized intelligence remained mostly same till age 60 and then starts to decline (Taylor & Bisson, 2020). It is no surprise that middle-aged adults have better knowledge in literature, history, vocabulary and current events. Cognitive declines are the most critical for older people; the declines in motor skills can be compensated by experience of the person (Di Pasquale, Miranda, & Neumann, 2020).

Primary mental abilities (PMAs) are used to measure the cognitive abilities of an individual. These are:

- Verbal Meaning: vocabulary test.
- Spatial Orientation: 3D thinking from different perspectives, mental navigation, manipulation of objects in space.
- Inductive Reasoning: pattern recognition ability of series and logically reason through problems in order to make predictions.
- Number: addition problems accuracy.

- Word Fluency: naming words according to a logical rule.

According to (Taylor & Bisson, 2020), Seattle Longitudinal Study (SLS) method, made by Schaie is one of the best ways to test these skills. This test shows that declines observed in numerical skills after age 60, inductive reasoning and word fluency after age 67, and verbal meaning and spatial orientation after age 74. These declines in memory often related or correlated with the declines in fluid intelligence. After mid 70s older individuals tends to rely on external sources such as lists to enhance their memory (Taylor & Bisson, 2020). Although this research did not include difference in education level among different age groups.

1 Processing speed

The declines in fluid intelligence negatively affect the processing speed and efficiency, working memory, and inductive reasoning (Taylor & Bisson, 2020). According to (Di Pasquale, Miranda, & Neumann, 2020), the age related cognitive declines are great considering speed, reasoning, measures of spatial ability. There are also minor declines that should be considered such as the relationship, between age and primary-working memory and age and episodic memory. Working memory or short-term memory, generally lasts between 15-25 seconds and it can transfer the learned information to the long-term memory for storage of the newly attained information. In long-term memory the information is maintained indefinitely until the information is summoned (Taylor & Bisson, 2020). Both the working memory and long-term memory declines with age. Working memory is very critical in case of learning abilities, and complex or novel problem-solving tasks (Taylor & Bisson, 2020). The spatial ability declines 5% each decade after 30 years of age. However, it seems that vocabulary knowledge after 50 years of age is increasing. “Correlations indicated that age was negatively associated with working memory performance and positively correlated with inhibitory performance.” (Di Pasquale, Miranda, & Neumann, 2020).

In a research mentioned in (Taylor & Bisson, 2020), 55+ aged individuals tested compared to 30-36 years old range individuals. It seems there is a significant decline to recall information after age 55 but there is no decline in recognition of information. This makes open-ended and fill in the blank questions harder on the other hand it makes multiple choice questions unaffected from age.

Considering the long-term memory, older people seem less effected. Semantic or factual memories such as rules and policies in their job they worked for years are not affected from age and well preserved. On the other hand, episodic memory shows greater decline, which is the ability to remember times, places, and contextual information such as remembering date or time of a prior meeting. But episodic memory for more personalized events seems not effected by age. Remembering future events or meetings is called prospective memory which seems declines with age. For well trained and learned older individuals procedural memory involves memory for how to perform tasks is not declining due to ageing (Taylor & Bisson, 2020).

The decrease in processing speed also reduces multi-tasking ability because of the speed to process the first stimulus is slow it is harder for older people to process secondary stimulus.

2 Implicit and Explicit Learning

Implicit learning is learning complex information in incidental manner that is without awareness of what has been learned. On the other hand, explicit learning is learner's conscious and deliberate attempt to learn, solve a problem, or acquire a skill. By ageing implicit learning capacity of motor skills are preserved while the explicit skill learning declines (Di Pasquale, Miranda, & Neumann, 2020).

3 Attention

It seems that vigilance attention increases with older age. Younger people's vigilance declines more over time compared to older people (Di Pasquale, Miranda, & Neumann, 2020). This makes older people more careful than younger people. However, age related declines occur in attention control such as selective attention tasks. Selective attention is the ability to find the important visual or verbal information inside background of irrelevant information (Taylor & Bisson, 2020). For example, checking the view while driving to avoid dangerous situations or cars. This type of attention is different from paying attention to read information. Older people get more distracted from irrelevant information compared to younger people when focus on target information is required. This decline in selective attention also makes older people worse at multi-tasking where they need to divide their attention on different simultaneous tasks (Taylor & Bisson, 2020).

4 Reaction times

Older people have longer reaction times compared to younger people. Increased age causes slower performance in speed related tasks. The reaction times maybe variable for each process and person to person.

Perceptual

1 Vision

Vision gets worse with age in several ways, including normative changes such as the loss of ability to focus on near objects (presbyopia) as well as age-related pathology including macular degeneration, glaucoma, and cataracts. Loss of accommodation to objects at varying distances, depth perception, diminished color discrimination and reduced acuity are common among older people (Silverstein, 2008). 7% of the people aged 65 or older reported vision related disability (Di Pasquale, Miranda, & Neumann, 2020).

2 Hearing

Older people have hearing problems that comes with age. 7-15% of the population is affected by hearing related problems (Di Pasquale, Miranda, & Neumann, 2020). Even after birth as we are ageing we start to lose the ability to hear higher frequencies. Older people generally have difficulties to understand conversations and localizing sounds in space. However, age related hearing loss is not very common as is generally thought (Di Pasquale, Miranda, & Neumann, 2020).

Organizational and societal perspectives

Keeping their older workers or employing them can be beneficial to businesses. It is seem that older workers better at problem solving, took less sick days and are more satisfied at their jobs compared to the younger workers (Sharit, 2020). Job and worker congruence is another aspect for organizations to consider. When the job demands fit with the abilities of workers, in this case the declined abilities of older workers, it results in higher performance and job satisfaction (Beier, Torres, Fisher, & Wallace, 2019).In group works age diversity proved to increase the performance when decision making is involved. With their greater institutional knowledge, experience and communication skills older workers are stabilizing factors in group works. Since the amounts of new workers are much less than old workers that are moving to retirement, when older workers retire there will be tighter labor market and shortage of various skills (Silverstein, 2008). Today's business world younger workers are more willing to change businesses in shorter periods for different and variable work experience which makes the institutional knowledge and experience harder to find that is present in older workers (Sharit, 2020). In the future the demand for knowledge work will increase, considering the declines in intellectual level are relatively low and experience increase the knowledge, older workers can have advantage over younger workers (Patrickson & Ranzijn, 2005).It is positively effects companies if the older workers are mentors to younger workers.

Age related preconceptions must be avoided in order to increase the employability of older workers. For example, older workers are technophobic, not interested in learning, unable to learn new skills, unreliable, worse performers than younger workers and prone to absenteeism (Sharit, 2020). Some organizations made some changes within in order to get benefit from the older workers. BMW renewed its production facilities by installing ergonomic seats, softer floors, enlarging the type on the computers and providing more supportive work boots which resulted in increased productivity and less absenteeism.

Productivity

Productivity loss is another concern for firms and organizations in terms of hiring older workers. According to (Vandenberghe, Rigo, & Waltenberg, 2012) workers aged 49+ are significantly less productive compared to younger counterparts. The major factor to exit from the workforce is poor health (Leijten & van den Heuvel, 2013). Poor health is mainly associated with older people. The health problems seen in older people are mostly musculoskeletal system and connective tissue, endocrine, nutritional and metabolic disorders, diseases of the respiratory system, diseases of the circulatory system, and mental and behavioral disorders The human errors caused by the declined capabilities of older workers are another aspect of production loss (Di Pasquale, Miranda, & Neumann, 2020). Human errors are considered vulnerability of industrial systems. Safety, production and quality have a strong correlation. Small safety problems may cause serious reduction in productivity and quality. The internal factors that affect the person's productivity are emotional well-being, coping and acceptance of the illness. There is also external factors effect productivity; these are autonomy, flexibility, and support from colleagues (Leijten & van den Heuvel, 2013). These internal and external factors are strongly related with work ability, job performance, and staying at work.

1 Adjustments for improved health and safety among older workers

Even if the older workers are less productive that doesn't mean that they can't be hired or continue to work. Most jobs don't require performance at full capacity, although older workers are working near their maximum capacity (Silverstein, 2008). To maintain the productivity demand/resource balance is an important consideration. Individuals internal and external resources should be balanced with the job demands. Job Demands-Resource Model (JDR Model) is suggested the balance of the demands and individual resources to improve productivity (Leijten & van den Heuvel, 2013). Personal and workplace adjustments plays and important role to maintain the balance suggested by JDR Model. Health behavior model Social Cognitive Theory (SCT) cognitive personal factors, environment at work and at home and individual behavior determines the outcomes of organizations productivity (Leijten & van den Heuvel, 2013). Both the JDR Model and SCT can be applied together in order to improve productivity in organizations.

A pathway method is created by (Leijten & van den Heuvel, 2013) in order to understand the effect of health on productivity of organization Figure 7.

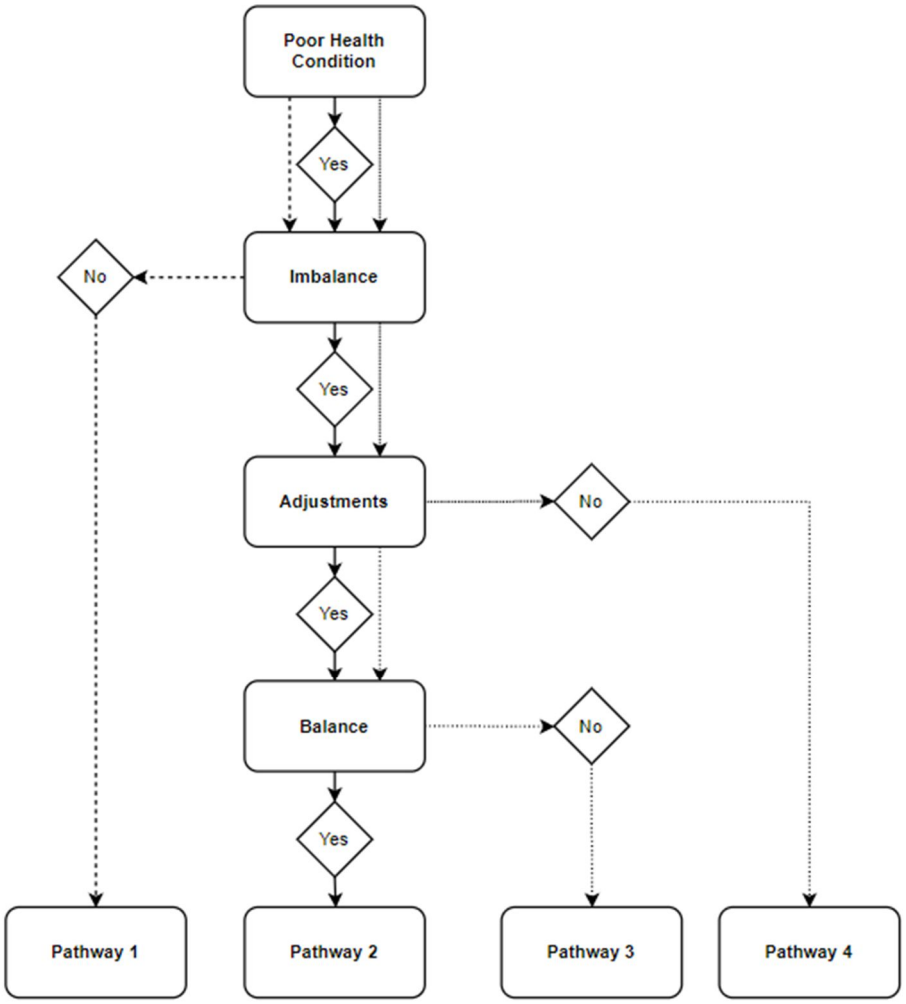

Figure 7 Pathway of how health affects productivity (Leijten & van den Heuvel, 2013)

The model depends on if an imbalance occurs between job demands and individual resources can be caused by night or shift work, or high physical demands or pressure. The 'Pathway 1' is

reached when there is no imbalance occur due to poor health conditions which seems to be a rare case and productivity is preserved (Maintained productivity no imbalance). The 'Pathway 2' is reached when there was an imbalance but adjustments made both in individual and organizational level and due to these adjustments balance occurs (Maintained Productivity after Adjustments). The 'Pathway 3' is reached after there was adjustments made to solve the imbalance but the adjustments were not enough to compensate production loss (Reduced Productivity after Adjustments). The reason behind this is there are some barriers present. These barriers are internal well-being factors that adjustments had minimal effect. These factors include psychological disorders or complaints, having experienced negative life events, low job motivation, job dissatisfaction, personal or partner's having life threatening illnesses, or partners passing away.

The 'Pathway 4' is reached when there was an imbalance and no adjustments were made (Reduced Productivity, no Adjustments). The quantitative research made by (Leijten & van den Heuvel, 2013) shows that majority of the cases Pathway 2 is reached which means adjustments are useful to diminish the negative effects of poor health condition.

The adjustments that can balance the demands and resources are discussed in the section Safety measures, high performance, and policies page:32

2 Labor costs of older workers

To fully understand the effect of age on productivity also the labor costs needs to be considered. The increase of older workers compared to total worker population will reduce the productivity of the organization. When the older workers share increase 10% compared to total workers the productivity of an organization can be reduced 2-2.7% (Vandenberghe, Rigo, & Waltenberg, 2012). Even though employing the older workers can reduce the labor costs it is still not worth for organizations to hire older workers. The effect of labor costs is still not enough to compensate the production loss. Considering the labor costs 10% increase in older workers share will result in 1.3-2.8% production reduction. Without negating the effects of age related declines in cognitive and physical attributes it is unlikely for organizations to keep or hire older workers.

Performance

Although performance loss is much more in jobs that experience gives little advantage and require more motor skills(ex: unskilled manual labor or fast paced data processing). In jobs that experience enhances the performance ageing makes positive impact on performance of the worker (Silverstein, 2008). After age 30 the job demand should decrease gradually corresponding to the age related declines in order to keep high performance and reduced health problems (Di Pasquale, Miranda, & Neumann, 2020).

1 Injury rates depending on age

Another performance advantage of older workers is in older ages non-fatal injury occurrence is much lower than young ages. So the frequency of the accidents gets lower when the age increases (Laflamme & Menckel, 1995). Maybe the only benefit of ageing on capabilities of a person is the sustained vigilance which makes older people more attentive than younger counterparts (Di Pasquale, Miranda, & Neumann, 2020). This can be because older people take less risk at work and in

life compared to younger people because of their experience. It should be considered that every person is different so the people that have pre-existing health problems will be more prone to injuries and older workers have more pre-existing health problems compared to younger people. Workers with poor health condition have higher probability to have accidents (Peng & Chan, 2020). So for a fair comparison pre-existing health problems should not be taken account or should include both age groups.

The research made by (Guest, Boggess, Viljoen, Duke, & Culvern, 2014) is evidence that supports that older aged workers injury rates are lower. In the qualitative research of 63 articles made by (Brenda & Katherine, 2020) shows that older workers aged 55+ are less likely to get injured compared to younger workers. The research examined aluminum smelter workers over 9 year period (January 1997- December 2005). Only the male workers considered and each year number of workers changed with highest amount 558 in 2002. They used company administrative files and live injury management system (IMS) information. They divided the age groups to "<30, 30-39, 40-49, 50-59, 60+". Although they divided 50-59 and 60+ age groups while considering the analysis they combined these two groups because confidence intervals for the 60+ age group were extremely wide. They also examined the Injury danger levels and divided it in to "first aid only (FAI)", "medical treatment (MTI)", "lost time injury (LTI) or "requiring restriction of duties with no lost time (RDI)" Which will be covered in section (Injury danger levels depending on age pg:25)

		Number of Injury (percentage of injury)					
		<30	**30-39**	**40-49**	**50-59**	**60+**	**Total**
Nature of Injury	**Sprains and strains**	61 (38)	279 (51)	514 (53)	275 (48)	9 (30)	1138 (50)
	Burns	25 (16)	72 (13)	104 (11)	62 (11)	3 (10)	266 (12)
	Contusions	23 (14)	78 (14)	125 (13)	64 (11)	4 (13)	294 (13)
	Foreign bodies	6 (4)	37 (7)	45 (5)	27 (5)	1 (3)	116 (5)
	Open wounds	24 (15)	34 (6)	57 (6)	42 (7)	4 (13)	161 (7)
	Fractures	2 (1)	1 (0)	5 (1)	5 (1)	0 (0)	13 (1)
	Superficial injuries	2 (1)	7 (1)	18 (2)	6 (1)	2 (7)	35 (2)
	Muscles/tendons	7 (4)	13 (2)	59 (6)	61 (11)	5 (17)	145 (6)
	Dermatitis/eczema	1 (1)	6 (1)	7 (1)	2 (0)	0 (0)	16 (1)
	Other	10 (6)	16 (3)	41 (4)	28 (5)	2 (7)	97 (4)
	Total	161 (100)	543 (100)	975 (100)	572 (100)	30 (100)	2281 (100)

Table 5 Injury occurrence rates and percentage depending on age groups (Guest, Boggess, Viljoen, Duke, & Culvern, 2014)

The highest injury type with no difference among age group is sprains and strains which covers 50% of the injuries in total. Burns seems to be the second most injury type for the <30 aged group while second most injury type for 50+ aged group is muscles and tendons problems. When compared with the number of workers, youngest aged group (<30) has the highest FAI required injury rate with 9.6%. While for the 30–40 age group, 6.9%; for the 40–50 age group, 6.3%; for the 50 and over age group, 7.2%. Even though the second high FAI injury rate group is the 50+ aged groups the difference between the 3 older aged groups are not significant.

Certain injury types are more common among older workers. Older workers were at greater risk of slips, trips, and falls compared to younger workers (Brenda & Katherine, 2020). Even the general injury rate reduces with age this type of injuries increase at older ages. It is also stated that women are more susceptible to injuries than men (Brenda & Katherine, 2020).

The reason organizations think that older workers are more prone to injury might be because even though the injury claim rates are similar the insurance costs of injury treatment for older workers might be higher (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). Injury care costs for ages 65-70 exceed the average costs (Brenda & Katherine, 2020). The lowest injury care cost is between the ages 18-24. Chronic diseases, which are more common among older workers, increase the care costs even more. These costs vary according to the post injury situation for organizations such as hospitalizations, days absent from work, forced early retirement, and poor rehabilitation.

1.1 Injury rates related to industry type

The injury rates are related with the industry that the worker employed. Depending on industry some older workers may be more susceptible to injury due to factors such as long work hours, fatigue, and decreased functional ability (Brenda & Katherine, 2020). Construction workers have the highest injury rates compared to all other industries (Peng & Chan, 2020). Working long hours in draining, and in high-stress environments makes construction workers more vulnerable to injuries. Organizations in the construction industry should take extra measure to ensure the safety of their employees. For example, nurse's experience increased fatigue and loss of functional ability due to work related problems. Musculoskeletal disorders occur in most of the agricultural workers (Brenda & Katherine, 2020).

Even though the injury rates of older workers are lower in general, some industries have exceptions that injury rates increases with age (Brenda & Katherine, 2020). These industries are agriculture, forest, fishing, mining, construction, and manufacturing sectors. These sectors have very high physical demands that exceed physical capability limit of older workers.

2 Injury danger levels depending on age

Older workers might be less frequently gets injured but the severities of the injuries are much higher when accidents happen (Laflamme & Menckel, 1995) (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). Older workers are more vulnerable and have twice fatal/severe accidents compared to younger workers (Peng & Chan, 2020). When considering non-fatal injuries older workers had lower sprains and strains rates but higher rates of falls and fractures results in average 28 days absenteeism (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). This causes older workers to be more absent at work if an injury happens. It also increase the work caused fatality rates. Fatality rates of 65+ aged workers are three times higher than the workers between 16-64 (Silverstein, 2008). These fatality rates differ according to industry. The rate of machinery-related deaths among males in retail trade was nearly seven times greater among older workers and for machinery-related deaths among males in transportation was nearly nine times greater (Silverstein, 2008).

		Number of Injury (percentage of injury)					
		<30	**30-39**	**40-49**	**50-59**	**60+**	**Total**
Type of injury	First aid only	148 (92)	461 (85)	839 (86)	497 (87)	28 (93)	1973 (86)
	MTI	8 (5)	56 (10)	79 (8)	33 (6)	1 (3)	177 (8)
	Restricted duties	3 (2)	15 (3)	30 (3)	23 (4)	0 (0)	71 (3)
	Lost time	2 (1)	11 (2)	27 (3)	19 (3)	1 (3)	60 (3)
	Total	161 (100)	543 (100)	975 (100)	572 (100)	30 (100)	2281 (100)

Table 6 Table that shows the severity of the injury (Guest, Boggess, Viljoen, Duke, & Culvern, 2014)

When considering the number of workers in each group, youngest workers (<30) has the highest non FAI injury rate with 4.4%. For the 30–40 age group, 3.38%; for the 40–50 age group, 2.36%; for the 50 and over age group, 2.49% (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). This makes the two older aged groups have less medical treated injury rates.

The research shows that the severity rates are higher for younger workers but older workers require more time to recover and return to work. Accidents reduce the work ability of the workers in general but especially older workers because the severity increases (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). If the solution to labor shortage problem is employing older workers then there is an urgent need to take steps to ensure their safety (Peng & Chan, 2020). Organizations should help employees to recover from the injuries and incidents by adapting the work environment for their needs or whether or not if the worker still fits in that task. Having support and leeway in the workplace reduces the absenteeism of older workers despite having chronic musculoskeletal pain (Richard & Durand, 2020).

3 The relation of work demand and abilities

Job demand is the requirement of physical, cognitive, and emotional effort or skills that are demanded to complete tasks in a certain job (Peng & Chan, 2020). To achieve high performance, job satisfaction and delay early retirement organizations must fit the job demands according to older workers abilities (Beier, Torres, Fisher, & Wallace, 2019). Ageing reduces the physical capabilities of workers but the job demands often don't reduce with time (Peng & Chan, 2020). When work demands does not fit the abilities of the workers the occurrence of musculoskeletal disorders, sickness absence and termed physical deterioration increases (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020)& (Peng & Chan, 2020). Workers that have chronic health problems experience more problems, need additional support and have lower work capabilities than healthier workers (Peng & Chan, 2020). There are three considerations to understand if the worker fits. Person-vocation fit examines the compatibility of person to career, person-group fit examines capability of the worker in team, and person-job fit examines if the job demands are aligned with workers abilities.

To understand the fit of a person two assessments needs to be considered which are person and environmental. Objective fit of person and job increases the job satisfaction and organizational commitment and reduce intentions to quit. Objective fit is found by combining self-reported assessments of a person about their abilities and job demands. For example, if a worker agrees or

disagrees “I know assembly line operations” and “My job requires assembly line operations”. Then this attribute is objectively evaluated by a test or rating. The combination of the results will determine objective fit.

Age related declines may change the balance of job demand and worker’s ability causing occupational stress and strain (Beier, Torres, Fisher, & Wallace, 2019). Misfit at job leads to adopting unhealthy habits which reduces the performance of the worker. When workers abilities and job demands relatively high or low the performance of the worker is higher and fewer health related problems occur. Because of their age-related decline in their cognitive, perceptual, and psychomotor abilities older workers are slower and less accurate when dragging-and-dropping, compared to carrying out two pointing tasks resulting in reduced performance. This puts older workers in disadvantage when performing repetitive and precision actions; simple selection tasks are more suitable for inexperienced older workers (Di Pasquale, Miranda, & Neumann, 2020).

When the reasoning demand is high and ability of the worker fits or higher than the demand they reported less chronicle diseases while the simpler jobs that require less reasoning, workers reported more chronicle health problems (Beier, Torres, Fisher, & Wallace, 2019). Knowledge demand is another factor effecting health. When knowledge demand and ability is high or low workers reported more health problems. This indicates that moderate levels of knowledge demand and ability is optimal for worker’s health. Polynomial regression is used to find the effect of congruence and incongruence. It is congruence when the job demands are same level of worker’s abilities. Incongruence occurs when job demands or worker’s abilities exceeds one another. When worker’s abilities exceed the job demands it may cause boredom which is a different kind of stress and strain but they report less health problems. Retirement is another consequence of incongruence of demands and abilities. Age related declines create the incongruence and lead workers to retire. Another reason can be since older workers do the same job for long time they become bored of the job if it becomes repetitive and routine which makes them think retirement. According to (Beier, Torres, Fisher, & Wallace, 2019), mismatch of physical and emotional demands are higher than the abilities of the worker they are more prone to retirement.

The fit of a person can be categorized in to three groups that represent the “stay-at-work cost”Figure 8 Shows stay-at-work cost relationFigure 8. It is determined by the difficulties to meet the work demands and its impact on outside activities.

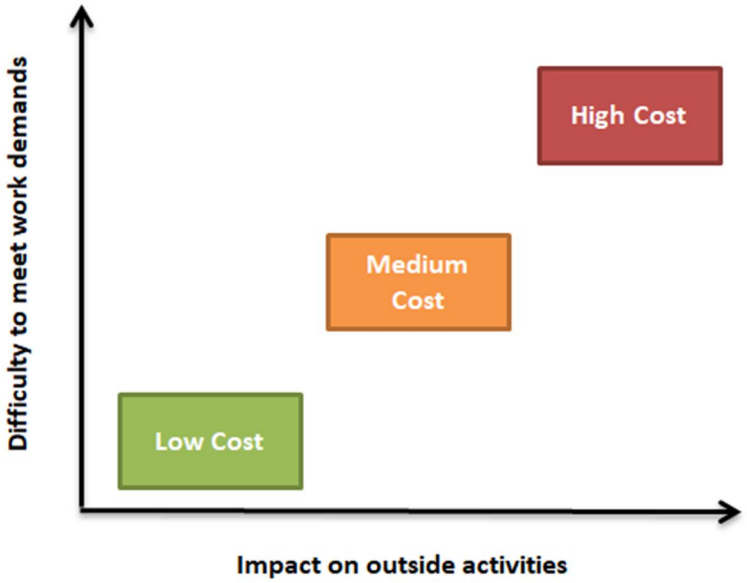

Figure 8 Shows stay-at-work cost relation (Richard & Durand, 2020)

Low cost group is the best in terms of performance. They can meet the work demands of tasks in allocated time and with intermittent symptoms that diminished to an acceptable level with rest. They can continue their outside activities with a very limited work related problems.

The second group is the medium cost. They have difficulties to meet the work demand of tasks and have work related pain afterwards the work hours. Workers in these groups develop strategies to handle the difficult situations in work to continue their occupation. They had to re-arrange outside activities such as, sport or recreational activities, or dividing up the time they spent on housework or outside home maintenance.

Last group is the high cost. They experience difficulties to complete almost all of their tasks. Working creates or increases their pain from health issues. Developing strategies to handle difficult tasks are not sufficient to reduce their symptoms. Resting may diminish some of these symptoms but most of them are chronic. Their personal activities outside the work affected the most. In fact, they limited all their activities outside work to conserve their energy for staying at work. Some of them completely cut off their sport and recreational activities. This sub-group mostly uses medication from doctors to be able to keep working. The high cost groups individuals are more likely to retire instead of continue working.

Teamwork and older workers

Teams are necessity for almost all organizations to solve complex problems and projects. Because of the new communication technologies and easier access to people all over the world team works are tend to benefit organizations even more. Older workers are tend to be more mature and better in communication skills and have more expertise on the field compared to the younger workers (Sharit, 2020). This seems to be an advantage for organizations that has aged workforce if

they rely on team works for their projects. Although older workers communication skills come in handy in teams there are some aspects that can be disadvantageous for them. For example, in 2019 COVID-19 showed us the importance of communication software and programs that require technological literacy such as Teams or Zoom which makes communication possible even being a far and different time zone. Older workers seem not skilled to use software by the organizations and also the younger workers seem not to rely on them with these technological platforms. Older people also reported communicating with organization through these digital platforms as burden for them and time wasting (Fischl, Lindelöf, Lindgren, & Nilsson, 2020).

Teams consist in virtual platforms demand personal flexibility and tend to be more productive due to less commuting and travel time, factors which may be appealing to older workers (Sharit, 2020). However team members should have the technological knowledge to use these platforms and they must be adaptive to the changes in the tasks and working with different people which they don't have enough time to learn how to work together. Older workers are not known better for their addictiveness and technological knowledge so these platforms will be difficult for them to use.

In older people cognitive processing declines which may lead to stress even in conventional team works. Cognitive declines of older workers have positive effect on team error rate, which means error rate increases with older workers, due to memory lapses and mistakes in work planning (Di Pasquale, Miranda, & Neumann, 2020).

According to Paoletti, Gilberto, Beier, & Salas (2019) teams consist of older average age performs better production quality, fewer sick occasions, and lower team burnout (Sharit, 2020). It shows that for work that requires high cognition age diverse teams perform better and doesn't take cognitive shortcuts but for low cognition demanding jobs age diversity has negative effect. Since higher cognition required jobs also require more communication and older workers are considered better at communication skills, they prove to be beneficial to organizations by promoting a culture of thinking through and discussing problems and tasks instead of finding a quick solution.

One age related stereotype is that older people are unable to learn new skills but knowledge generally increases with age and with the help of technology and proper training these negative effects can be discarded (Sharit, 2020). Also younger workers consider older team members that are not passionate for team success and their contributions to the team is not enough. Organizations can create working atmosphere and culture that minimize these concerns of younger workers and focus on preparing the older workers for the demands of these kinds of age diverse teams.

Age also brings the work knowledge, experience and proper working behavior which improve the team functioning. They can use this knowledge to improve the team communication and coordination which results in better performance from the workers. Therefore, older workers can be a valuable asset for organizations with their knowledge, experience and work skills since their younger counter parts are more willing to change jobs.

Documenting and transferring institutional knowledge from older workers

Institutional knowledge and experience are the main assets of older workers that are very important for organizations. After the retirement of the older worker generation the loss of the work

knowledge they have is not something that organizations are willing to lose. Organizations can use Human Resource professionals and managers that promote the knowledge transfer from older workers to younger and less experienced ones. Thus, older workers will stay at production and train the younger generation.

There are four main knowledge types that a worker can possess (Sharit, 2020):

1. Explicit knowledge: the knowledge that is easily expressed such as a simple rule governing operations or transactions.
2. Tacit knowledge: the knowledge that can be hard to express and known by individual, such as controlling an industrial process which requires highly learned procedural skills.
3. Intellectual knowledge: the knowledge encompassing more refined facts and concepts about various kinds of subject matter.
4. Social knowledge: the knowledge about interpersonal relationships and access to social networks, such as how to deal with difficult people or behave in difficult situations.

Mentoring

Mentoring is one of the fundamental methods that an older employee can transfer knowledge to younger employee. According to the Society of Human Resource Management mentoring is an efficient way to transfer tacit organizational knowledge between employees (Sharit, 2020). For example, NASA uses a phased retirement method that old NASA employees train the young employees on the job by mentoring them. Also older workers prefer mentoring type of knowledge transfer the particular reason for this circumstance is they feel valued and needed at their job. Especially when older employees considering retirement, adding them to mentoring programs where they can work part time and more motivated in a gradual retirement (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). Both parties can benefit from mentoring, while the young employees perform the physically difficult task at the same time they can get advantage of the older employees experience and knowledge. This type of knowledge transfer makes the younger workers less biased towards working with an older worker which improves the inter-organization relations and promotes future knowledge transfer (Sharit, 2020). Not all of the older workers can be eligible for mentoring, choosing the employees for mentoring based on knowledge level and operations that are difficult to automate will be more impactful for organizations success (Sharit, 2020).

Task and cognitive task analysis to support knowledge transfer

Task Analysis (TA) is another method for knowledge transfer where the job is difficult to capture or use the other knowledge transfer methods. It breaks down all the physical and cognitive activities and defines each step for a task or operation (Sharit, 2020). With this method the older employee who is more skilled, can see the steps that the younger employee does and address to the exact point where the information is not clear, misleading or understandable. It also enables to see which work steps the system operation would allow the correction of errors from the previous steps.

Cognitive task analysis (CTA) is a type of TA that gives more insight to the knowledge transfer by observable task performance. An example of a CTA method is Applied Cognitive Task Analysis developed by (Militello & Hutton, 1998)It has three parts done by the subject-matter experts, first the task diagram that highlights the difficult cognitive aspects of the task, second, the knowledge audit, subject-matter experts describe how to use the knowledge and skills, third, the simulation interview, a challenging scenario is presented to the SME who, in response to probes of events within the scenario, provides situation assessments, actions, critical cues, and potential errors (Sharit, 2020). Older employees can be the subject-matter experts that use this technique for knowledge sharing.

It can be challenging to perform TA and CTA since it requires data collection methods such as videos, audiotapes, verbal protocols or 'think aloud' techniques, and simulation exercises. Although this technique is better to identify the details while tacit knowledge transfer can be difficult compared to other methods.

Knowledge engineering

Knowledge engineering is a method to obtain useful knowledge and expertise of the job and transform it in to an artificial program (software) (Sharit, 2020). These artificial programs capture the behavior and reasoning of the experts and emulate. These systems are called Expert Systems (ES). ESs can be used for simple tasks like set of rules or more complex structures that help deeper reasoning. Older workers can be the source of knowledge for these types of programs and they can verify if they work properly. Although for this method organizations will need programmers to do the ES.

There is also case-based approach in knowledge engineering. In this type software is created to record cases which are problems that occur in the past and their solutions. Afterwards when a new problem occurs the software compares this problem with the past ones and if there is a match the solution will be displayed to user. Older workers can play an important role for the database of this type of software for programmers.

Simulation of work processes

Simulations can be used to capture detailed context for training workers for different complex circumstances. There are different types of simulations, for example, high-fidelity simulators can be built to mimic real-world physical and cognitive operational environments (e.g., flight or nuclear power plant simulators) or computers based graphical simulators for jobs such as industrial processes (Sharit, 2020). These technological methods can be used to record and preserve the knowledge and expertise of the older workers in order to train other workers. For example, a software can be used to train new workers on how to deal with the industrial process they are assigned or a video recording of an older worker performing a process can be a good way to show new workers how to handle it.

Society

Governments in are concerned about the effect of ageing workforce on society in general (Patrickson & Ranzijn, 2005). If we consider the society, the working people pay the retirement fees of the seniors. Since in the future the demographic percentage of older people increase that means

more taxes for younger tax payers for retirement fees. Increased birth rate and promoting 'brain migration' is not sufficient in short term (Patrickson & Ranzijn, 2005). The non-working old people who have either been unsuccessful in finding work, prefer to participate in a reduced capacity, or have chosen to exit the workforce permanently (Patrickson & Ranzijn, 2005). Many of the older people have capabilities that are enough to maintain high level of functioning and well-being to keep contributing to the society (Zacher, 2015). Governments are also supporting workers to work longer and stay at job to encourage economic growth and reduce retirement costs (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). This changes the traditional approach of retirement at age 65. Government approach is mostly public statements from politicians to encourage old people to continue working as long as they can for better financial retirement. They are also make public announcements of those employers who employ older workers but the effect of this is minimal since they think younger worker are better in general (Patrickson & Ranzijn, 2005). Remaining in the work force means to continue contribution and benefit the society. Working longer may also benefit the worker's mental, physical and cognitive health depending on worker and job (Beier, Torres, Fisher, & Wallace, 2019). If the older workers continue to work and pay taxes this can relive the tax pressure on the younger working class. Currently the employment rate of people older than 65 is very low, the majority of the 65+ year old employees are the ones that are high-demand highly skilled or professional occupations (Patrickson & Ranzijn, 2005). In many countries the retirement system is based on large amount of younger workers supporting the retirement fees of the small number of older workers (Silverstein, 2008) but this demographic is changing and it is a problem for society in the future. Not only the demographics of population will lean more to older people but also the life expectancy after age 65 is increasing. According to (UnitedNations, 2020), in 2020 life expectancy after age 65 is 17 years which expected to increase to 21 years in 2100. This actively demonstrates that older people will both increase in number and also live longer than before. Considering also the younger workers percentage will drop, retired older workers are an upcoming problem for society. In societal perspective it is beneficial to employ older workers.

Another problem is that the labor costs of older workers. There is a negative relation between the employment rate and the cost to employ older workers (Vandenberghe, Rigo, & Waltenberg, 2012).

Safety measures, high performance, and policies

It is evident that in the future large amount of older people will continue to work. Keeping work environment safe and hospitable for their needs and capabilities will result in increased productivity and performance for organizations. 'Successful ageing at work' is a concept that is the result of active, healthy, and productive aging at work can be adopted by organizations to get most benefit from their older employees (Zacher, 2015). It is the combination of concepts from work and family balance, to employee development, to occupational health and safety. The main criteria for successful ageing are the consideration of both subjective well-being and objective well-being of an individual (Zacher, 2015). Subjective well-being is evaluation of one's life as satisfying and fulfilling, and attitudes toward one's own aging. Objective well-being is dependent on physical diagnosis of diseases. The individuals that are free from physical and mental pathology are considered

successfully aged. The factors that affect objective well-being are a low probability of disease and disability, maintenance of high physical and cognitive functioning, and continued engagement in social and productive activities (Zacher, 2015).The factors that affect overall well-being of an individual are income, education, physical and mental health, cognitive functioning, social relationships, personal autonomy, and personality characteristics.

There are three action regulation strategies that people can use to achieve successful ageing, compensating the age related declines (Zacher, 2015);

1. Selection, optimization, and compensation (SOC) strategies are used to counter the age related declines by maintaining relatively high levels of functioning and well-being. To use SOC people actively selects goals, optimize their pursuit of these goals, and compensate for factors that may impede goal achievement, make better use of their available resources, maximize gains and minimize losses.
2. Assimilative and accommodative coping model is in times of critical life transitions; individuals influence their development consistent with their personal preferences and adjust their personal preferences consistent with contextual constraints.
3. Life span theory of control the development and maintenance of behaviors that align the environment with individuals' needs with ageing.

In the section "Performance(pg:23)" its stated that injury rates are lower for older workers while their severity is much higher. If the correct measurements are not taken organizations can't take advantage of this situation and severity, disability, cost and risk of fatality will be high. Under right circumstances older workers will get less injuries and sickness compared to younger workers. Organizations should develop programs to fulfill the needs and boost the capabilities of older workers. Although some industries have higher injury rates compared to other. According to (Guest, Boggess, Viljoen, Duke, & Culvern, 2014), the transport industry has the highest injury rate with 24 per 1000 employee per year. Which makes easier to adopt safety measures for some industries but harder for others. The workplace should be design for expected large amount of older workers and future needs. According to (Silverstein, 2008), "The concept of designing work to match the physical and cognitive capacities of workers applies equally well at all ages and there is some evidence, mostly from the Nordic countries and the European Union, suggesting that carefully designed employer programs can provide age friendly working environments that preserve the capacity of employees to function safely and effectively as they age."

The work ability of a person is depends on some self-reported individual and environmental factors (Silverstein, 2008). These are:

- The physical and cognitive demands of work
- The psychosocial work environment
- Health status and physical impairment
- The individual's general well-being and supportive resources

Since 1981 in European Union Work Ability Index (WAI) is used which is a quantitative value coming from employee questionnaire to find the employee's work ability (Silverstein, 2008). It is

developed by Professor Juhani Ilmarinen in the Finish Institute of Occupational Health to improve the health standards of the workplace (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). WAI is a predictive tool of early pensioning and work disability. It is seen that the employees with lower WAI retire more often and fatality rates are higher while the employee's with higher WAI retirement and fatality rates are much lower. WAI changes person to person. Even though it is not directly reduced by age, age related declines will often result in lower WAI. Higher WAI predicts a healthier life till retirement and ability to function better in work related or daily tasks (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The factors results in higher WAI are:

- Adjustments in the psychosocial work environment (flexible work schedules, teamwork, age-management skills for supervisors).
- Worker skills and competency building.
- Adjustments in physical work environment (physical workload, rest/work schedule, repetitive motion, and regulation of one's own work and breaks).
- Health and lifestyle promotion (physical exercise, risk factor reduction, occupational health services).

If these factors are improved or enhanced for older workers their WAI will also increase results in less retirement and fatality. There are also some factors that decrease WAI:

- Decreased satisfaction with restless and noisy workrooms.
- Decreased leisure time physical exercise.
- Increased standing at work.
- Decreased recognition and esteem at work.
- Stress and burnout.
- Musculoskeletal and mental symptoms.
- Overweight.
- Smoking.
- Problems with mobility, vision and hearing.

The study made by (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020) shows that the main factor that effect WAI is the health status (perception of the employee) of the employee. If the employee thinks that they are healthy they perform better at work. Organizations that help their employees that had accidents and chronic diseases to return their work would benefit greatly in terms of performance. Organizations should consider individual's needs to make the work environment most suitable. The main factor of negative effect on WAI is the sleeping disorders. It affects all age groups not only older workers. The employees in high physical and mental demanding jobs are the most vulnerable of this condition.

The peak level of WAI is between ages 25-29. Employees younger than 25 have lower WAI compared to the peak group. Also the older employees older than 30 have lower WAI values. Women after age 50 have an increased decline in WAI but for men they experience this decline after age 60. This shows a difference in sex considering WAI and performance. This is caused by the extra duties outside of the work that women have such as childcare, domestic care, care of sick relatives.

Menopause can be another reason for women to have lower WAI. Women are also more receptive to psychological changes which affect their WAI more than men.

Promotions to managerial positions increase WAI of the experienced employees. These position changes help older workers to better fit the demands and abilities. Chronological age effects WAI negatively but it is not the main factor. Mentioned above, health perception has 4 times greater impact on WAI than chronological age. Throughout their career employees lose motivation to work and plan on their future and retirement. Organizations can add intervention programs in order to keep the employee motivation high (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020).

Management commitment

The management commitments also play an important role in creating a safe work environment by improving Occupational Health and Safety (OSH), hence minimizing risk and accidents in the workplace especially for aging workforce. The organizations that are properly implementing safety policies and strategy issues in strategy, experience reduction of factors that might cause disease or accident in the workplace (Berhan, 2020). Thus, in order to investigate the role of MCs in improving the health and safety of employees at the workplace, a model has been developed after conducting a questionnaire in 100 manufacturing industries in Ethiopia (Berhan, 2020). Regarding the most workplace accidents and injuries in the metal manufacturing sector, the questionnaire was filled by supervisors or managers of the companies. As an outcome, a conceptual framework was developed in order to depict the relationships among the constructs.

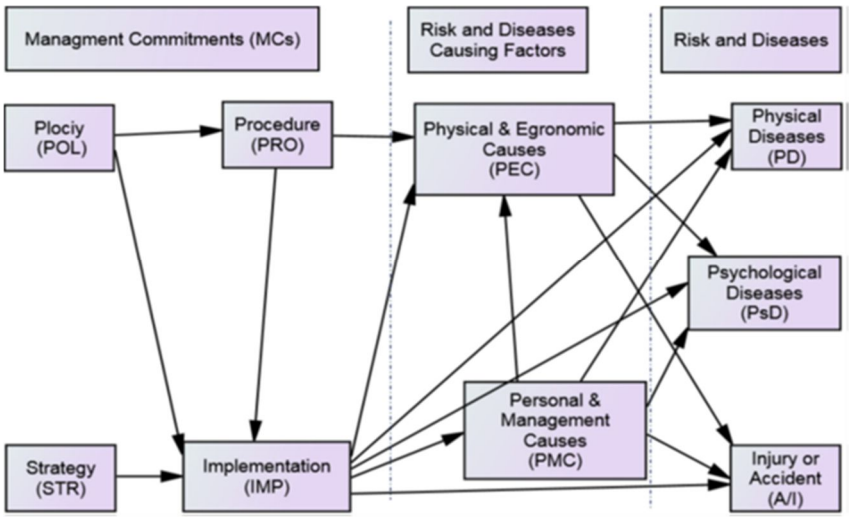

Figure 9 Conceptual Framework (Berhan, 2020)

The model assumes that organizations that have OHS policy, OHS strategy in their strategic document and implement accordingly are believed to improve the OHS in the workplace. As displayed on Figure 9, the policy (POL) has a direct effect on procedure (PRO) whereas policy also has both direct and indirect effect on implementation (IMP). The first construct includes safety policy (POL), strategy (STR), procedures (PRO) and implementation Practices (IMP) which are required by the organization in its safety policies and strategy issues. Those strategy issues motivate managers to formulate safety guidelines and procedures. Moreover, policies and strategy documents need to be cascaded down to employees as procedures and practices in the workplace. The other construct is

risk and disease-causing factors (PEC/PMC) which are related to human and ergonomic contributing to the high prevalence of occupational diseases and accidents in the firm. In this model, it is believed that while safety policies and strategic issues are properly formulated and implemented, the effect of PEC/PMC would be minimal. In order to measure the management commitment of organizations and employers, a study was conducted interviewing multiple employers and employees from different size of organizations across 13 sectors (manufacturing, agriculture, education, transport, mining etc.) in United Kingdom, aiming to understand their perception of the benefits that aging workers provide to their organization, any concerns regarding an ageing workforce, how they transfer health and safety knowledge and what health and safety age management strategies they had implemented (Drake, Haslam, & Haslam, 2017).

When the employers were asked if they had implemented any health and safety policies, a little less than half responded positive, including:

- Introduced additional health surveillance as workers age (mainly for those in specific roles)
- Additional risk assessments completed based on role and capability
- Flexible working hours
- Introduced behavioral safety program using observations
- Introduced an age limit on specific tasks
- Enhanced supervisor observations
- Introduced personal development/self-analysis courses

Some employers stated that they are depending on the existing health surveillance, hence not needing additional measures and some responded they were unsure how to handle their ageing workforce. Another issue stated is the reporting health problems. The employees are not stepping forward to share information about potential problems they may be experiencing due to fear of the consequences (Drake, Haslam, & Haslam, 2017). Some participants who reported some capability changes and discomfort due to aging were dismissed or lost the chance of promotion. Besides, employees don't trust the confidentiality of their conversation with their managers or supervisors because they are subjected to ridicule by colleagues after reporting health problems, which is a lack of respect and dignity. If employers are not identifying problems they will be unable to identify specific risk factors and risk groups and so will be unable to implement necessary interventions. The mutual trust is crucial in order to create a positive safety ambience in the workplace.

The employers may face a difficult condition in implementing an age management strategy because it may be viewed as discriminatory. However, under the Equality Act (Gov.uk, 2014b, Equality Act), a legitimate aim might include health, safety and welfare protection of older workers and the Health and Safety Executive (2016a, Health and Safety Executive) state that it can be justifiable to discriminate in respect to age if it is proportionate to achieve a legitimate aim i.e., changes to a workplace required to ensure older workers are safe and can remain in work. The employers usually come across Human Resources Department blocking any suggestions, pointing out discrimination but offering no guidance. The participants agree on that the implementations must be

fair and for all old workers, thus delivering a steady support and helping the ones who are reluctant to report otherwise (Drake, Haslam, & Haslam, 2017). Besides, they feel the absence of an age awareness training program and believe that it would help younger managers understand and be more sympathetic when older workers experience age-related issues. This program also provides knowledge regarding potential measures that the organizations could take if someone's capability declined. The organizations sometimes experience significant cost due to those new measures, absenteeism and the potential increased numbers of employees who may need adjustments or have constraints placed on their performance. However, it is important that the employers assess the job demands, work environments and capability requirements and also to have a general idea of which tasks have no age issues and those that could be a problem.

Another aspect of the management commitment is the succession planning and knowledge transfer. Younger workers may sometimes see older workers as 'blockers' to their promotion chance. Moreover, in case of notice periods, the ones who are intending to retire give only one month's notice, thus making it difficult to fill technical roles at such short notice. New recruits should be employed and receive health and safety training before older employees leave the organization. Otherwise, the organizations may face problems in recruitment and training of new employees alongside with transferring health and safety knowledge (Drake, Haslam, & Haslam, 2017). This also creates a pressure and harmful effect on the remaining employees who are to train the successors. Ultimately, the organizations can't grasp the information and depend only on the informal knowledge sharing. Some organizations use experienced mentors to pass on knowledge or arrange various meetings, training sessions where the employees share their experiences to improve their workforce. But due to the lack of succession planning those meetings come out to be ineffective, so health and safety knowledge is lost when older workers retire. The headcount is indicated to be the top reason why some organizations are reluctant to employ a successor before someone had retired.

When the employees are asked what the employers could implement in order to help retain older workers and keep them healthy and safe in the workplace, they suggested (Drake, Haslam, & Haslam, 2017):

- Fairer/consistent actions/support
- Policy on age that is communicated to everyone
- Flexible working or job share
- Increase health checks and include capability questions during any personal development reviews with
- supervisors
- Environmental improvements: lighting, flooring
- Age awareness training for managers
- Be able to access occupational health and advice discreetly
- Options to change jobs or work in different ways

- Change shift times or shift patterns
- More frequent breaks
- Recruit successor before person retires and remove headcount as a company target
- Risk assessments should include person/equipment/job profiling
- Provide gym facilities
- Remove time pressures/work overload
- Have an age-balanced workforce
- Job rotation
- Better rest facilities/quiet areas
- Hold discussion groups for older workers and seek their opinions
- Invited to training
- Better job manuals that include knowledge capture

On the other hand, in order to get an early diagnosis of the older workers and detect capability changes, the organizations should perform more frequent periodic health surveillance rather than being depending only on the Occupational Health.

Consequently, a co-ordinated approach including human resources, operational management, health and safety and occupational health personnel is required to deal with aging workforce proactively rather than reactively.

Managers themselves need training about ageing to understand the importance of older workforce (Lee, Czaja, & Sharit, 2009). Older workers also need to be engaged in training and have support from managers.

Programs and policies

Programs and policies are required to ensure the workers age with high WAI so they can work longer and healthier. These programs and policies are required to ensure successful ageing of employees and maintenance of the health of older employees. Successful ageing at work is depended on four factors. First factor is the subjective and objective well-being of the employee, these depends on work motivation, job performance, turnover, job attitudes, and occupational health and well-being (Zacher, 2015). Second factor is the temporal patterns, which is the understanding and determining the changes that occur to employee's overtime. Third factor is the explanatory mechanisms, which is investigation of age-related changes if it is positive or negative on an individual. Fourth factor is examining how person and/or contextual factors interact with age in predicting mediators and, directly or indirectly through the mediators, work outcomes (Zacher,

2015). Older people are heterogeneous group and the ones deviate positively compared to average age related trajectory can be considered successfully aged. The table below represents the four strategic programs and the policies suggested by (Silverstein, 2008):

Four strategic dimensions for programs and policies			
The work environment	**The organization of work**	**The employee**	**Social support**
Ergonomics and human factors engineering	Alternative forms of work organization	Health promotion, disease prevention and management	Community based support services
-	Vocational rehabilitation and return to work	Training and skill development	Access to health care
-	-	-	Protection from discrimination

Table 7 Four strategic dimensions for programs that meet the needs of an aging workforce

1 The work environment

The requirements of the work should not exceed the capabilities of the workers to prevent injuries and performance loss. Musculoskeletal disorders, cardiovascular disease, early retirement, and long term sickness absence is often cause by high demands of physical abilities in work (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The physical and mental demands of the jobs may lead to reduced occupational health and more stressful work conditions. It is desired that young workers to age without injuries or other health problems so that they can keep on working when they are older. This can be achieved by methods such as workplace ergonomics and human factors engineering. The possibility to negotiate with the organization about the changes and needs in the work environment, is a key factor for workers whom are old and/or have chronic musculoskeletal problems (Richard & Durand, 2020). According to (Silverstein, 2008), "The principles of ''universal design,'' aimed at products and environments that can be used safely and effectively by people of widely ranging differences in age, size and other characteristics, are especially useful for creating age-friendly workplaces."

The demands of the job play an important role to determine the effectiveness of ergonomics. The effect of shift work on WAI is negative, which means shift works are not preferred by workers especially women workers (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The number of women working is increased compared to past centuries which increase the average work time of the families. Increased work times increase the occurrence of occupational accidents and reduced productivity (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). It is important to take into account worker's capabilities, age, gender, health status, financial resource, lifestyle, sleep, quality, support from family, responsibilities within the family and society.

Difficult working conditions, long labor times and night shifts reduce WAI and increase the chances of musculoskeletal disorders (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). Employees reported that manual handling tasks are the most challenging for them. Organizations need to do risk assessments in order to reduce injury risks and replace the task with mechanical equipment to reduce the MSDs risks.

There are some conditions in the work environment that reduce WAI and productivity. These are: age discrimination, no recognition from managers, conflicts with co-workers, and dealing with angry clients/patients. The positive factors for WAI are: the safety feeling at work, flexible working hours, job satisfaction, and when work hours match with family time. For older employees safety at work mostly affects WAI negatively, they think working effect their health (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The other factors are generally positive. Flexible working times seems the best way to reconcile work, private and family life as they may have caring responsibilities, or to attend medical treatment in case of health problems. Stress and absenteeism can be the result of not managing these factors correctly.

Ergonomics is an important factor for older employees in the work environment. The age related declines put them at greater risk for MSDs which makes ergonomics more important for older employees than younger employees (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). Reducing the chances of MSDs and increase the performance, ergonomic intervention programs can be adopted.

Safe design is one of the methods to prevent musculoskeletal disorders. When implemented correctly modified work can 2.5 times fasten the time to return job in occurrence of subactue work-related back pain. According to (Silverstein, 2008), “Modified work programs consistently increase return to work rates twofold and reduce disability days in half”.

The factors effecting WAI are mostly related to Occupational Health and Safety related. Occupational Health and Safety Management Systems (OHSMS) can be implemented by organizations in order to keep employees safe and healthy (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). OHSMS should include active and healthy ageing process.

1.1 Balance

It’s not uncommon for workers older than 50 years old have problems with balance which cause injuries that are consequence of falls and trips. To help the older workers have their balance it is possible to use handrails along travel routes, housekeeping to reduce clutter, slip resistant walking surfaces, repair of uneven or wet floors, and the use of color contrast between stairway risers and treads.

1.2 Vision

Vision gets worse with age in several ways, including normative changes such as the loss of ability to focus on near objects (presbyopia) as well as age-related pathology including macular degeneration, glaucoma, and cataracts. Loss of accommodation to objects at varying distances,

depth perception, diminished color discrimination and reduced acuity are common among older people. There are few ways to improve vision for older workers, increasing the light intensity 50% more than for younger workers, increasing the test lighting levels 3 times to help them see details, task lights should be placed to the side and in front of the worker to reduce shadows, increased contrast for stair edges and curbs, and high luminance fluorescent fixtures to enhance color discrimination (Silverstein, 2008).

1.3 Hearing

Older people have hearing problems that comes with age. Even after birth as we are ageing we start to lose the ability to hear higher frequencies. Older people generally have difficulties to understand conversations and localizing sounds in space. Hearing related losses effect workers performance in manufacturing environments (Di Pasquale, Miranda, & Neumann, 2020). This increases the importance of audible signals for safety. A simple solution would be speaking more loudly, more slowly, spending more time to explain concepts, explaining concepts one-by-one or step-by-step (Patrickson & Ranzijn, 2005). The speech rate should be reduced to make older workers understand better and speech compression on automated systems such as voice mail should be eliminated.

1.4 Strength and endurance

Ageing makes humans lose muscle mass which results in loss of strength. It is important for organizations to amply the methods of workplace ergonomics to reduce the physical stress on younger and older workers. Reduced bone density and fracture tolerance increases the odds that older workers to be more likely injured due to lower biomechanical tolerance. The energy required to cause serious injury reduces with age (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). According to (Silverstein, 2008), methods to achieve this are; Strategies for fitting the workplace to the worker include substituting mechanical for manual strength, reducing highly repetitive tasks, allowing adequate recovery time, reducing static and stressful postures, and job rotation. There are some environmental implications that can reduce the risk of slips, trips, and falls which are common among older worker. Removing physical obstacles, improving lighting, and safety reminders may be effective to reduce injury risks (Brenda & Katherine, 2020).

1.5 Smart device usage

Motor control and coordination abilities seem to be an important factor effecting the interaction of older people with touchscreens. The declines in motor control and coordination reduce the accuracy of successful tapping on touch screens (Lin & Ho, 2020). These unsuccessful interaction caused by problems in the timing of gestures, the difficulty of controlling the speed of tapping, and failure to complete dragging actions. Younger people perform better at these tasks compared to older people (Lin & Ho, 2020). There are also different preferences considering hand gestures to use smart devices between young and old people. These gesture differences seem not relevant with completing the tasks correctly. When it is asked to use the same gestures as younger people, older people performed worse than their actual gestures. To improve their success at using the smart

devices with touchscreens, increased button sizes and spaces between buttons have been suggested (Lin & Ho, 2020).

Declines in processing speed, working memory, and executive function also reduces the successful interaction between older people and smart machines. To overcome this location of the important information should be located in the center of the screen and that information should be colored different than the rest so that they can detect it easier (Lin & Ho, 2020). This reduces the cognitive load of searching for older adults with low information processing abilities. It is more difficult for older people to remember past experience and previous steps with the smart device interface. It is recommended to have a 'Home' button in every screen for an easy return back.

Older people aged 50 or more have heterogeneity, this means that one single interface design may not be sufficient for every older user (Lin & Ho, 2020). Also the skills and willingness to use smart technologies is not fixed with age and shows diversity among the age group (Jari Pirhonen & Katariina Tuominen, 2020).

1.6 Tangible changes

To reduced discomfort or inconvenience tangible changes can be made such as new desk or chair. These changes reported to be not effective to reduce imbalance (Leijten & van den Heuvel, 2013).

2 The organization of work

For employees to be more productive and safer design of the work relationships plays and important role. There is a lack of design improvements for engineers to better accommodate the ageing workforce, that organizations should put effort and methodological dimensions (Di Pasquale, Miranda, & Neumann, 2020). Design of the work relationships should include decision control, work schedules, information transfer, and avenues for conflict resolution, supervisory relationships. Certain means and possibilities provided in employee's work condition can make them able to develop stay-at-work strategies (Richard & Durand, 2020). These include work schedule, the content of their tasks or the tools provided. Scheduling changes include different work times, reduced working hours, and reduced shift work, working from home, and increased break possibilities. Content changes are assignment of older workers in to new tasks. Scheduling and content changes are made to reduce or alternate the physical demands for older workers (Leijten & van den Heuvel, 2013). Flexible working times such as flexible arrival and departure times, or the possibility of reducing their working hours or of taking leave as needed make older workers be able to continue their occupation. Some older workers may need extra day off at the end of the week if they had pain from working in the previous day. Software can be adopted in order to remind older workers that have health problems to take breaks during working (Leijten & van den Heuvel, 2013). In the research of (Lee, Czaja, & Sharit, 2009), older people stated that the best working condition for them is part-time employment with flexible schedule, and being able to obtain job training.

Relationship adjustments can include both work and personal relationships. Task take-over is one of the most effective methods in this category and is similar to content changes mentioned above. The tasks that are difficult for older workers are taken-over by colleagues, supervisors, or

relatives. This method seems to be very effective to reduce the imbalance (Leijten & van den Heuvel, 2013).

Some organizations allow older workers to modify their tasks that require too much physical demands or working with an assistant if there is a lot of movement (Richard & Durand, 2020). Physically demanding tasks are delegated to younger co-workers instead. Some industries have higher injury risks for older workers. These are agriculture, forestry, fishing, and hunting; construction; mining, quarrying, and oil and gas extraction; and transportation and warehousing (Brenda & Katherine, 2020). Tasks of older workers working in these industries should be modified in order to fit their physical capabilities to work demands. Many of these tasks can be also modified informally without the knowledge of the organization. These can be individual work strategies to handle complex tasks or arranging working times or required time (Richard & Durand, 2020). Older workers should be able to ask help from their younger co-workers or doesn't do demanding tasks all together. These are possible only with a good employer and employee relationship and work environment. According to (Richard & Durand, 2020), applying these changes older workers still performed the required demanding tasks.

Older workers require some assistive tools to perform well at their tasks. These tools can vary depending on each individual. Some general tools required are headphones, stools or adjustable chairs. Some of the workers ask these tools from their managers which show the need of good work environment and relationship.

2.1 Safe design of workplace to reduce injuries and human errors

Safe and more productive design needs to consider human reliability analysis (HRA) methods in order to predict the likely occurrence of human errors (Di Pasquale, Miranda, & Neumann, 2020). HRA is used to quantitatively estimate human error probability. Well-designed manufacturing systems and adopted organizational strategies that consider human are physical, perceptual, and cognitive capabilities and limitations are necessary to reduce human system errors. A good design of age friendly work place will return with benefit to the organization such as safety, productivity, and competitiveness (Di Pasquale, Miranda, & Neumann, 2020). The changes in the design of the workplace could also potentially benefit the younger age group and improve their performance and productivity.

Low stress, empowerment of the workforce, autonomy, good relations between management and workers, delegation of control, low grievance rates and encouragement of long-term commitment of the workforce are the factors that create low injury risks (Silverstein, 2008). At the same time factors that have an effect on human errors are characteristics of human beings, industrial plant, the environment, the individual, and the organization (Di Pasquale, Miranda, & Neumann, 2020).

Socio-technical systems (STS) are used to design technology in an effective and safe way for people to improve productivity and eliminate negative effects such as injuries and human errors. Every system that produce goods or customer service that utilizes social system, involving people, and a technical system, including the tools, techniques, and knowledge can be considered a STS.

Occupational safety is strongly related with the health condition and physical work capacity of older workers (Peng & Chan, 2020). Occupational hazards must be managed and identified in order to promote occupational health. Health promotion programs must be provided to older workers to improve their health and work capacity. Physical activity is a good way to reduce the non-fatal chronic diseases and increase work capacity (Peng & Chan, 2020). These programs may include lectures, group discussions, training workshops, presenting training booklets, and pamphlets regarding regular physical activity.

In case of injury, multidisciplinary and active approaches are more beneficiary as opposed to passive approaches (Guest, Boggess, Viljoen, Duke, & Culvern, 2014). In the active approach, supervisors and the workers participate together in developing measures to prevent injuries. This method shows reduced rate of incidence of musculoskeletal symptoms and an earlier return to work for those with sub-acute musculoskeletal injuries.

Job designs role is very important to reduce the stress and increase productivity of the older workers. Better mental health reduces the occurrence of severe accidents (Peng & Chan, 2020). The general implications to improve mental health include job stress prevention and control interventions, establishing positive leadership practices, ensuring work is meaningful, improving mental health literacy, and promoting help-seeking (Peng & Chan, 2020). The main considerations of design for older workers are flexible hours, phased retirement, telecommuting or job sharing or part-time work which can potentially increase the recovery of older people from work (Silverstein, 2008) (Di Pasquale, Miranda, & Neumann, 2020).

2.2 Flexible paced assembly lines to reduce musculoskeletal disorders among older workers

Many industries such as, meat cutting industry, automobile industry, or the manufacture of domestic appliances uses monotonous assembly lines (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020). Operators working in traditional assembly lines do repetitive movements and works under time constraints. This increases the chance of musculoskeletal disorder occurrence of these operators (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020). Traditional assembly lines tend to increase the stress and blood pressure of the workers while flexible assembly lines that are consist of smaller groups that can alter the pace and content of the work impact on stress and blood pressure are reduced (Silverstein, 2008). Flexible assembly lines becomes more popular due to being able to produce customizable products which differ from a reference model by the existence of optional procedures requiring the placement of supplementary components or the performance of additional tasks during assembly (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020). Performing flexible assembly with fixed pace will increase the muscle activity and decreased amplitude and structure of motor and movement variability because the workers accelerate their normal working speed. Increased work pace also causes less time to rest between tasks which will increase the muscle fatigue. Working under these conditions can be challenging for all workers but especially difficult for older workers because of their age related capability declines.

Age related declines causes increased biomechanical loading on the upper limbs during assembly or computing tasks. Older workers have different level of scapular elevation angle of the neck, shoulders, elbow and wrist during computing tasks. Older people have different engaging back movements and movement of the lower limbs during repetitive tasks involving manual handling.

Flexible pacing distributes the work load to several cycles to reduce the negative effects of customized flexible assembly lines. Machine-paced repetitive movements make older worker work at their maximum capacity. This increases the chances of injuries and discomfort. Flexible times allow older workers to adjust their pace according to the tasks and increase their speed temporarily depending on situation (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020). Most of the older workers experience musculoskeletal pain during work. In Europe 55% of the workers continue to work with pain (Richard & Durand, 2020). Having support and leeway in the workplace reduces the absenteeism of older workers whom already have chronic musculoskeletal pain (Richard & Durand, 2020). Reducing some activities and continue to work actually helped them to maintain their health.

The laboratory based study of (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020) which investigated the effect of different pace time effects on different age groups of 25-30 years old and 55-60 years old. Participants were asked to perform a repetitive customized assembly task simulating an industrial process. The pace times divided into two, constrained condition (CC), which workers need to work in a certain time restriction versus flexible condition (FC) which workers doesn't have any time restriction but production penalties if the task completes much longer than the CC. In the end of the study, FC took significantly longer than CC. Under CC, younger workers performed much better than older workers but there was no difference under FC. FC can be a way to negate the effects of ageing in assembly lines. Under CC, both age groups made more production penalties/mistakes compared to FC. Older people performed much better under FC considering production penalties. FC also reduces the muscle activity in both younger and older workers except for few specific muscles.

Flexible pacing improved work performance and reduced biomechanical load during customized assembly (Claudon, Desbrosses, Gilles, Pichene-Houard, Remy, & Wild, 2020). Flexible pacing proved to be beneficial not only for older workers but also for younger workers.

3 The employee

The responsibility of the workers is to take care of themselves to live and work healthy and happy but it is not always possible. Ageing improves certain abilities of people such as, work experience, expertise, wisdom and strategic thinking (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The most severe declines occur in mental and physiological aspects of old people. 70% of the deaths cause by chronic diseases which increases with older age. These diseases make people unable to work or continue a functioning life long before death. There are also non-lethal chronic diseases such as hearing loss and obesity which results in high medical costs. Medical care costs of 65+ aged people are 4 times more than 40 year old person (Silverstein, 2008). For organizations the cost of employing an older person can be even more. These chronic health problems have negative effects on night shift workers after age 30 experience sleeping disorders (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). The chronic diseases may cause absenteeism and productivity, workers' compensation, employee

turnover and replacement, and life insurance benefit costs. Some chronic diseases require ongoing treatment for a long period, implying that they might have to work less. Social support, physical and mental health, and reductions in physical work capacity are critical to reduce severe accidents for older workers (Peng & Chan, 2020). It is also important to adjust job resources and job demands to compensate the age related declines among older workers.

Moreover, lack of flexibility or adaptation to new technology and equipment, slower learning during training, problems in enduring shift work, low productivity over a fixed time span, and high rates of sickness absence are included in age-related problems in manufacturing industries (Di Pasquale, Miranda, & Neumann, 2020).These chronic diseases are effected by blood pressure, body weight, and cholesterol of the person. Health problems such as aneurism makes older people get tired too fast that they cannot function efficiently (Jari Pirhonen & Katariina Tuominen, 2020). These values changes from person to person this causes differences among the same age groups. Promoting healthy habits such as not smoking, healthy diet, and moderate physical fitness can prevent these diseases or delay as much as 10 years (Silverstein, 2008).

The adjustments in personal life can have positive effects on work performance. These changes mostly limit the personal life in order to improve work life (Leijten & van den Heuvel, 2013). Resting after work or limiting weekend activities in order to save energy and refrain from activities that could worsen health complaints are considered as personal adjustments. There are also work style adjustments such as slowing down general work pace to reduce stress, switching task focus in order to increase job satisfaction and/or decrease specific demands, and avoiding certain bodily positions/movements to decrease physical demands.

3.1 Working Hours and Shift Work

Shift work or Night work is a challenging situation for workers to adapt to temporal changes from biological and social aspects because it may affect psychophysical homeostasis (circadian rhythms, sleeping/wake cycle), performance efficiency (vigilance, errors, accidents) and family and social relations; as well as it poses a risk factor for several psychosomatic disorders, in particular gastrointestinal, psychoneurotic and cardiovascular illnesses; hence higher economic and social costs for the individual, the enterprise and the society (G. Costa & S. Sartori, 2007). The tolerance to shift work begins to reduce at the age of from 40 to 50 years. The reasons for such increased vulnerability of aging workers towards shift and night work can be related to psycho-physical, social and working conditions.

First of all, aging decreases ability of circadian adjustment to night work and increase sleep disturbances, so that the effort involved in adjusting from day to night work may become less and less bearable with advancing age. The body clock generates a weaker signal, due to both molecular and functional changes that make it less responsive to light and that make less stable the circadian system thus resulting in a decrease of the amplitude and a higher proneness to internal de-synchronization of the various circadian rhythms. Hence sleep troubles in particular are higher in aging people and more in aging shift workers. The natural reduction of the length of the main night sleep, the earlier wake up and the reduced quality of sleep increase sleepiness and napping of aging

people during the day. On the other hand, the increased morningness makes more difficult to sleep during the day after night work, due to the more advance rise of the circadian rhythm of body temperature (G. Costa & S. Sartori, 2007).

From the gender point of view, it appears that the shift work affects women shift workers more than it does to male ones, which can be explained by psychophysical constraints they have to face in relation to their family commitments, hindering their coping strategies and compensative actions (Costa, 2005).

Considering from a social point of view, the shift work tends to put the workers away from social life. Especially the shift work on weekends interferes with mass programmed events such as games, ceremonies, gatherings, concerts etc. thus hindering the participation and integration of aging workers into the society. Eventually this decreases the tolerance to fatigue and ability to cope with the stress due to shift work.

Shift work can be a triggering factor for some disorders such as sleepiness, sleep disturbances, reduced physical fitness, chronic fatigue and oscillatory fluctuations of alertness which can significantly influence work ability, and contribute to "human error", leading to consequent work accidents and injuries. Thus there is an obvious difference between work ability index scores between day and shift workers. On the other hand, it has to be taken into account that aging people require a stable life regimen and a regular timing of food and drug administration. So, they are likely to suffer from adaptation and tolerance to irregular working hours.

Considering all those factors supporting age discrimination or unequal treatment at workplace of older workers, the managers and ergonomists are obliged to consider ageing workers as more vulnerable subjects in relation to shift and night work and introduce new measures such as working time arrangements taking into account the worker's personal preferences. Besides there are some specific recommendations for aging workforce by (G. Costa & S. Sartori, 2007)

(a) Consider possible limitation or abstention from night work after 45–50 years of age;

(b) Give priority to transfer to day work

(c) Let choice of the preferred shifts (e.g. morning shifts)

(d) Reduce work load

(e) Shorten working hours and/or increase rest periods

(f) Arrange more frequent health checks

(g) Give proper counseling and training on the best coping strategies concerning sleep, diet, stress management, and regular exercise.

To sum up it is mandatory to introduce flexible and personally customized interventions in order to give ageing shift workers a sufficient support for maintaining satisfactory work ability and to avoid age discrimination and work disability related to shift work.

There are also differences among sex; women have lower WAI values in general compared to men. This is because of the 'double work burden' where they have a paid employment and most of

the share of the domestic load (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). Child care reduces women recovery time from work and the sleeping time.

The cognitive changes come with age makes older workers process information slower than younger workers. According to (Silverstein, 2008) there are some guidelines to support older workers in this manner:

- Providing 2 times the amount of time to train older workers to allow self-paced learning.
- Use visual mediums for spatial skills.
- Minimize distractions and background noises.
- Avoid high working memory (ex: drop down menu on computers).
- Instant feedback for fixing mistakes.
- Use step by step format for how-to applications.

3.2 Training

Education does not end after graduation from a vocational school or university, in order to stay relevant with the new technologies lifelong learning and vocational training must continue throughout career of employees (Piatkowski, 2020).At all ages training is a way to improve cognitive and physical capabilities. Different training methods will be more optimal for different age groups considering older people can learn new skill too but it is slower (Patrickson & Ranzijn, 2005). Although ageing doesn't directly decrease the work motivation, yet it reduces motivation for some tasks such as training because with older age people are less adaptive to new tasks (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020). With training older workers can outperform younger workers but it doesn't change the fact that age related losses will continue (Silverstein, 2008). Lack of training can be a barrier for older worker's employment. 80% of the older adults aged between 51-76 years, would like to return back to work but 50% said that they lack the required training (Taylor & Bisson, 2020). Experience is the key factor to compensate the age related capability declines, which increases by training (Di Pasquale, Miranda, & Neumann, 2020). The older workers that have many years of experience in a specific job, may increase their knowledge base and awareness, and learn new information which improves their performance. Training is also beneficial for older workers whom are already employed. Older people are paid more in organizations but they are susceptible to job cuts because of it (Taylor & Bisson, 2020). Learning new skills and knowledge may prevent these cuts and increase their value in the organization. Training is also another way for older workers to be part of active, engaged ageing beside their economic benefits.

For organizations to be competitive in the market proper training has an important role at all stages of workers career. The design of training programs should address all age groups but understand the needs of the older workers which are growing up in numbers. Age discrimination can be very problematic for organizations because of the costly ligitation. Proper training programs benefit organizations to negate the age discrimination. Organizations believe that it doesn't worth

the cost to train older workers because of the reduced employment time (Patrickson & Ranzijn, 2005). Organizations also see trainability of older workers is very low (Lee, Czaja, & Sharit, 2009). In U.S. yearly training time of workers aged between 25-34 years have 37 hours training while the workers aged 55 or older receive only 9 hour per year (Taylor & Bisson, 2020). They get less support form organizations for learning and development activities (Lee, Czaja, & Sharit, 2009). However younger workers tends to change job more often compared to older workers that trained and have experience over a specific job for many years. In U.S. 32.8% of the older workers that are train in various positions in organizations continued to work in the same organization in 4 years, on the other hand only 6.1% of the younger workers remained (Taylor & Bisson, 2020). This shows that older people even after 50 years old are more loyal to the organizations than younger people who change job every 3-4 years (Patrickson & Ranzijn, 2005). Willingness and motivation for training and self-improvement is an important factor for a successful training (Lee, Czaja, & Sharit, 2009). Ageing seems to negatively affect motivation for self-improvement.

Training methods that include exercises to guide attention may help to reduce the effects of decline in working memory by the selective allocation of attention resources (Di Pasquale, Miranda, & Neumann, 2020). Many papers suggested that experience improves performance of the worker, reduced human-system errors and productivity of the organization by. Organizations that utilize the training of their workforce will have experienced older workforce which will be beneficial in long turn. In the words of (Laflamme & Menckel, 1995), “skills and experience can compensate for age-related physical and cognitive declines only when the job demands remain lower than overall work capacity and that this compensation is not feasible when work organization and working methods are rigid”. Older workers seem to prefer trainings in groups where they can learn and share knowledge with colleagues (Lee, Czaja, & Sharit, 2009). They also performed better with hands-on and active learning trainings. Older workers reported that constant feedback on correctness is important for them to learn much faster (Lee, Czaja, & Sharit, 2009).

3.2.1 Training of cognition and information processing

During training trainee uses it’s cognitive and information processing capabilities to interact with the design and presentation of the training program, in order to predict the learning outcomes (Taylor & Bisson, 2020). The most critical areas of cognitive training are literacy, information technology ability, problem solving, and numericity. Training demands workers to do problem solving in the specific are to attain new knowledge about their jobs.

The training performance and outcome are strongly related with the trainee’s fluid and crystallized intelligence, this makes evaluating these measures important to oversee the job and training performance (Taylor & Bisson, 2020). General reasoning ability, or G, which is strongly related to fluid intelligence test measure is used to predict the training performance of the workers. It also has small relation to predict the crystallized intelligence which is referred as ‘Gc’ but it requires the use of crystallized intelligence in order to solve new problems and puts demand on the fluid intelligence which is ‘Gf’. According to (Taylor & Bisson, 2020), the correct evaluation of these G-based test measures has productivity coefficients from 0.31 to 0.77 in predicting performance in training. “In occupations ranging from pilots to entry level technical occupations in health, science, and engineering, to firefighter performance, rendering G loaded tests our best predictor of training

performance" (Taylor & Bisson, 2020). It also shows that matching the test results with the demands on crystallized and fluid intelligence improves the outcomes of the training.

Training often requires abilities such as an efficient psychological refractory period, ability to use inductive reasoning, increased working memory capacity, and manipulation of new information. These demands are connected with fluid intelligence which known to decline starting from early adulthood (Cognitive changes page: 18). This makes training older workers harder compared to younger workers. The new materials represented during training may decrease the effectiveness of the training; on the other hand training programs that utilizes the familiar materials related with their jobs to teach new skills may have positive effect since they can use their crystallized intelligence in order to compensate the losses in fluid intelligence. Although it is questionable that crystallized knowledge will be helpful to learn new knowledge and skills.

Declines in working memory should be considered when designing the training for older workers. As explained in the section Processing speed pg:19, While recall of information is effected from age, recognition of information is unaffected. This makes multiple choice decisions easier for older workers both in training and also at work (Taylor & Bisson, 2020). Older adults becomes more dependent on external sources to improve their memory, these can be lists and notes. This makes easier to train older trainees if external memory resources are used.

3.2.2 Implications for training according to the age related declines

Training requires cognitive and information processing abilities to be effective, this makes training older workers more challenging due to their declines in these areas (Taylor & Bisson, 2020). However, the design of training in order to master a new skill or information, considering the cognitive and information processing demands, may be effective not only for older workers but also all age groups.

To design an effective training program changes in fluid and crystallized intelligence should be the main concern. There are recommendations made by (Taylor & Bisson, 2020), in order to design an effective training for older workers. It is also considered the relevance of cognitive skills to the training environment. It is possible to improve the training effectiveness by taking in to account the declines in information processing ability and fluid intelligence.

1. The materials provided in the training program should be divided in to modules that consider the differences in knowledge and experience among workers. For beginners that are learning a new area of work should start with the basic vocabulary and the structure of the job or process. On the other hand experienced workers can skip this module and start from the intermediate level, which contains familiar materials that reduce the demand on fluid intelligence and rely on crystallized intelligence. Fitting the training according to the level of worker will increase the efficiency of the training program with better learning curve.
2. Self-paced training may help older workers to understand and learn training tasks much effective. Older adults perform better when the learning demand is splinted in to time interval instead of constrained time training. Giving workers few days to study the material will result in better test performance compared to testing right after

showing new information. Self-paced training is considered one of the best ways to compensate the age related declines seen in older workers.

3. Older workers require more time to complete tasks in training. Allowing this extra time will result in better learning and increased efficiency of training. Reduced time pressure to finish tasks closes the gap between older and younger workers. Older people can sacrifice time for more accuracy (Lin & Ho, 2020). However, in technology use both of them required simultaneously.
4. Provide memory aid for older workers. Without any memory aid it is difficult for people to remember more than 4 novel items. Older workers can use external memory aids in order to reduce the effects of memory declines and improve their learning. When allowed external materials for older people, during the training older and younger workers performs similarly (Taylor & Bisson, 2020). Older workers also rely on external sources more often than younger workers, this show that external sources are helpful for older workers to keep up with younger counterparts.
5. Practice and repetition of the training materials improve learning of older workers. Working memory capacity is increased by practice for job-specific tasks. Practice is more beneficial for older workers to improve the outcomes of training. Organizations should give extra time to practice on the tasks that require working memory. The practice should continue until the benchmarks are completed by all trainees.
6. Multiple training sessions are better compared to longer single session training. Repetition increases the probability of transferring the information to long-term memory. Splitting the training will reduce the demands on fluid intelligence, this increase the performance in training. Breaks between the sessions provide extra time for trainees to screen the training material and learn faster. Fast training that are done after period of time from the initial one are called “booster training” which improves the learner’s outcome.
7. Encouraging questions during the training will make the information retranslated and easier to understand for older workers. Questions also repeat the important information for the trainees which increases the learning outcome. Another aspect is that trainers that have good relations with their trainees increase the commitment of the learners to the task. Questions and instructors style is important to form this relationship.
8. Highlighting the critical information and eliminating the unnecessary information presented will reduce distraction and improve attention. Highlighting critical information will benefit older workers since their selective attention is declined due to age. In the selective optimization with compensation model, older workers selectively focus on what is most important, work harder to perform well in those top-ranking areas, and rely on external aids to cope effectively.
9. When training involves repeated appointments and/or different locations, provide reminders and map links via email, text, or posted calendars.
10. The attention of the older workers decrease with age. Clear identification of the goals and the purpose of the training may help older trainees to pay attention to the relevant parts of the training. This helps them to organize and remember information efficiently. This may also improve the motivation of the trainee, since they will know when the new and demanding information will occur. Explaining the utility of training

for additional opportunities within the firm can enhance their involvement in the training session. The identification of the training opportunities and personal development may increase the engagement and motivation of the workers.

11. If individual modules are presented, a brief summary of each module, its relationship to the previous module, and its relevance to training goals should be noted.
12. Training programs with simulated tasks were found to benefit senior users in using mobile smart device (Lin & Ho, 2020). Also older people prefer dragging tasks more than rotation using interfaces.

3.2.3 Animated Graphics

There are numerous studies which have shown that graphics can improve comprehension, insight and learning. The aging workforce may benefit it in order to adapt new technologies and possess faster and persistent learning skills (Lai, 2012). Since a simple image or animated graphic can replace long textual descriptions, a more efficient way of processing information is achieved, avoiding cognitive overload (Lai, 2012). There are two types of graphics: static and animated. In order to compare them with classical learning "learner produced", an experiment was conducted on 185 participants by (Lai, 2012). There are three categories:

• Learner produced: the learner is given a textual description then associates it with the new, to be learned information, developing their mental imagery.

• Static graphic: a picture or chart is presented to the learner.

• Animated graphic: a demonstration of motion of a process is presented.

The focus of the study is to examine compare each of these three categories of graphics across a single complex learning task for both immediate and longer retention time periods. As a result, participants in each of the graphic interventions showed significantly greater levels of performance than individuals who did not get any graphical description. Those receiving text and graphics consistently outperformed those who received textual materials only. Moreover, it was observed that the graphics helped the participants to keep and recall in the long run.

Another study has been performed to interpret the psychomotor tasks to be conducted on tablets based on the Cognitive Load Theory (CLT) and interaction principles. The current generation of tablets contains dual or even quad-core processors, accompanied by powerful graphics processing units that can display detailed, 3D rendered graphics on large multi-touch interfaces. Thus, they have developed quite useful especially for psychomotor training and assembly tasks, thanks to the benefits of the new technology such as augmented reality, virtual reality, and gesture-based tablet computing (Marraffino, Killilea, & Singer, 2012).

In case of assembly tasks, the sequences of the actions, controlled movements of the body and proper coordination of manipulation of components are crucial to be successful. Additionally, a certain level of knowledge of the relationships among the components or objects being assembled is required (Marraffino, Killilea, & Singer, 2012). Examples include assembling a car engine or a weapon system. In order to overcome the complexity of assembling tasks, those assistive tablets provide a

learner centric environment which describes a lifelong, adaptive and individual learning alongside supporting critical thinking in the operational environment.

Various types of interactivity with respect to the interface of tablets:

- Interactive animations: the user makes a simple input, allowed just to start, stop or control the pace of animation.
- Dynamic Automated Graphics (DAG): apart from interactive animations, it also contains making menu selection, tapping on a component on a touch screen. The animation wouldn't be controlled after initiation; the order of the steps of the task is most significant.
- Dynamic Interactive Graphics (DIG): the graphics can be manipulated and translated through digital space, but only through active and appropriate effort from the user.

According to multiple studies, the animations have proven to be more effective and better tools than presentations of static images or texture in case of performing assembly tasks, training and teaching.

To explain the effectiveness of animations to train psychomotor tasks, cognitive load theory was developed as a framework to describe how learners process information from working memory to long-term memory. There are three types of cognitive load: intrinsic, extraneous, and germane, which are additive (Marraffino, Killilea, & Singer, 2012). Intrinsic cognitive load is the effort associated with a specific topic, extraneous cognitive load refers to the way information or tasks are presented to a learner, and germane cognitive load refers to the work put into creating a permanent store of knowledge, or a schema. If the three loads exceed the capacity of working memory, learning does not occur. Since the interaction allows the individual to control the pace of the instruction, it has a significant effect on the learning process. By reducing the learner's cognitive load on working memory, it increases the capacity for processing new information into long-term memory.

DIGs and DAGs represent different level of interaction with graphics and animations. DIGs are the most interactive; every manipulation of the graphical representation is controlled by the individual (Marraffino, Killilea, & Singer, 2012). Individuals control the pace at which they learn the psychomotor task which decreases the amount of cognitive load. However, there is also drawback to using DIGs. The learner is free to engage in exploring how the components interact with each other by moving them across the screen. Unfortunately, this may not provide enough contexts for learning to occur. Even though DAGs behave as DIGs, they have a significant advantage over DIGs. DAGs can neglect potentially distracting information that can be present in animations, allowing the learner to focus on the task at hand. To sum up DAGs and DIGs can reduce cognitive load placed on the learner by allowing them to more precisely control the interaction of the animations.

3.2.4 Training for fourth industrial revolution

With integration of smart manufacturing, digitalization, and industry 4.0 highly repetitive and routine jobs will be handled by robots and automation. The workforce occupied with this kind of tasks will most likely lose their jobs or need to be reassigned to new tasks which utilize creativity,

innovation, and social interaction. The speed of new technological developments is so rapid in today's world and will increase speed in the future. To adapt the integration of new technologies that change in daily basis demands higher level of skills and knowledge, thus lifelong learning and continues vocational education is required for employees (Piatkowski, 2020). Older workers that are not experienced the need of technological knowledge will have to engage in continues training activities in order to stay relevant in the work force (Lee, Czaja, & Sharit, 2009). Organizations that invest in training their employees will benefit from increased capital and able to enter new markets.

Science, math, technology, and engineering fields will be the main focus of education requirement for future technologies. The labor market in 2020 estimated to be in shortage of 1 million workers that has the required abilities in these fields (Piatkowski, 2020). The workforce that is capable enough in these areas is desired by organizations constantly. This increases the importance of training investments in these areas at every stage of career including current employed personnel. Older employees are considered less adaptive to changes and lower learning capacity compared to younger employees. Understanding their needs to implement lifelong training and continuous vocational training is crucial for future success of organizations (Piatkowski, 2020). Unfortunately, organizations still consider lifelong training of both older and younger workforce as an additional cost instead of requirement.

4 Social support

The work performance depend not only the factors at work but also on the workers daily life which becomes more challenging with ageing. Since ageing makes vision and hearing worse driving can be a challenge for older workers. Public transportation or carpooling can be adopted for safe travel to work. Some of the older workers have other responsibilities such as caregiving for a sick or disabled relative (Lee, Czaja, & Sharit, 2009). There are also psychological effects, if an older worker worries about well-being of his/her older spouse cannot perform highly at job. Organizations may find solution to these problems by work based carpooling and elder care benefits. (Peng & Chan, 2020) mentions the importance of social support in order to reduce the injury rates and poor mental health among older employees. Family support and family motivation have positive impacts on adoption of health behaviors by workers, but work–family conflict is a barrier to behavior change of health promotion programs (Peng & Chan, 2020).

Visibility is another aspect of social support. Lack of visibility is that supervisors and colleagues are not paying attention to the health problems of older workers. Ignoring the health problems can increase the severity and lead to absenteeism.

Assistive technologies and Wearable devices

Technological development advances rapidly in today's world. It was inevitable that wearable technologies would arise that support humans especially workers in their jobs and life. It is

potentially one of the ways that can help older workers by supporting their autonomy and improving their life quality both in life and work (Farivar, Abouzahra, & Ghasemaghaei, 2020). These devices not only support the physical activities but also give useful data about the user such as their nutrition, health records or sleeping habits. It is highly beneficial for older adults to use high mobility technological devices in order to track or remind them the self-management of various diseases and encouragement of healthy behaviors (Lin & Ho, 2020). Smart watches have an important role for tracking and monitoring older peoples health conditions. Online services becoming more popular for public and private health care providers (Jari Pirhonen & Katariina Tuominen, 2020). These devices can monitor chronic diseases and conditions and give useful advice or training programs for rehabilitation or reduction of symptoms (Lin & Ho, 2020).

Usage of digital technologies

Digitalization is seen as solution for increased care and pension costs of older people (Jari Pirhonen & Katariina Tuominen, 2020). The new technologies can rearrange public services, time schedules and tools for self-care more effectively. Technology allows people to work or entertain remotely which can be beneficial for older people whom have difficulties to travel. In 2020, Covid-19 also showed us the importance and the possibility of remote working for all age groups.

Digital technologies also improve the social participation such as, interactions with others, a community, or society (Fischl, Lindelöf, Lindgren, & Nilsson, 2020) where without these technologies it will be much difficult for older people and leads to social isolation (Lin & Ho, 2020). Technology also allows older people to keep in touch with their families more often since it is difficult to meet in person because of the routine daily jobs (Jari Pirhonen & Katariina Tuominen, 2020). Digital technologies that can be used for social interactions can be listed as: personal computers, smart telephones, and computer tablets, the software in these devices, as well as the Internet and World Wide Web (Fischl, Lindelöf, Lindgren, & Nilsson, 2020).

Today most of the everyday services are becoming internet-based and this trend seems to increase in the future (Jari Pirhonen & Katariina Tuominen, 2020). For example, many banks are promoting their clients to use online services with their pricing policies to reduce face-to-face contact. In Finland, most of the people handle their tax affairs online which is encouraged by the government (Jari Pirhonen & Katariina Tuominen, 2020). They are also using electronic prescriptions which are mandatory in every pharmacy. Integration of internet in daily life services can only be possible with availability of infrastructure and affordability for new technologies. Government's policies play an important role since these availability condition changes for each country. The lower socioeconomic group of older people will most likely be excluded from the benefits of digitalization (Jari Pirhonen & Katariina Tuominen, 2020).

These technologies have potential benefits in health and well-being of older people. However they are hesitant to use these devices because of their complexity and their declines in cognitive and physical capabilities. Just monitoring health of the older people is not enough to compensate their loss of physical capabilities. To help them in their daily and work life there are exoskeletons which supports their body posture and applies assistive force if needed (Sharit, 2020). Even if it seems perfect for the older workers they have their own set of problems. It is also not studied well enough

in general and especially for older users even though their potential benefits (Farivar, Abouzahra, & Ghasemaghaei, 2020).

Willingness to use wearable devices by older workers

It should be considered that every person is different and how much their mental and physical capabilities declined through aging. Although the benefits of wearable and assistive devices the adoption decision among older people depends on perceived usefulness and ease of use (Lin & Ho, 2020). Age related declines effects the willingness to use wearable smart devices among older people (Lin & Ho, 2020). Despite the fact that people aged 65 or older use technology less frequently, digitalization seems to have an positive effect on older people's life (Jari Pirhonen & Katariina Tuominen, 2020). According to the article published by (Farivar, Abouzahra, & Ghasemaghaei, 2020), there are three factors effecting the intention to use wearable devices among older adults. These are complexity, cognitive age and subjective well-being.

1 Cognitive age

It is know that cognition and information processing is reduced by age (Farivar, Abouzahra, & Ghasemaghaei, 2020). The age we consider in our society is the chronological age which is the time passed since birth is not a relevant for measuring if the senior is willing to use wearable devices. Chronological age is an index and is not direct cause of behavioral change (Zacher, 2015). The deciding factor is more likely their cognitive (biological) age which is the self-perception of individual's age. Every person experiencing age differently this creates a distinction between biological (cognitive) and chronological age (Di Pasquale, Miranda, & Neumann, 2020). Age should be treated as a dependent variable of specified aspects or parameters of the function describing the changes which occur over age for a given behavioral variable (Zacher, 2015). The effecting factors of cognitive age are diet, exercise, and sleeping habits refer to how old or young a person feels. Depending on these factors age related changes can be positive (gain of skills), negative (loss of skills), or curvilinear (gain followed by loss and vice versa) (Zacher, 2015). Older people with younger cognitive age reported fewer depressive symptoms, slower cognitive decline, better physical health and capabilities. The older people whom see they belong to younger age group or feeling younger are more willing to use new technologies (Farivar, Abouzahra, & Ghasemaghaei, 2020). The older people that are unwilling to use digital technologies are reasoned their age, health status, or difficulty to learn new things (Fischl, Lindelöf, Lindgren, & Nilsson, 2020).

2 Complexity

The perception of complexity plays an important role for older workers to adopt using wearable devices. Complexity of the device is another factor determining the will to use it in older aged group. Complexity is relative measure which people thinks the innovation is difficult to use or understand compared to others (Farivar, Abouzahra, & Ghasemaghaei, 2020). So for older workers the more complex the technology is the willingness to use reduces significantly. Many of the people above 65 years of age are 'digitally disengaged' because of increased complexity and reduced capacity (Fischl, Lindelöf, Lindgren, & Nilsson, 2020). There are two type of complexity considering the usage of wearable devices. Input complexity is the type that the difficulty perceived by the user

to give input data to the wearable device (such as weight, height). Output complexity is the type that the difficulty perceived by the user to read the output data from the wearable device (such as hearth rate, distance walked). For example, automated telephone access to healthcare services seems too complicated for older people to handle (Fischl, Lindelöf, Lindgren, & Nilsson, 2020).

3 Subjective well-being

Subjective well-being is also considered to determine the intention to use wearable devices. Subjected well-being is the individual's evaluation of their lives (Zacher, 2015). People that has positive subjected well-being evaluate their lives are going well (Farivar, Abouzahra, & Ghasemaghaei, 2020). Subjective well-being considers three aspects to evaluate; Agitation describes anxiety and worries; attitude toward aging refers to individual's perceptions of the changes in their lives as they age; and dissatisfaction measures how dissatisfied are individuals with their lives (Farivar, Abouzahra, & Ghasemaghaei, 2020). It is expected that the higher the individual sees their subjected well-being the more they are passionate for their lives and reaching goal which has should have a positive impact on adopting wearable devices and lower levels of subjected well-being they people show more anxiety and stress which makes the more hesitant to try new and uncertain technologies. Higher subjective well-being also means higher accessibility to digital technologies both financially and more leisure time (Fischl, Lindelöf, Lindgren, & Nilsson, 2020). It is possible that subjective well-being is affected by digital inequalities. The people that don't use or rarely use digital technologies often live in rural life, have lower education, and have lower income (Fischl, Lindelöf, Lindgren, & Nilsson, 2020). The cost of the products and family support also influenced smart device adoption (Lin & Ho, 2020).

According to the report made by (Farivar, Abouzahra, & Ghasemaghaei, 2020) which is based on a survey made to 280 older people, the lower subjected well-being in a person increases their intention to use wearable devices. They also find that the relation with subjected well-being and cognitive age to be reverse so the lower subjected well-being a person has the higher they think their cognitive age and more willing to use wearable devices. If the subjected well-being is high cognitive age has negative effect. According to complexity only the output complexity has a negative effect on willingness to use wearable devices. There was no evidence that input complexity affects the intention to use.

				Intention
Subjected well-being	High	High	Cognitive age	Lowest
	High	Low		Good
	Low	High		Best
	Low	Low		Low
Output complexity	Higher			Negative effect
Input complexity				No effect

Table 8 Relation between subjected well-being, cognitive age and complexity to intention to adopt wearable devices

Exoskeletons

Physical decline is one of the main characteristic of ageing. Older people have lower energy to spend, muscles get weaker reducing the lifting and carrying capacities, joints lose their mobility and

bones lose their flexibility results in more fatigue. These devices made to improve their physical abilities to increase their quality of life (Farivar, Abouzahra, & Ghasemaghaei, 2020).

Supporting the physical features that declined and improving their condition can be achieved by exoskeletons. Exoskeletons are wearable devices that support the body posture, provide aid in physical activities by additional force and torque (Sharit, 2020). Older workers can benefit from this technology that increases their declined physical capabilities and perform the jobs that are difficult for automated machinery. Although these wearable devices can benefit the older workers they seem to be more appealing to younger counterparts. Only 3.3% of the users are 65+ aged while 17% are aged from 25 to 34 (Farivar, Abouzahra, & Ghasemaghaei, 2020).

There are two types of exoskeleton, passive and active. Passive exoskeleton provides only assistive forces that reduce the load on the body and support the posture by springs and elastic bands that can store and dissipate energy (Figure 10). Active type has actuator that also creates additional force and torque to help the physical activities such as lifting and carrying (**Error! Reference source not found.**). The aiding force can be controlled on demand according to the performed task.

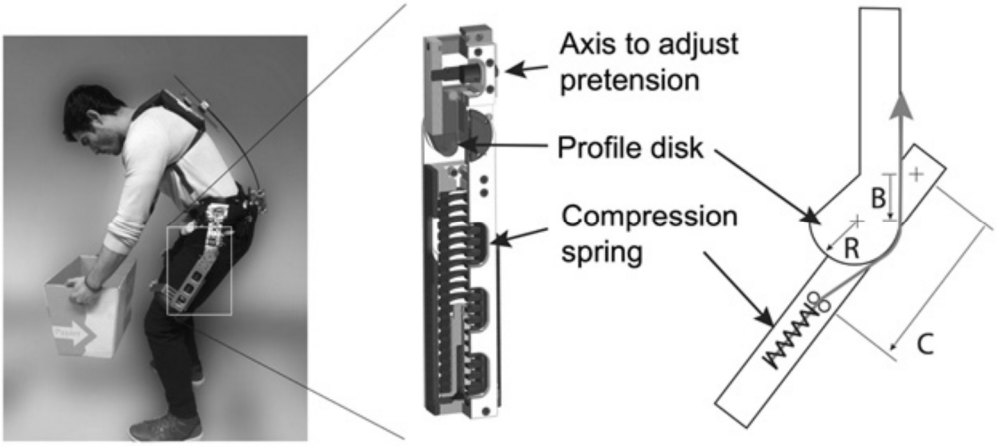

Figure 10 Picture of the spring-based, passive hip actuator on the SPEXOR exoskeleton prototype The right side illustrates the coil spring, which is compressed during hip flexion. (Sharit,2020)

Figure 11 ***Picture of the parallel-elastic actuator on the Robo-Mate active trunk. The spring is implemented with a bungee cord and acts in parallel to a gear motor, hidden by the black cover in this picture*** **(Sharit, 2020).**

The direction of the assistive force is also important distinctive factor. Perpendicular forces, compared to parallel forces, do not create forces that will load the lower back that might injure the spinal discs. Parallel forces are generally created by exosuits which are not rigid bodies but body segments that pull two body parts together by elastic cables or bands. Exoskeletons are consisting of rigid frames that actuators connected to the body by parts worn by people. Rigid frames are parallel to the body and create perpendicular forces. The counter weights placed on the shoulders pull the upper torso back to support the back extension. For example, carbon fiber rods can be used which act both as force generators as well as structures to transfer forces between the user's pelvis and torso (Sharit, 2020).

Active exoskeletons are mostly used for heavy weights that require an assistive force to aid the movement while the passive exoskeleton is only for supporting the posture of the body and support the body under lightweights. Although there are none rigid exoskeletons which seem not very supportive but they are easy to wear especially under the working clothes which are psychological better for the older worker. They also doesn't create the connection problems that caused by the connection of rigid body with the human joints.

1 Examples of the use of exoskeletons for work operations

Some factories and businesses have already been invested in exoskeletons. EksoVest is a passive exoskeleton that is used in Ford factory. This exoskeleton supports the upper body by easing strain when lifting and performing overhead tasks which some Ford employees, including older employees, perform up to 4,600 times per day (Sharit, 2020). EksoVest is currently being tested in U.S. and planning to expand in Europe and South America. Lowe's, which is the second-largest chain of home improvement stores in the U.S., is exploring the use of an exoskeleton that combines soft and rigid components in a pilot program at one of its stores. This exoskeleton is intended to help workers offset some of the strain on their muscles and joints as they pick up and move heavy and awkward items (e.g., bags of cement or paint buckets). Another example of the usefulness of exoskeletons for work operations comes from a Japanese hauling company (Tatsumi Shokai

Logistics). This company has invested in an exoskeleton that assists many of their older employees in their frequent loading, unloading, carrying, and bending tasks (Financial Tribune, 2016), thereby enabling them to keep working as efficiently as they can for as long as possible.

2 Challenges for Older Workers in Using Exoskeletons

Exoskeletons are newly emerging technology and there is not user involvement during the design and development. Although it can be used in many fields such as military, rehabilitation or supporting older adults, using them with older workers in industries should bring extra precautions. The development of standards and regulations to support the use of exoskeletons in the workplace are only just beginning to emerge (Sharit, 2020). The devices should be easy to put on, comfortable to use and prevent falling.

Exoskeletons may have many benefits but these devices can be as much as harmful if not made correctly. Design of the active (rigid) exoskeletons is very important to minimize the harmful effects because the misalignment of the exoskeletons and the human joints may generate forces that cause discomfort. Also the assistive forces that support the body such as torso and legs can create reaction forces on the user's pelvis, lower back or abdomen (Sharit, 2020).Also the actuators of the rigid exoskeletons limit the movement of the user the particular reason for this circumstance is their large size and weight. Passive (soft) exoskeletons on the other hand create unwanted compression forces on the spine and joints which are already fragile in older workers.

Another challenge is the need of control of the active exoskeletons. There has to be a control mechanism to initiate the assistive force. Measurements from environment or user should be obtained. Electromyography can be used to capture data from the user or a control panel that the user input the information.

For older workers not limiting the movement and preventing discomfort is very important to improve the usability. Design of the exoskeleton plays an important role to minimize these effects. Forces acting on the body should be distributed and materials used should not create heat from continuous usage. Exoskeleton also required adjusting for different bodies which is another consideration for design. Sensors can be implemented on the exoskeleton to obtain information about the activities of the user and do adjustments accordingly (Sharit, 2020).

Advantages of digitalization for older people

It is evident that technology and digitalization is a strong tool to make daily life easier for all age groups. For older people it can be a useful tool to improve their quality of life. They can track their health, use it for disease control (Lin & Ho, 2020), get electronic prescriptions from public and private health care (Jari Pirhonen & Katariina Tuominen, 2020).

1 Improvements in everyday life

The most outstanding benefit seems to be the accessibility to different information from internet (Jari Pirhonen & Katariina Tuominen, 2020). Older people can get information about certain illnesses and health care, guidance and information about their hobbies, as well as social contacts

and entertainment. Older adults use internet and smart devices also for entertainment such as, playing video games, watching videos, and getting information about their hobbies and sports. Digitalization makes the errands much easier by lowering the queue times and smoother interactions. Banking operations are becoming highly digitalized in most of the developed countries (Jari Pirhonen & Katariina Tuominen, 2020).

2 Improvements in communication

Other than the potential benefits of digitalization mentioned above, it can be a strong tool to maintain and create new social contacts for older people (Jari Pirhonen & Katariina Tuominen, 2020). It is easier for older people to keep in touch with their relatives living far away or another country. The communication soft wares such as WhatsApp and Skype mentioned by older people as a tool to communicate much cheaper with their child working abroad (Jari Pirhonen & Katariina Tuominen, 2020).

Disadvantages of digitalization for older people

Although their potential benefits there are some drawbacks of digitalization and some reasons for older people to not willing to use new technologies mentioned in the section 'Willingness to use wearable devices by older workers' page:56

1 Rapid development of technology

The potential benefits of digitalization cannot be discarded but the rapid development of new technologies makes older people harder to adapt. Many of the older people require help from a relative or a friend in order to get used to new technologies (Jari Pirhonen & Katariina Tuominen, 2020). Older people needs clear instruction in order to use smart devices. It is difficult for older people to track the changes and relations smart devices and digitalized world. The age related physical declines merged with rapid developments in technology makes it harder for older people to feel relevant in digitalized world (Jari Pirhonen & Katariina Tuominen, 2020). The fast developing technologies also cause older people to have anxiety about how fast they were expected to adapt.

2 Effects of age related declines on technology usage

Many older people have problems using technology because of their age related declines in both physical and cognition. These problems occur in accessibility, design and physical characteristic of the technology. Older people that have shaking hands have problems using the cursor correctly (Jari Pirhonen & Katariina Tuominen, 2020). The tiny texts written in smart devices makes older people demotivated to use them. Because of the age related declines in vision it is much harder for them to read tiny texts. The recommendation made by (Lin & Ho, 2020) can be adopted in order to create a better usability for older people (see: Smart device usage page: 41).

3 Inequalities of accessibility of digital technologies

Older people may face with problems while using digital services. For example, in developed countries most of the banking actions are done by using internet services. Older people go to banks if they cannot complete their task by using internet. Banks charge extra fees for people that don't use online services which is difficult for older people (Jari Pirhonen & Katariina Tuominen, 2020). This

forced intention of organizations make older people feels discarded. Even relatively modest steps towards, for instance, automated phone-based services and more regular updating of their information in the health and social care system, were experienced as burdensome and irritating for older people.

Older people are heterogeneous group and their socio-economic situation is different. Some people cannot afford the computer setup or internet bill which makes life difficult for them in digitalized world. The people that don't have access to digital technologies often live in rural life, have lower education, and have lower income (Fischl, Lindelöf, Lindgren, & Nilsson, 2020). The gap between rich and poor will likely to increase with the world becoming more digitalized.

Industry 4.0, Automation, Digitalization and Smart manufacturing

Industry 4.0 is considered the fourth industrial revolution in which smart manufacturing systems will combine digital production, network communications, computer technologies and automation (Piatkowski, 2020) smart manufacturing technology, cyber-physical infrastructure, and data control systems to realize predictive and adaptive behaviors (Di Pasquale, Miranda, & Neumann, 2020). Automation of the work activities replace workforce with robots, artificial intelligence and sensors. Today the processes that can be automated are not many. 60% of all occupation has potential of 30% to be automated and this number will increase to 50% in two decades (Sharit, 2020). The changes in the areas such as, Internet of Things (IoT), Internet of Services (IoS), CPS (Cyber-Physical System), robotics and artificial intelligence, Big Data, cloud computing and augmented reality will be the base of industry 4.0 (Piatkowski, 2020). The organizations that utilize this new technology will benefit from higher product quality and production efficiency.

Industry 4.0 generally associated with increased efficiency in production but it will have major impacts on labor market and transform the demands, as well as the required skills of employees (Piatkowski, 2020). Adoption of industry 4.0 will change the requirements of jobs by changing work dynamics of the operators, creating new interactions between humans and machines and form strong connection between digital and physical world. The use of direct input devices, such as touch screen and eye-gaze input, can improve the performance of older users throughout from the simplest to the most advanced digital devices (Di Pasquale, Miranda, & Neumann, 2020). These devices don't require a spatial or spatiotemporal link between the motor activity performed by the user and the calculated position of the cursor on the screen. Although it should be considered that demands of these devices have different requirements on people's capabilities which make compatibility between the device demands and worker abilities play important role to determine the performance increase. This new revolution will require new design and engineering approaches for production systems that uses robotics, automation, digitalization and other technologies in order to enhance and augment the capabilities, such as cognitive and physical, of humans. With emerging intelligent manufacturing plants there will be necessary changes in employee professional qualifications and competences such as digital skills which require continuous professional development (Piatkowski, 2020). The workers of the future will be considered smart and skilled

operators that can perform tasks in cooperation with robots and work aided machines, and also be able to use advanced human-machine interaction technologies, human cyber-physical systems, and adaptive automation aimed at providing human–automation symbiotic work systems (Di Pasquale, Miranda, & Neumann, 2020).

When considered the rapid advances in technology, it is not a surprise that automation will redefine the jobs of people. Organizations need to use both workforce and the automation in optimum way to perform the tasks by maximizing their joint information processing, decision making, and control behaviors (Sharit, 2020). To accomplish this automated robots and workforce must be able to communicate and understand their actions which require some protocols. Even though people are not directly involved in the actions of automation it is required to be observed by people and take the control in case it is needed and do adjustments. To check the automation and take action if necessary requires a lot of cognitive skills which know to decline with age. These cognitive abilities would be needed to support information-processing activities directed at tracking the system's operations and status; monitoring what the automation is doing and planning to do; building and 'running' mental models to explain the behaviors of these intelligent agents; and co-ordinating one's assessments with those of intelligent machine partners (Sharit, 2020).

Employees require skills that are correlated with the technological advances of the modern market. Organizations should adopt "Lifelong learning" in order to prepare employees from every age group and each professional group during every stage of their career. Organizations provide career development and training opportunities to their employees will benefit from skilled workforce compatible with new technologies (Piatkowski, 2020).

The effects of digitalization and industry 4.0 on labor market

There are many scenarios about the future of employment due to the effects of new high technologies adoption. Complete automation seems to be the worst case scenario for human workforce and considered domination of technology over humans (Piatkowski, 2020). Optimistic views foresee a new and better workplace that considers primarily the human needs. When considered the rapid advances in technology, it is not a surprise that automation will redefine the jobs of people. Organizations need to use both workforce and the automation in optimum way to perform the tasks by maximizing their joint information processing, decision making, and control behaviors (Sharit, 2020). Industry 4.0 not only replace the repetitive and hazardous tasks but also effects the intellectual tasks such as transport, office administration or follow-up or consumer services (Piatkowski, 2020).

The requirement and employment rate for highly skilled workers in areas of engineering and automotive industries will increase 6% (Piatkowski, 2020). Those employed in knowledge occupations are more likely to keep their employments with growing old, possibly until 70 years of age or even more (Patrickson & Ranzijn, 2005). Rapid developments in technology are going to cause transition to a knowledge-based economy (Lee, Czaja, & Sharit, 2009). The skills of current highly skilled employees will not be enough for the future and the work demands exceed their skills. The simple manual labor workers will most likely to lose their jobs to automated machines. However, older workers reported that automation and mechanization of certain demanding tasks made them able to continue working (Richard & Durand, 2020). Qualified employees will need to improve their

skills constantly in order to cope with the emerging changes. Low qualified personnel should obtain new skills in creative and social areas and change tasks to the areas that are not affected by automation in order to continue employment (Piatkowski, 2020). Older workers that have expertise can be re-assigned to non-physically demanding tasks by their employer because of their rare expertise (Richard & Durand, 2020). The repetitive, burdensome, hazardous tasks can be handled by robots. Organizations investing in human resources and vocational training can minimize the negative effects of new technologies (Piatkowski, 2020). The labor market policy has to be adjusted in order to cope with the expected increase dynamics and greater requirements for relocation of employees.

Organizations have an important role on how to implement these new technologies corresponding to secure human resources that can face the challenges of the reconstructed manufacturing systems. The employees required to be flexible and be able to work autonomous. Employees should adopt lifelong learning and improve their skills to stay relevant with their jobs.

New skills and abilities demands for industry 4.0

The new technologies come with new skill requirements from employees. 21st century brings changes to work environment which created new knowledge, skill, and ability requirements for workers (Lee, Czaja, & Sharit, 2009). Already complex skill requirements of today's world will demand more complex skills in the future with the adoption of new technologies. Intellectual capital will be the source of profit for organizations regardless of the industry (Patrickson & Ranzijn, 2005). Intellectual capital is the combination of firm-specific knowledge, innovativeness, occupational competencies, and creativity. Increase in automation will also increase the usage of computers, more interaction with interfaces and new communication technologies. Today, most of the older people are 'digitally disengaged' from using new interaction technologies. Digital disengagement makes it harder for them to adapt the new technological developments and its demands (Fischl, Lindelöf, Lindgren, & Nilsson, 2020). However the average age of the population increases and older people are becoming a fast-growing group of computer users. This indicates that increased number of computer usage, electronic devices and information systems among older users whom will perform computer-based tasks in the future (Di Pasquale, Miranda, & Neumann, 2020). The main skill requirements more likely will be digital literacy skills and capacity of lifelong learning starting with an early education to make future workers capable of working with new technologies (Piatkowski, 2020).

The employees will be demanded to combine the skills they have in areas of math, science, engineering, and technology with soft skills such as psychology or sociology (Piatkowski, 2020). The machines will be able to handle manual and repetitive tasks but the creative and innovation tasks will require human resources. Integration of older workers with automated systems can be beneficial for organizations. Automated machines can replace the repetitive and routine tasks which lets the workers to focus on those tasks which utilize creative and affective processes. Experienced older workers can have more awareness to anticipate future problems, and on ways to improve system processes working with automated systems. Aging is not always result in performance loss, it depends on the job. For jobs that continuously changing and require rapid decision making older workers are at disadvantage but for the jobs that doesn't have time limit and requires knowledge-based decision making older workers will not lose performance. Automated machines takes over

most of the procedural and predictable tasks which leaves the people to monitoring the work processes, diagnostic/inferential skills for interpreting intelligent machine-based information, judgment and decision-making skills for handling exceptions and anomalies, and communication skills. Older workers are better at these skills compared to younger workers. This makes organizations that have older workers at an advantage when considered automation because older workers have better knowledge about what automation can accomplish and better instincts regarding the reliability and effectiveness of the automation. "It has been argued that older workers should be poised to take advantage of this growth in demand for knowledge work, given that intellectual capacity rarely shows any sign of decline prior to seventy years and this is one area where experience can be of benefit" (Patrickson & Ranzijn, 2005). Flexibility will be the key factor of humans, when considering unconventional and personalized processes. If workers can't adapt the changes of the future demands society may face with increased unemployment. The workforce not prepared for the emerging industrial revolution will be discarded form the labor market (Piatkowski, 2020).

The most important skills for future workforce expected to be:

- The active learning capacity.
- Creativity, both in artistic and technological level.
- Digital literacy skills.
- Ability to work with other people and devices in order to solve technical problems.
- Knowledge sharing.

The technical skill that require knowledge for manufacturing processes are not enough alone, and required to be combined with social skills such as, communication and cooperation with other individuals to achieve creative problem solving.

Innovativeness will be highly demanded from future workers (Patrickson & Ranzijn, 2005). It is driven by the creativity in technological level and associated with young people rather than old workers. Older workers are better at task- and organization-specific abilities if they can keep up with the new technological advances they can be a source of expertise. Employers see older workers as liabilities because of the lack of adaptability, new ideas, and flexibility (Patrickson & Ranzijn, 2005). However, they have desired capabilities such as, stability, experience, reliability and there are strong evidence that they are just as adaptable, flexible and innovative as younger ones (Patrickson & Ranzijn, 2005). The belief that older workers don't have these qualities is just stereotypes and biased thoughts.

Mechanical engineering will be one of the most required expertise with the industry 4.0, digitalization, automation and robots (Piatkowski, 2020). The materials and construction elements of the robots design will require the interaction of engineers from different sectors. Like past industrial revolutions, new technologies will force innovative services to combine and change the workforce dynamics.

With organizations starting to adopt industry 4.0, the importance of manufacturing and research and development labor will increase while the hierarchical management in organizations will decrease in importance. It is possible to implement industry 4.0 only with a new business model

utilize quality employees that are capable of using and understanding tasks of complex processes of new technologies (Piatkowski, 2020).

"According to the World Economic Forum report, 65% of children born after the year 2007 will work in professions which do not yet exist" (Piatkowski, 2020). It is important to revise education system in order to prepare the younger generation for the upcoming demands of the labor market. It is responsibility of government organizations and individuals to adapt lifelong learning, obtaining new skills, creating training programs required to work with digitalization.

Digital platforms changed the dynamics of labor market and workflow of organizations (Piatkowski, 2020). Organizations adapted to use internet as a tool for online meetings both for recruitments and work. It allows worldwide working options for employee and organizations. In 2020, COVID-19 showed us the importance of online communication technologies for continuation of work. In the future we can expect that usage of this technologies will increase, demanding the skills that enables working remote form the employees. Workflow has been rearranged for many organizations to be able to continue work activity will also increase the working from distance.

Future of employment

Globalization changed the employment methods of competitive organizations to stay in line with the demands of economic turmoil (Piatkowski, 2020). Today, lack of digital skills is an obstacle for employment of older workers (Lee, Czaja, & Sharit, 2009). Most of the older workers reported that insufficient knowledge of technology is the greatest obstacle in their employment. The current long-term employment model will not be sufficient to attract the quality employees. Organizations are forced to be more flexible both in employment and also in labor times and tasks. Rapid changes in the nature of work will force organizations to adapt the internal work requirements and external circumstances (Patrickson & Ranzijn, 2005). They need to adjust the number and different abilities required by the changed conditions. The working times and costs of the employees should be adjustable depending on the employment model (Piatkowski, 2020). The flexibility in working times attracts and influences their human resource depending on tasks and improved performance. In flexible employment a small group of employees are permanent who has key roles and large group of employees that are flexible (Piatkowski, 2020).

There are risks to adopt flexible employment model. It makes automation and unemployment much easier due to the contracts is not permanent. This also makes decreased motivation and loyalty to the organization because of the short-term employment. The situation may lead to social inequalities and divisions due to adoption of new technologies. The employees who couldn't adapt to the new technological developments are more vulnerable to become outcasts.

However, digitalization may reduce the differences between sexes. Flexible working times will make more women to be able to employ and also have time for domestic care.

Adaptability, new ideas, and flexibility will be the requirements of the employment demanded by organizations (Patrickson & Ranzijn, 2005). Many organizations still believe that older workers are worse at these qualities compared to younger workers. Organizations are willing to keep their productivity at the highest level possible. Employees see the developments in technology are too fast and organizations adopting them are thinking about profit and productivity but not improvements in

their life (Jari Pirhonen & Katariina Tuominen, 2020). Although, many of the organizations see their current older employees as productive, they are not willing to hire a new older employee because they are unknown to them to invest in compared to investing in younger employee (Patrickson & Ranzijn, 2005). For organizations older workers are less attractive the particular reason for this circumstance they are not well adapted to technology, especially because they were born before the internet they have difficulties to adapt to the technological advances. While the younger workers that grew up with technology and internet are easily adapted to the new systems and continuously developing technologies. In the future the 'new' older workers will be grown with the internet age and more intertwined in to technology (Sharit, 2020).

In the past century, older workers are obliged to retire after certain age either because of their health or organization's decision. Currently, older workers have more options after retirement age to consider (Patrickson & Ranzijn, 2005). They can remain at their current job, change their job to another full time or part time, or decide to end their active working completely. The deciding factor between these options is a consequence of health, financial position and motivation to work (Patrickson & Ranzijn, 2005). The individuals that have good health, rare or highly demanded skills and willing to continue earning money can continue their occupation regardless of age. Financial situation seems to be the main factor effecting retirement decision (Patrickson & Ranzijn, 2005). Individuals who think that retiring too soon will decrease their financial status are more hesitant to retire.

The general idea is that governments want older workers to continue with their occupation but organizations are opposite (Patrickson & Ranzijn, 2005). in Europe and North America are proposing to implement vigorous measures to improve labor force participation and stay-at work rates among people aged 55 years and over (Richard & Durand, 2020). The decision of the older individual plays an important role for determining the status of occupation. Both older employees and organizations come together in order to decide the options for prolonging their employment in a way to benefit both parties.

1 The employment options for older employees

Organizations started to realize the impact of ageing workforce on labor market. Not many of them have required policies to maintain their older workforce. For some organizations talent shortage will have even greater impact on labor market than ageing workforce. Organizations that find creative ways to utilize their talented or older workers will benefit with increased productivity and knowledge base (Patrickson & Ranzijn, 2005). Part time jobs and short-term contracts are the options to keep the talent by organizations. Older, unskilled, or inexperienced workers seem to settle on these options.

The older worker population should not be considered as a whole but divided in to groups depending on their contribution to the organization by maintaining the productivity and highly demanded skills (Patrickson & Ranzijn, 2005). Re-education may be required for those who can contribute to make them able to adapt new technologies.

2 Human resource management methods for older workers

Talent loss at all organization level is one of the concerns of the organizations in an increasingly competitive environment for highest productivity possible (Patrickson & Ranzijn, 2005). Independent from age, recognition and separation of the talented has become critical. Flexibility will be as much important, in human resource management to adjust employees and talents for the needs of new technologies (Piatkowski, 2020). For talented older workers that have skills that are rare to find will be able to continue work or find new jobs, being able to determine their own terms of employment regardless of their age (Patrickson & Ranzijn, 2005). Organizations side, they need to identify talented individuals, understand their goals and motivations and adjust workplace and develop individualized programs to meet these needs, otherwise they may retire or move elsewhere (Patrickson & Ranzijn, 2005). Organizations need to stop seeing older workers as a whole group but identify the individuals that can continue contributing to the productivity. This can be achieved by collecting data from each individual about their intentions, expectations and aspirations. Later, they can determine the range of employment options for each individual which can range from full-time employment, part-time employment or retirement. Talented individuals should be retained in the organization even if it is partial.

The ability to be productive for older workers depends on the nature of the occupation (Patrickson & Ranzijn, 2005). There are differences between demands of skills required, adaptation, and creativity for each occupation. For example, the ability demands for a scientist or engineer are not the same for a driver or manual worker. At some tasks, depending on the nature of occupation, older people can become more productive than younger people.

2.1 Keeping the motivation fresh

Older employees achieve almost all of their goals throughout their career and are not motivated for further advancement in the organization (Patrickson & Ranzijn, 2005). Reassigning them to new and different tasks, possibly a completely new job within the organization may increase the motivation and excitement for them. According to (Patrickson & Ranzijn, 2005), older workers can continue working till their 90s if the job is interesting and within their abilities to perform. Even demoting to a lower but different position can be interesting with less responsibility and more time for personal life.

2.2 Gradual retirement

Gradual retirement is considered one of the best ways for preventing knowledge loss with retirement of older employees. Older employees are the most experience ones then know the organizational policies and behaviors as well as procedures for production. Instant loss of this knowledge source because of retirement is a huge loss for organization. There is increasing acknowledgment that external factors, such as caring needs and other responsibilities can impact productivity, and working hours and conditions for many employees are increasingly being modified on an individual basis to reflect this (Patrickson & Ranzijn, 2005). This method of retirement becomes more popular among organizations throughout the world. As mentioned in the section ‘Documenting and transferring institutional knowledge from older workers page: 29’, older employees can be integrated in to part time mentoring programs as part of their gradual retirement. Especially when

older employees considering retirement, adding them to mentoring programs where they can work part time and more motivated in a gradual retirement (Varianou-Mikellidou, Boustras, Nicolaidou, Dimopoulos, Anyfantis, & Messios, 2020).

Sustainable Development

The manufacturing, agriculture and service industries are the main factors that drive the economy of our world. However, apart from those, an effective management of occupational safety and health plays a crucial role to run a successful business (Jilcha & Kitaw, 2016). The sustainable development of a citizen and a nation depends on health and safe working groups at their workplace as the German philosopher (1788–1860), Schopenhauer, emphasized on the importance of health by stating that ‘‘health is not everything, but without health, everything is nothing”. Sustainable development cannot be thought without considering environment, society, economy and their working condition.

According to World Health Organization, the occupational health covers the precautions for occupational medicine, occupational hygiene, occupational psychology, safety, physiotherapy, ergonomics, rehabilitation, etc. Besides, the International Occupational Hygiene Association (IOHA) generally defines occupational health and safety as the science of anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment.

The unsafe working conditions, low economic status as well as an unstable politics bring unsustainable development, major economic losses for enterprises and societies as a whole, including lost productivity and reduced work capacity (ILO, 2014). All those lead to the loss of gross domestic product and migrations especially from developing or poor countries in Africa to Europe. So, it is obvious that the lack of occupational health and safety has a major effect on the productivity, competitiveness, reputation of enterprises, well beings of individuals and their families along with an economic burden at nation level.

The sustainable development can be defined as the optimum use of resources in all respects or strategy to meet the needs of the present world population without causing adverse effect on health and on the environment, and without depleting or endangering the global resource base, hence without compromising the ability of future generations to meet their needs (P. Gilding, M. Hogarth, & H. Humphries, 2002).

The company’s focus on product development or process improvement more than workplace and service innovation, for sustainable development. However, they forget that the workplace innovation (WPI) has social, economic and labor market impact. The WPI can be defined as the implementation of new and combined interventions or measures in the fields of work organization, human resource management and supportive technologies (Pot, 2011). So WPI concerns the design of the organization, the management tasks, and the jobs with the common goal of improvement of organizational performance and quality of working life. It therefore affects not only the internal functions of an organization but also the external functions such as network relations. WPI includes low stress risks, high job autonomy, lower physical workload, continuous development of competences and better labor relations which results in sustainable development stability of a

country (R.H. Westgaard & J. Winkel, 2011). Thus, it is safe to say that working in safe and healthy conditions improves the employees' performance, increases their motivation, raises the productivity, and consequently improves the quality of the product as well as increases the sales and revenue. The quality of the products produced in a company influences people's health in the society and significantly affects the environment in which people live and work.

When considering the sustainable development with OHS and making a link between them, it should be taken into account the 6 significant pillars: social, economy, environment, technology, culture and politics.

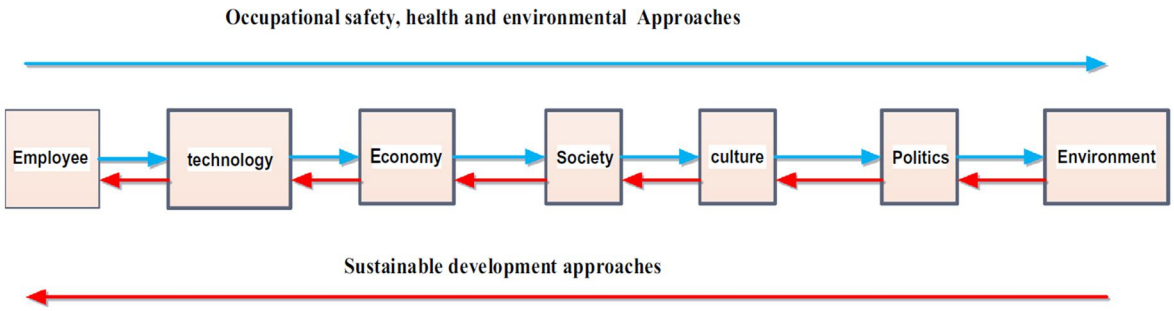

Figure 12 OSH and sustainable development approaches (Jilcha & Kitaw, 2016)

A positive vibe of culture introduces a good social motto in which all the people are dedicated to participating in the sustainable development through improving all the contributing factors. Similarly, with a stable and self-sustained political policy, people are secure, and systems are leading toward the development roads. Technology is a tool to improve working conditions and get priority. The improvement becomes a priority as well by optimization of economy and social standards. Moreover, the culture dynamics and the culture of the society should be taken into account while improving the working environments. Neglecting the politics lead to unsustainable development.

As indicated on the Figure 12 above, the OSH primarily addresses the employee whereas the sustainable development addresses the environment.

The purpose of the sustainable development is to save the limited natural resources of the future generations while taking care of the concerns of the society (Jilcha & Kitaw, 2016). Both the employers and the employees should be aware that they need to initiate a compromising working environment and build the pillars of OSH-sustainable development to achieve an inclusive sustainable development. Supporting innovative work environments creates a comfortable and secure place for employees, which increase the sustainable development of the citizens first and then of the whole country. All those aspects of improvement of occupational safety and health, job systems, personal characteristics, occupational injuries and diseases, cost of occupational injuries, occupational environment, society, government, stakeholders and employers, employee participation, work culture, management culture, and family or as an individual are associated with workplace innovation and sustainable development.

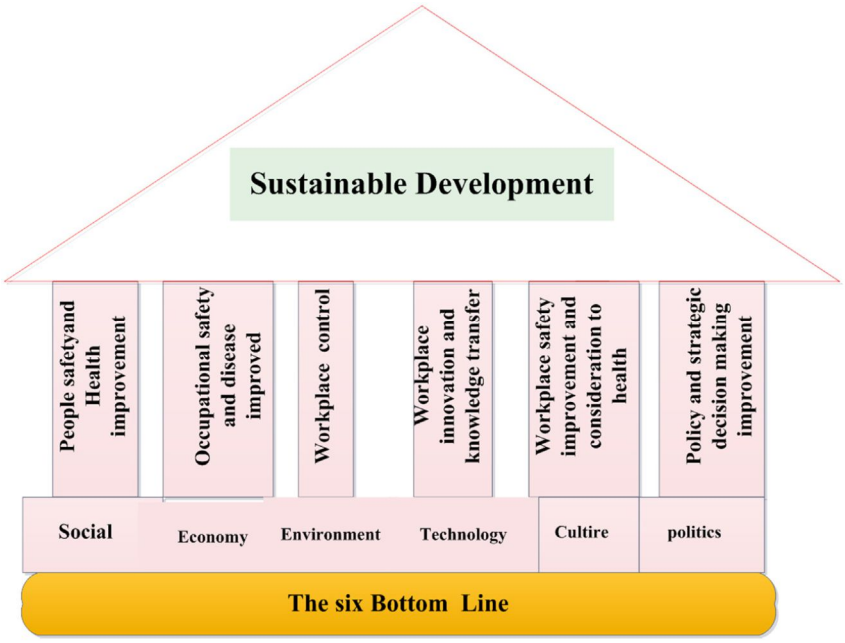

Table 9 The pillars of sustainable development (Jilcha & Kitaw, 2016)

As indicated the six bottom lines in the Table 9 The pillars of sustainable development (Jilcha & Kitaw, 2016), it cannot be expected to achieve a sustainable development without health workers, safe working places, society satisfaction, stable politics and a positive culture. Otherwise, the organization faces financial crises which in return introduce a challenging situation of unstable economy for employees, customers and stakeholders. Then, the employees are demoralized, which affects the quality of the products unfavorably. Even a worse scenario where the business reputation is damaged and market share reduces along with growing medical expenses due to the occupational accidents. Consequently, the occupational safety and health directly affect the employees, while indirectly affect the society, technology, culture, economy, politics and environment in the long term. Those all factors rest upon each other, whatever affects one, directly or indirectly impacts the other. Such that the lack of sustainable society and economy causes unhealthy, discouraged and ineffective workers, this in return affects their productivity. Consequently, the organization gets damaged since it is a part and territory of the society.

Sustainable Employment

Another aspect for the sustainable development is sustainable employment which is very important and concerns both the employers and the employees. A definition of sustainable employability by Van der Klink is as “Sustainable employability means that, throughout their working lives, workers can achieve tangible opportunities in the form of a set of capabilities. They also enjoy the necessary conditions that allow them to make a valuable contribution through their work, now and in the future, while safeguarding their health and welfare. This requires, on the one hand, a work context that facilitates this for them and on the other, the attitude and motivation to exploit these opportunities” (Jac J L Van Der Klink, Ute Bültmann, Alex Burdorf, & Wilmar B Schaufeli, 2015). The organizations are aware that the workforce is ageing; therefore they are heavily depending on the contribution of older workers. Eventually, the sustainable labor market participation of aging workforce has come into prominence. This situation obliged companies to encourage the sustainable

employment and widen the labor participation of older workers (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017).

There are two essential workplace characteristics for employees' sustainable employment: intrinsic job value and age supportive climate. As long as the workers see the task responsibilities as meaningful, challenging and developmental a job can be considered to have intrinsic value. These aspects are considered motivating, and for older employees specifically because they are connected to the emotionally meaningful goals that are increasingly pursued over the lifespan (Laura L. Carstensen, Derek M. Isaacowitz, & Susan Turk Charles, 1999). The other characteristics are the age supportive climate. Not providing sufficient care for the situations of old employees at the workplace might restrict their opportunities and affect unfavorably their sustained labor participation, which in return damage the motivation of old workers.

There are three significant indicators of sustainable employment for any employee to have satisfaction at the workplace: employability, work engagement and affective commitment. These aspects are associated with human strength, health and functioning in organizations and are considered essential for employees to remain and contribute at work (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017).

The sustainability was defined as general worldview according to which people should strive to fulfill the needs of the present without compromising the needs of future generations by the United Nations in 1972 (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). The organizations have to make arrangements in such a way that the workforce resources are encouraged, rather than exploited, so that they are still useful and contributing in the long term. This is the base of association of sustainability and employment. In a sustainable employment, the workers of all ages are willing to remain working now and in the future with a healthy, motivated and competent manner.

Employability can be defined as the individuals' ability to sufficiently fulfill work in current and future jobs, inside and outside the current organization (Erik Berntson, Magnus Sverke, & Staffan Marklund, 2006). The individuals' characteristics, such as their abilities, talents, experiences and knowledge play a crucial role in contributing to employability and labor market participation. Therefore, the employees should spend effort to continuously develop and update their skills and expertise in order to be stay employable and to avoid any decline in their abilities, because the employability directly affects their appeal in the labor market.

The work engagement requires a positive, fulfilling, work-related state of mind, which comes with dedication and absorption (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). The workers with a high attitude of work engagement represent high energy levels and mental resilience at work. Dedication refers to being strongly involved at work and experiencing a sense of significance, enthusiasm and challenge while absorption implies being fully concentrated and happily captivated in a job, where time passes quickly, and one has difficulties with removing oneself from work. Considering that engaged employees are better in organizing personal resources, display better health and perform better on tasks, work engagement seems to be a crucial indicator of sustainable employment.

There are three distinct types of organizational commitment: affective, continuance and normative commitment (Maira Worek, Barbara Covarrubias Venegas, & Sonja Thury, 2019). Affective commitment relates to how much employees want to stay at their organization. They typically identify with the organizational goals, feel that they fit into the organization, satisfied with their work and are generally great assets for organizations. Continuance commitment relates to attachment owing to the costs in case of leaving the organization such as when employees feel that they need to stay with their organization because their income won't improve if they move to another organization. Normative commitment relates to being obliged to remain with the organization, employees feel that leaving their organization would have harmful consequences and feel a sense of guilt about leaving. Affective commitment is considered as an indicator of sustainable development rather than continuance or normative commitment because affective committed workers seem to be more productive, responsible about turnovers and proactive at contributing than continuance or normative committed ones. Besides affective commitment prevents the workers who are getting close to retirement from feeling a sense of work disengagement. For these reasons, affective commitment is considered an important indicator of sustainable employment.

As the workers age, their needs, motivation and perception of work context might age. Aging workers prefer intrinsically rewarding job features such as meaningfulness and recognition, over extrinsically rewarding job features, such as salary and promotion (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). Besides, even though working in the same field, the workers at various age ranges may experience different treatments and opportunities, which is an important concern.

As the employees age, some aspects of work become more decisive over others, depending on the motivation, skills and preferences to certain job characteristics (Jutta Heckhausen, Carsten Wrosch, & Richard Schulz, 2010). Since aging causes reduced working memory and physical strength, the tasks requiring long working hours and competition seem less engaging for older workers. Whereas the tasks that require experience and let them gain more resources such as intelligence, work related expertise and skills are likely to suit to them. Therefore, the improvement opportunities and challenging tasks are more notable work aspects for older workers (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). Another point of view is the time perspective of employees on the pursuit of goals. It is observed that the young workers are more inclined to knowledge acquisition and career advancement, whereas the emotional goals and tasks that are intrinsically and affectively rewarding are more attractive for older workers (Laura L. Carstensen, Derek M. Isaacowitz, & Susan T. Charles, Taking Time Seriously A Theory of Socioemotional Selectivity, 1999). This implies that intrinsically rewarding features of the work, such as meaningful work, appreciation from others, receiving recognition are more valuable than extrinsically rewarding features.

Regarding the sustainable employment of ageing employees and the intrinsic value of a work, there are four important work aspects: meaningfulness, recognition, challenge and learning value (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). Meaningfulness of a work comes with a sense of accomplishment, purpose and contribution. The employee obtains recognition when he/she feels the embracement for their effort and contribution to the organization. A task becomes challenging when it requires the employee to use their potential, arouses curiosity and make them enjoy solving complex and creative problems. Learning value raises competency among workers and benefit their improvement. So those four aspects help the employees fulfill their basic psychological needs, which

is necessary for optimal functioning and personal well-being and encourage employees' intrinsic motivation (Edward L. Deci & Richard M. Ryan, 2009).

There is a correlation between the sustainable employment and the jobs with high intrinsic value. The challenging, meaningful jobs that provide recognition boost the employment (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017). Similarly, the intrinsic job value is related to work engagement. The meaningful work, challenge, learning opportunities and recognition from colleagues and employers bring higher levels of work engagement and also contribute to employees' vitality and health (Fairlie, 2011).

The affective commitment depends on the intrinsic job value too, as sustainable employment and work engagement do. The affective commitment of an employee rest upon their positive believes concerning the way they are treated and supported by the organization. Therefore the same correlation can be said also for affective commitment that providing employees with work that is meaningful, appreciated, challenging and developmental is likely to increase levels of affective commitment (Karen van Dam, Tinka van Vuuren, & Sofie Kemps, 2017).

These intrinsic work aspects play a more important role for older workers with respect to younger ones in case of sustainable employment. Older workers need to challenged, use their potential and be recognized for their contribution. The satisfaction they get from using their talents and creation makes them remain motivated at the workplace and also make them inclined to postpone their retirement.

Discussion

This thesis has been made to clarify and understand the employment of ageing workforce and the effects of Digitalization. In this section some observations will be made and answers to the guiding questions will be provided based on the findings in the section Findings. First of all, this thesis considers older workers age as 65 and older but some of the sources that used considered younger ages as older age group. The youngest age for older workers considered was 40 according to our resources but it was rare. There are two reasons for selecting 65 as older age limit. The first one is every year the life expectancy increases (see section Ageing population page: 14) so in the future 50 or even 60 will be mid age for workers. To keep the validity of this thesis in the future it was reasonable to consider the oldest age in our resources. The second reason is the methods, strategies, and assistive technologies in the sources that considered younger ages were 50 and older which includes 65 and older workers.

The first observation is that older people are not a homogenous group and show differences among themselves. Chronological age is not a direct source for evaluating an individual but a dependent source. For a correct evaluation of an individual in performance, productivity, and capabilities depends on factors such as cognitive age, subjective well-being, and objective well-being. Capabilities of people decrease with ageing but most jobs don't demand maximum capabilities in order to perform well. Older people mostly work near their maximum capacity. These factors

contribute to the calculation of Work Ability Index (WAI) to understand if the worker is fit for a certain job or task.

The second observation is the importance of balance between job/task demands and availability of resources/capabilities. The balance between demands and resources results in higher WAI and WAI directly improves productivity and performance. Most of the resources tried to achieve balance by adjusting the demands in the work environment, the organization of work, employee level, and social support to meet the declined capabilities of older workers. It was surprising that very few resources tried to improve declined capabilities of older workers by using new technologies since most of the resources used in this thesis are from year 2020. The only technology adoption for improved physical capabilities was Exoskeletons (see section Exoskeletons page: 57) and cognitive capabilities was mobile smart devices (see section Usage of digital technologies page: 55).

The third observation is in the future it will not be the age that is determining factor for employment. Digitalization, Industry 4.0, and smart manufacturing will bring robots and automation that will handle the repetitive, manual, and hazardous tasks and only the jobs that require creativity, innovativeness will be handled by humans. People that have high level and rare skill in areas such as engineering will probably keep their jobs regardless of age. People with low skill cap jobs will be replaced with robots or reassign to new task/job and need proper trainings to be able to interact with automated machines.

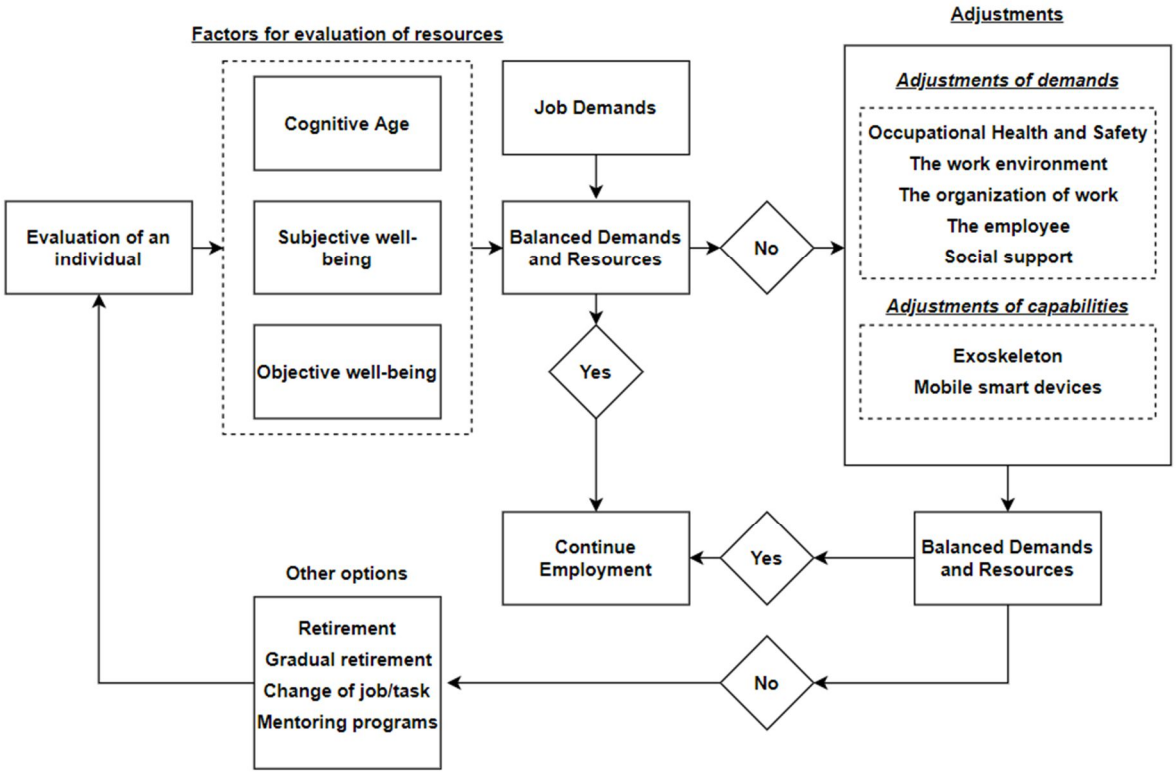

Figure 13 Evaluation of an individual in order to understand fit to certain job or task

Figure 13 shows the steps to understand if an older individual is fit for the job or task. This process is necessary to evaluate an older individual because of the heterogeneity of older aged people. Every person is different than other and aged differently. Chronological age is not a direct

factor for evaluation and each individual should be evaluated separately. In the first step the individual should be analyzed by factors of Cognitive age, Subjective well-being, and Objective well-being. The next step should be the comparison of individual's resources and job demands. The best way for evaluating if the person is fit for the job is the calculation of WAI. If a person's WAI is high then job demands and individual resources are balanced and the individual can continue employment without any performance or productivity loss. If the person's WAI is low then individual's resources are not enough due to declined capabilities comes with ageing. To balance the job demands and capabilities some adjustments needs to be made to keep the performance and productivity high. These adjustments can be made to job demands for improved and better conditions according to person's needs or to improve the capabilities of older people. Adjustments of demands mainly focus on Occupational health and safety, the work environment, the organization of work, the employee, and social support. These adjustments are explained in detail in the section Safety measures, high performance, and policies page: 32. Adjustments to improve the physical and cognitive capabilities were relatively less mentioned in the articles. To improve and support physical and musculoskeletal strength exoskeletons are suggested. To help and guide the cognitive abilities smart devices are suggested. After the adjustments made another evaluation to see if the person is fit for the job has to be made. These adjustments may or may not increase WAI. If the increase in WAI is sufficient enough then the employment of the person can continue. Sometimes WAI increases but it is not enough and results in performance and productivity loss. In the situations when WAI is not sufficient there are other options for employers and employee to discuss together. These options include retirement, gradual retirement, change of job/tasks, and mentoring programs. The retirement option is for people that has very low WAI and have severe health problems that bring difficulties for employment.

The greatest advantage of older people probably is the knowledge and expertise they have acquired in many years. Sudden loss of this knowledge and expertise is such a loss for organizations. Gradual retirement and mentoring programs offer options for reduced work times and demands but also keeps this knowledge and transfer it to new employees. If the employee still wants full time employment then change of job or tasks can be applied.

The most outstanding block for employment of older workers is the stereotype and discrimination of older workers. Both organizations and younger workers believe that older workers are burdensome, less adaptive, less innovative and creative. Under right circumstances older workers showed similar if not better performance than younger workers in these areas but still organizations are hesitant to employ, train, or invest in older people.

This thesis will help to better understand and improve the theoretical and practical knowledge concerning the five research questions about employment of ageing workforce and the role of Digitalization, Industry 4.0, and Smart manufacturing.

1. Why employment and continuation to work of ageing workforce is needed?
2. What are the declined capabilities of the ageing workforce?
3. What are the methods to reduce the effects of declined capabilities?

4. What are the future expectations from older workers due to fourth industrial revolution?

5. What is the role of Industry 4.0, Smart working and digitalization on ageing workforce?

RQ 1: Why employment and continuation to work of ageing workforce is needed?

The first research question aims to clarify and understand the importance of ageing workforce. Almost all of the articles used in the findings discuss the importance and effects of ageing workforce on organizations and society. According to the recent data provided by (UnitedNations, 2020), both in the world and in Europe percentage of older population increase. Accompanied by increased life expectancy will mean that in the future there will be older workers more than younger workers. This alone shows the necessity for adaptation of organizations, employers, and the society to the ageing workforce to stay competitive and well-functioning.

There are factors that increase the willingness of older people to continue to work. Financial reasons are the most effective factor for people to postpone retirement. Healthier older adults willing to work more in order to sustain and support their family members. In some of the countries, costly social security and health insurance force older workers to stay at work. Financial reasons seem to be a forcing factor instead of positive effect on will to work. The more positive factors increase the will to work is social interactions and self-fulfillment the work provides to older adults. Ageing makes people more preserved with their social interactions. Many older adults don't go out or meet with new people. Going to work is an excuse for them to get out of the house and interact with other individuals. Engaging in social interactions and productions reduces the cognitive decline rates and promote healthier life for them. Continue working and being part of a team fulfills the need of self-fulfillment, being useful to others and the society. Older adults feel happier when they are appreciated by co-workers for their experience and expertise. Active involvement on production and team works feed the self-fulfillment and increase happiness among older adults.

For organizations employing older workers may be beneficial in most cases. The main reason for employing an older adult is because of the experience, expertise and work related knowledge they have. To reduce the severity of knowledge loss due to retirement of older workers, organizations adopt gradual retirement and mentoring programs in order to maintain and transfer this valuable knowledge. Older workers are more loyal to organizations compared to younger workers. Today, younger workers change their occupation in every 2-3 years while older workers stay at the same occupation for many years combined with their expertise. This makes investments on older workers more valuable. Injury rates of older workers during occupation are lower compared to younger age groups. For organizations employing older workers create better safety at work. However, some articles discuss the reduced productivity and increased severity of injury among older workers. Older workers in team works seem to be stabilizing factor. They are better at institutional knowledge, experience and communication skills and performance is increased in team works that require decision making. The age diverse groups are more efficient in team project that organizations should consider employing older workers. However, lack of technological adoption to use digital

communication platforms and importance to fit the demands and cognitive/physical resources should be attended before employment of older adults.

In Societal point of view, the working people pay the retirement fees of the seniors. Since in the future the demographic percentage of older people increase that means more taxes for younger tax payers for retirement fees. This is a problem for governments and functioning of the society. Many of the older adults still maintain enough cognitive and physical resources to continue working and contribute to the society. The biggest challenge is the stereotypes and age discrimination of organizations and colleagues. Governments promote employment and support the organizations that employ of older workers. In the future government's support and organizations will to employ older workers should increase in order to maintain a functioning society.

RQ 2: What are the changes occur on capabilities of the ageing workforce?

Second research question is to understand the changes and differences between old and young adults are important to meet the challenges for employment of ageing workforce. Modifications and adaptations can be made in order to successful ageing at work. Older workers that aged successfully can maintain high performance and productivity and continue their occupations. Ageing generally cause negative changes on human body. As we age our body changes, with age the amount of brain cells and muscle tissue reduces. Only vigilance attention seems to improve by ageing. This makes older people more careful than younger people.

The declined capabilities can be categorized in to three groups which are physical, cognitive, and perceptual. Physical declines occur on thermoregulation, cardiorespiratory, muscular strength, bone density. The most common physical disease among older workers is musculoskeletal disorders. These declines reduce the physical capabilities and resources of individuals to meet the physical demands of jobs. Physically active individuals can protect their physical strength in to late ages. The cognitive changes among older people are more complicated. Older people tend to maintain their "crystallized" intelligence till very old ages but their "fluid" intelligence starts to decline earlier. The difference between these cognitive process decline speeds shows us that older people maintain their experience based knowledge while their instantaneous processing reduces with age. This implies that organizations that focus their training programs and task assignments for older workers utilizing crystallized intelligence will benefit. However, declines in fluid intelligence effect processing speed, explicit learning, selective attention. These declines effects both job performance and life quality of older adults. Smart devices can be used in order to support older individuals in these areas. Every individual is different and these declines vary person to person. Individuals adopted a healthy life style, diet, and physically active can maintain capabilities. These activities should be encouraged by society and organizations.

Some of the articles discuss productivity loss due to older aged employees because of their reduced capabilities. Organizations need to negate the negative effects of ageing or meet the job demands to the reduced capabilities in order to keep the productivity high. Older people have difficulties adapting the new technological developments. Many older people have problems using technology because of their age related declines in both physical and cognition. These problems occur in accessibility, design and physical characteristic of the technology. It is difficult for older

people to track the changes and relations smart devices and digitalized world. The age related physical declines merged with rapid developments in technology makes it harder for older people to feel relevant in digitalized world. Special training methods need to be integrated in order to make older people adapt the new emerging technologies. These training methods are discussed in the section Training page: 48.

RQ 3: What are the methods to reduce the effects of declined capabilities?

Third research question is to find methods, technologies, and policies that will help older workers to employ healthier, happier, with maintaining high performance while not reducing the productivity of organizations. Most of the articles presented methods in occupational health and safety, programs and policies, changes in the work environment, the organization of work, the employee, and social support. The involvement of new technologies in these adjustments was minimal. This kind of adjustments can be applied and adopted by any organization or employee in order to improve quality of life at work for older employees.

The main idea of these adjustments is to balance the demands and resources by successful ageing at work. 'Successful ageing at work' is a concept that is the result of active, healthy, and productive aging at work can be adopted by organizations to get most benefit from their older employees (Zacher, 2015). Older people are heterogeneous group and the ones deviate positively compared to average age related trajectory can be considered successfully aged. In the section Safety measures, high performance, and policies page: 32, there are strategies to improve the overall well-being of the employees. These strategies must be adopted by organizations in order to get the most benefit from their older employees.

The methods and policies are divided in to four main categories which are the work environment, the organization of work, the employee, and the social support. The adjustments in the work environment category are aimed to reduce the injuries and improve safety of older employees. These adjustments utilize the workplace ergonomics and human factors engineering. If younger workers age without injuries and have better than average health they can continue their occupation in old ages. This benefits both organizations and the employee. Organizations will keep their employee for many years without productivity loss while employees have better work conditions and reduced stress and health problems. The important factor for successful work environment is the communication between the managers and the employees. Communication is necessary to understand the cause of the safety problem and methods to solve. Older workers have problems with balance, vision, hearing, and strength. The work environment should be adjusted in order to reduce the effects of declined capabilities of these workers. Some of these adjustments are simple like adjusting the light intensity or speaking louder which can be applied by any organization. Organizations apply these changes will have better performance from their older employees.

The adjustments in the category of the organization of work focus on decision control, work schedules, information transfer, and avenues for conflict resolution, supervisory relationships. Scheduling changes include different work times, reduced working hours, and reduced shift work, working from home, and increased break possibilities. Content changes are assignment of older workers in to new tasks. These changes are made to reduce or alternate the physical demands for

older workers and meet the demands with their resources. Older workers require this flexibility in time and procedures to better allocate their capabilities in order to meet the work demands. If the demand is too high such as physically difficult tasks, younger workers should be assigned or help the older workers. Relationships in work also included in this category. Age discrimination and stereotypes should be eliminated by proper training and dedication of the organization.

There are also adjustments that are focused directly on the employee. The responsibility of the workers is to take care of themselves to live and work healthy. Chronic diseases seem to a major problem for older workers in their occupation. The chronic diseases may cause absenteeism and loss of productivity, workers' compensation, employee turnover and replacement, and life insurance benefit costs. Every person is different and should be evaluated separately. People that take care of themselves can delay the chronicle diseases and continue to work. Adopting a healthy life style, promoting healthy habits such as not smoking, healthy diet, and moderate physical fitness is up to employees and organizations should promote. Articles also mention the negative effects of shift work and night shifts on older workers. Tolerance for shift works starts declining at ages 40-50 and at older ages such as 65 it should not be possible for older workers. The training of older workers is important for them to maintain their capabilities and learn new skills to adapt new technologies. However, it cannot prevent the declines in capabilities for older workers but reduce the decline rates. Organizations are hesitant to train their older workers because of the lower employment time and stereotype that it is hard to train older workers. These challenges seems to be not realistic because older workers that are properly trained can continue their occupation and more loyal than younger workers. While younger workers change jobs frequently the training provided is less beneficial. It is true that older workers are difficult to train with the general training methods but adaptation of these training methods to the needs of older workers will improve their learning abilities. Training requires cognitive and information processing abilities to be effective, this makes training older workers more challenging due to their declines in these areas (Taylor & Bisson, 2020). There are methods to improve the training experience for older workers. These methods try to focus more on crystallized intelligence rather than fluid intelligence. This makes training easier for older people to understand and learn. The methods for training older workers are mentioned in the section Implications for training according to the age related declines page: 50. These adjustments in the training methods are not complex and can be easily applied such as highlighting critical points or providing materials in modules. Following these steps will be a guide line for organizations to train their older employees. Well trained workers increase the performance, productivity, and safety in the work place. These methods are especially valuable for older workers but can also have positive effects on all age groups.

The social support is another aspect that should be considered to help older workers to perform better at work. The work performance depend not only the factors at work but also on the workers daily life which becomes more challenging with ageing. Articles suggest carpooling since it is difficult for older people to use private cars to travel work. Flexible working times are necessary for older workers if they need to take care of their sibling or partner at home. Performance loss occurs if the worker is preoccupied by worrying about their sick relative needing care. Organizations should provide social benefits for older workers to keep their mental health.

The effect of these changes can be monitored with WAI. WAI is a quantitative tool to understand if a person is fit for the job or task. If WAI is high the person's performance is high at that

job or task. The organizational and policy adjustments should improve WAI for older workers for them to continue their occupation.

These safety, policy, and organizational changes aim to adjust the demands of job or task to meet the resources of older workers. On the other hand few articles 5 out of 39 provide solutions to improve the declined capabilities of older people by using new technologies. These technologies help older people in the areas that their capabilities are not enough to complete tasks successfully. Using smart or wearable technologies are relatively new concept to improve quality of life at work. The articles examined are relatively new and provide the most recent research on this subject. There are two technologies that are suggested for older adults to improve their capabilities.

The first one is the use of Exoskeletons in order to improve and support physical capabilities in order to complete physically demanding tasks. Older people have lower energy to spend, muscles get weaker reducing the lifting and carrying capacities, joints lose their mobility and bones lose their flexibility results in more fatigue. Exoskeletons provide support to joints and gives additional force and torque to the user to complete physically challenging tasks. These devices can be simple like passive exoskeletons without actuator that only support the posture and protect the joints. There are also complex exoskeletons with actuator that provide additional torque for extra strength. Design of the exoskeletons is crucial and should be guided by users experience otherwise the rigid bodies may cause discomfort and further problems on the user. If well designed, these devices can be useful for older people that require additional physical support and improve their performance. Since every person has different body structure, exoskeletons should be adjustable. Unconscious use of exoskeletons can cause more harm than benefit. These devices should be carefully examined before introduced to older workers.

The second assistive technology is the use of mobile smart devices to support the decision making of older adults. Smart devices are not only used for decision support system but also for tracking the health variables of older adults and give positive feedbacks to improve their health. Examples for smart devices are personal computers, smart telephones, and computer tablets, the software in these devices, as well as the Internet and World Wide Web. It is highly beneficial for older adults to use high mobility technological devices in order to track or remind them the self-management of various diseases and encouragement of healthy behaviors (Lin & Ho, 2020). Even though the potential benefits of smart devices older people are hesitant to use them. The negative factors affect the decision to use smart devices is physical and cognitive declines and complexity of the devices. Age related declines cause shaking hands and poor vision which makes difficult to navigate and acquire information from smart devices. Design of the smart technologies and software should be specifically adjusted to meet the needs of older people. When the negative sides to use technology are reduced, smart devices increase the quality of life for older people.

Aside from the technological assistive tools for older people, in the future automation of manual labor tasks will redefine the jobs for all age groups. For older workers, repetitive, burdensome, and hazardous tasks will be replaced by robots and automated machines. This might seem beneficiary for older workers but manual labor workers will probably be replaced by machines or they will be reassigned. This will increase unemployment at all age groups but especially for older workers. Older workers are less adaptive to new technologies if proper training is not provided. New technologies will require interaction between machines and humans for increased productivity which

might be difficult for older workers. The older workers will high level of experience and expertise will probably keep their jobs and continue to work regardless of their age but manual labor workers with low education will be replaced. Human resources management has great importance to find the balance between automation and humans. When the interaction of robots and automated machines with humans is well managed it can be beneficial for workers and also organizations with increased productivity.

Answer to this question provides useful information for organizations and older employees to understand and apply the necessary adjustments in order to increase efficiency, productivity and performance. The demographical changes show that in the future this change will not be optional but necessity to be competitive in labor market.

RQ 4: What are the future expectations from older workers due to fourth industrial revolution?

Fourth research question is to foresee the future expectations of the fourth industrial revolution from older workers. Industry 4.0 is considered the fourth industrial revolution in which smart manufacturing systems will combine digital production, network communications, computer technologies and automation (Piatkowski, 2020) smart manufacturing technology, cyber-physical infrastructure, and data control systems to realize predictive and adaptive behaviors (Di Pasquale, Miranda, & Neumann, 2020). New technologies will change the traditional work methods and work environments. Digitalization will increase the productivity and efficiency but it will also transform the labor market and skill requirements. Adoption of industry 4.0 will change the requirements of jobs by changing work dynamics of the operators, creating new interactions between humans and machines and form strong connection between digital and physical world. Integrating touch screen and eye-gaze input to production devices can improve performance of older workers. Older workers that have problems using the cursor due to declines in motor and spatial activities can benefit from these devices. The increase in performance will be strongly related to the compatibility between digital devices and capabilities of older workers. The importance of design of the new technologies emerges to increase this compatibility to augment the capabilities of older workers. Instead of handling manual labor, in the future workers are demanded to be highly skilled and smart who can cooperate with robots and automated machines in order to complete tasks. In the future cognitive demands seem to increase for all age groups while physical demands will highly reduce. For organizations just adopting automation will not be sufficient enough to be competitive. Optimization of human resource and automation will bring the most profit for organizations. The communication between human and robots will have great importance. Humans will most likely not involve in direct production but observe the automated robots and take actions if necessary. To understand the operations and take correct action requires high cognitive ability which declines with age. This can be a serious problem for future employment of older workers. To maintain or delay the decline of their cognitive abilities life-long learning is suggested. Organizations provide career development and training opportunities to their employees of all age group will benefit from skilled workforce compatible with new technologies.

The future requirements of jobs can be summarized with Intellectual capital. Intellectual capital is the combination of firm-specific knowledge, innovativeness, occupational competencies, and creativity (Patrickson & Ranzijn, 2005). Increased computer and digital devices usage is also

expected. Today, disengagement of older people from technology is a barrier for them to be employed in future jobs. However, today's younger generation that grows up with technology will be the older workers of the future. The effect of getting older with technology is still unknown and potentially digitally engaged older population can be expected. Further research is required to understand the level of integration of future old workers with technology. Digital literacy skills and life-long learning capacity will be the requirement to be employed in smart manufacturing. Manual and repetitive tasks will be automated while tasks that require creativity and innovativeness will still need humans. This shows that it is not the age that is the problem but the education and knowledge of a person. With the tasks that require rapid decision making older people are at disadvantage but in the future knowledge based decision making will increase in importance. Interaction with machines will require judgment and knowledge based decision-making skills combined with communication skills which older people are better at. This makes organizations that adapt and utilize their older workforce increase their competitiveness. Innovativeness is mostly associated with young people. This is partially true because today's older workers have difficulties to keep up with rapid development of technology. They are seen like a burden for organizations because of their lack of adaptation and innovativeness. However, they have desired capabilities such as, stability, experience, reliability and there is strong evidence that they are just as adaptable, flexible and innovative as younger ones if they have proper training and life-long learning.

If the adaptation of all age groups, especially older workers, is not provided a massive unemployment can be expected in the future which will cause societal problems.

RQ 5: What is the role of Industry 4.0, Smart working and digitalization on ageing workforce?

There are different scenarios about the effects of fourth industrial revolution on labor market and older workers. Negative scenarios predict the total domination of machines and production will be headed to total automation. In this scenario there will be no need for human resources and huge unemployment is expected for all age groups. In the optimistic scenarios need of humans will be a priority for designing the workplace. If the technology is used to improve the work conditions and occupational health employment of older workers will be much easier. Robots and automated machines can support older workers where their declined capabilities are not enough to meet the job demands. Organizations that utilize both human workforce and automation in an optimum way can have an edge in competitiveness.

The requirement and employment rate for highly skilled workers in areas of engineering and automotive industries will increase 6% (Piatkowski, 2020). Intellectual capital will gain importance with the adoption of industry 4.0. Older workers that are highly educated and employed in knowledge occupations can keep their jobs and continue working regardless of their age. Automation of repetitive and demanding tasks will allow older workers that employed in knowledge based occupation to continue work otherwise they would retire. However, current skills of these employees will not be enough for adapting the rapid development of technology. Life-long learning is necessary for employees and organizations to make their workforce ready to adapt the changes. Qualified employees that integrated in life-long learning can improve their skills and continue their employment. Low skilled manual labor employees will probably lose their jobs to automated machines. Low qualified personnel should obtain new skills in creative and social areas and change

tasks to the areas that are not affected by automation in order to continue employment. Organizations investing in human resources and vocational training can minimize the negative effects of new technologies.

Current older age people's lack of digital skills is an obstacle for their employment. In the future the generation that grew up with technology will be the new older workers whom are well adapted to technology. Technological adaptation optimistically will not be an issue for older worker employment. The traditional long-term employment model will not be attractive for both organizations and employees. Flexibility in employment and labor times will have crucial importance to stay competitive and adaptive to occurring challenges. Rapid changes in the nature of work will force organizations to adapt the internal work requirements and external circumstances. They need to adjust the number and different abilities required by the changed conditions. The working times and costs of the employees should be adjustable depending on the employment model. Flexible working times and employment will be more attractive for employees that they can choose tasks that suit them instead of jobs.

Talent shortage will be the main problem for organizations that doesn't find creative ways to utilize their ageing workforce. Older workers have the most experience in job-specific and procedural knowledge. Part time jobs and short-term contracts are considered as good ways to keep the knowledge inside the organization.

In the end, talented and highly skilled older workers will not have problems to be employed but they need to be integrated in life-long learning programs. Low skilled workers will be unemployed when fourth industrial revolution will replace them with machines.

Table 10 Subjects of ageing workforce based on articles

Study	Organizational and societal						Human Resource Management								Technology		Ageing Workforce		
	Work related injury	Performance	Productivity	Knowledge transfer	Society	Team work	Balance of demands and resources	Occupational health and safety	Ergonomics	Training	The work environment	The organization of work	The employee	Social support	Assistive technologies and wearable devices	Digitalization, Industry 4.0, Smart manufacturing	Population demographics	Reasons for older people to work	Capability changes
(Berhan, 2020)	√	√	√					√				√	√						√
(Brenda & Katherine, 2020)	√										√	√					√		
(Carolyn Drake, Roger Haslam & Cheryl Haslam, 2017)		√	√	√				√			√	√	√						√
(Claudon, Desbrosses, 2020)												√							
(Cleo Varianou-Mikellidou, Georgios Boustras, 2019)	√	√	√	√			√	√	√		√	√	√				√		√
(Erik Berntson; Magnus Sverke; Staffan Marklund, 2006)		√	√				√					√	√						
(Farivar, Abouzahra, & Ghasemaghaei, 2020)															√		√		
(Fischl, Lindelöf, Lindgren, & Nilsson, 2020)						√									√	√			
(Frank Pot, 2011)		√	√					√			√	√	√						
(G. Costa & S. Sartori, 2007)		√	√				√		√				√				√		√
(Giovanni Cosat, 2005)	√	√	√		√		√	√			√	√	√	√					√
(Guest, Boggess, 2014)	√				√			√			√	√							√

Table 11 Subjects of ageing workforce based on articles (continued)

Study	Organizational and societal						Human Resource Management								Technology		Ageing Workforce		
	Work related injury	Performance	Productivity	Knowledge transfer	Society	Team work	Balance of demands and resources	Occupational health and safety	Ergonomics	Training	The work environment	The organization of work	The employee	Social support	Assistive technologies and wearable devices	Digitalization, Industry 4.0, Smart manufacturing	Population demographics	Reasons for older people to work	Capability changes
(Jan Fekke Ybema, Tinka van Vuuren & Karen van Dam, 2017)		√	√				√		√		√	√	√				√		√
(Jari Pirhonen & Katariina Tuominen, 2020)											√		√		√	√			
(Jari Pirhonen & Katariina Tuominen, 2020)											√		√		√	√			
(Karen van Dam, Tinka van Vuuren & Sofie Kemps,2017)		√	√				√				√	√		√					
(Kassu Jilcha, Daniel Kitaw, 2016)		√	√		√	√		√			√	√	√	√					
(Laflamme & Menckel, 1995)	√									√									
(Lai, 2012)										√					√				
(Lee, Czaja, & Sharit, 2009)								√		√		√		√		√			
(Leijten & van den Heuvel, 2013)			√								√	√	√						
(Lin & Ho, 2020)										√	√				√				
(Maira Worek; Barbara Covarrubias Venegas, 2019)		√	√			√						√	√						
(Matthew D. Marraffino, John P. Killilea, 2012)										√					√				

Table 12 Subjects of ageing workforce based on articles (continued)

Study	Organizational and societal						Human Resource Management								Technology		Ageing Workforce		
	Work related injury	Performance	Productivity	Knowledge transfer	Society	Team work	Balance of demands and resources	Occupational health and safety	Ergonomics	Training	The work environment	The organization of work	The employee	Social support	Assistive technologies and wearable devices	Digitalization, Industry 4.0, Smart manufacturing	Population demographics	Reasons for older people to work	Capability changes
(Militello & Hutton, 1998)				√															
(Patrickson & Ranzijn, 2005)		√	√		√					√	√		√			√		√	
(Paul Gilding, Murray Hogarth, Rick Humphries, 2002)	√	√	√					√			√	√	√						
(Peng & Chan, 2020)	√							√			√		√	√					
(Piatkowski, 2020)										√						√			
(R.H. Westgaard ,2011)	√	√	√					√	√			√							
(Richard & Durand, 2020)	√	√									√	√				√	√	√	
(Sharit, 2020)		√	√	√		√									√	√	√	√	
(Silverstein, 2008)	√	√	√		√					√	√	√	√	√			√		√
(Taylor & Bisson, 2020)										√							√		√
(UnitedNations, 2020)																	√		
(van der Klink, J.J.; Bultmann, U., 2015)		√	√				√				√	√	√						

Table 13 Subjects of ageing workforce based on articles (continued)

Study	Organizational and societal						Human Resource Management								Technology		Ageing Workforce		
	Work related injury	Performance	Productivity	Knowledge transfer	Society	Team work	Balance of demands and resources	Occupational health and safety	Ergonomics	Training	The work environment	The organization of work	The employee	Social support	Assistive technologies and wearable devices	Digitalization, Industry 4.0, Smart manufacturing	Population demographics	Reasons for older people to work	Capability changes
(Vandenberghe, Rigo, & Waltenberg, 2012)			√		√													√	
(Varianou-Mikellidou, Boustras,2020)	√						√	√	√	√									√
(Zacher, 2015)					√			√			√	√	√	√	√			√	

Conclusion

The ageing workforce has been a growing subject to organizations and employers, especially in the last decade. It does not only concern the operational performance or productivity, the economy and society are also both depending on it. Although ageing workforce has been broadly discussed by many authors in the existing literature, many organizations unfortunately have failed to take actions or measures about it. This thesis has been developed under the base of developing a concept on ageing workforce and its effects on the organizations. The problem statement aimed at the research is to find out the contribution and declined capabilities of ageing workforce, the measures and adjustments to be taken by organizations to support ageing workforce and the role of Industry 4.0 and digitalization on ageing workforce. The declines in motor, cognitive, perceptual capabilities, physical changes such as musculoskeletal disorders, shift works, age discrimination at workplace and work ability indexes have a major effect on the performance of ageing workforce. Identifying those characteristics in an organization is a top priority in coping with ageing workforce. Besides, the employers as well as the management commitments play an important role in creating a safe work environment by improving Occupational Health and Safety, safe design of workplace and providing assistive technologies, hence minimizing risk and accidents in the workplace. The human resources should be evaluated based on the cognitive age, subjective and objective wellbeing and then assigned job demands in order to achieve balanced demands and resources. In this case, the employment of the individual continues. Otherwise, some adjustments are to be performed based on demands such as the work environment, social support and OHS, and based on capabilities such as assistive devices. In case the balanced demands and resources are achieved, the employment of the individual continues as before. However, if not, it may lead to gradual retirement, change of task or monitoring programs. On the other hand, both the employees and the organizations will have to adapt the new work requirements and dynamics of labor market introduced by Industry 4.0 and digitalization for their future employment.

A descriptive analysis was performed about ageing workforce in terms of research methodology, theoretical/empirical, qualitative/ quantitative, data gathering, project scope, Ageing Workforce topic, Industry 4.0, Smart Manufacturing, and Digitalization. Then 96 papers have been reviewed. Although there is no limitation on the publication year, it was observed that majority of the studies have been published after 2005, which indicates that the significance of ageing workforce has increased during the last decade and it is a growing research area. The research findings shows that the studies have mainly focused on the effects and the challenges of ageing workforce, management strategies, training programs, improvement of workplace design, sustainable employment of ageing workforce and the assistive technologies.

This thesis contributes to both literature and practice by reviewing the literature on ageing workforce. It provides a rich discussion for the theory by examining and classifying the studies in terms of different aspects. Considering Industry 4.0 and digitalization, this study will provide an insight into the future employment of ageing workforce and become a guide for future researches. Furthermore, it would contribute to provide a comprehensive understanding of ageing workforce on the sustainable development based on society, culture, politics, economy and environment. On the

other hand, with the trend of increase in ageing workforce, this study will raise an awareness of ageing workforce defining characteristics, challenges and how to overcome them.

One of the limitations on the thesis is the number of keywords. A wider keyword list would improve the research area. Moreover, Industry 4.0, smart manufacturing and digitalization are the new subjects that have been unveiled in the recent years with respect to ageing workforce. Therefore, there are a limited available articles and studies regarding the effect of Industry 4.0, smart manufacturing and digitalization on the operational performance, occupational health and safety, employment of ageing workforce. Hence, further research may be directed to investigate this impact in the future researches. Another limitation is the document type criteria. Only journals, articles and reviews are included in the research. This topic can be studied in future research with considering also conference papers and books.

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