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REVIEW ARTICLE

Possible Impacts of Human Enhancement Technologies on the Older Workforce*

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ABSTRACT
The importance given to Human Enhancement Technologies (HET) in the literature is increasing daily. Both the fact that the technologies available today will become widespread in the future and the technologies that we are close to reaching because of rapidly continuing research, HET will become a part of both our daily lives and work life in the future.
The elderly population continues to increase both in number and proportion of the total population. It is estimated that this change will be reflected in the labour market shortly and that the older workforce will account for almost half of the total labour force.
There are several issues that reduce the employability of older people. In general, older people are associated with illness, disability, memory loss and cognitive decline, physical decline, loneliness and depression. They are also perceived to be more costly in enforcing health and safety standards. HET can help to overcome some of the problems faced by the older workforce. In this study, the concept of HET will be discussed, and the effects of HET on the older workforce in the labour market will be evaluated.

Keywords: Human Enhancement Technologies, elderly, older workforce, labour market, employment

Introduction

Human Enhancement Technologies (HET) refer to the use of current technology to surpass human physical and mental capacities, beyond merely treating and rehabilitating people. Many ideas that were once confined to science fiction have now become feasible with today's technology. Although the examples applied to humans currently represent a very small portion of the population, laboratory studies and the budgets allocated to these studies are rapidly increasing, especially under the influence of thought movements led by certain groups.

The concept of human enhancement has a dual nature. On the one hand, technological advancements, societal and personal needs, and desires have begun to create pressure towards the goal of a "developed society" from a political and cultural standpoint. On the other hand, certain social groups and scientific networks, led by the philosophical movement of Transhumanism and influential figures in the scientific world, have started to steer social and political tendencies to accelerate research on technologies that make human enhancement possible.

It should be noted that the current technology has not yet reached a stage where it can provide individuals with significant advantages over "unenhanced humans" in practise. However, evidence is increasingly suggesting that methods are progressing towards making this possible soon. Even now, there are technologies in the research and development phase that can visibly alter human physical and cognitive existence.

If the current trend continues at the same pace, it is anticipated that the mentioned technologies in this field will soon become an integral part of working life, like laptops or smartphones. In fact, some applications have already started to be used in our lives without we realising it. These technologies are expected to cause significant changes in the social and political perception

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of society, similar to previous technological revolutions. No development in the social and political sphere should be considered separately from production relations and, consequently, the labour market. The changes that these new technologies will cause in human resources are likely to have the greatest impact on labour relations.

The history of technology shows that the most significant social changes occur through production relations. Therefore, it is essential to study the potential impacts of HET on working life to be prepared for the near future of the world. HET is progressing beyond a dream to become an ordinary part of our lives. The advancements in this field have become unstoppable, and discussions about whether to prevent them seem to be a thing of the past. In this case, studies in this field are of great importance to minimise potential problems in the labour market in the near future and to ensure that this transition process is managed with the least damage and error for humanity.

It is evident that human enhancement is not merely a scientific phenomenon. Technologies and trends can have both beneficial and harmful effects across many layers of the political arena. While they can create new opportunities for society and individuals, they also bring significant risks and can change the known concept of humanity and cultural notions as new social needs arise. Therefore, it would be wrong to approach HET with a "laissez-faire" attitude or to adopt a completely preventive approach. Policies that maintain a balance between these extremes need to be developed.

One of the most important groups that HET is expected to affect in the labour market is the older workforce. As is known, the proportion of the population aged 65 and over is increasing worldwide (World Health Organisation, 2022). However, due to some disadvantages that arise with ageing, the older workforce is not preferred in the employment process. In addition, older people are already not expected to work as being old is associated with retirement (Özen & Özbek, 2017; Atay, 2023). Old age comes with a variety of problems like social status and role changes, feelings of inadequacy and helplessness, lack of self-confidence, loss of authority, dependance, loneliness, fear of rejection and fear of death (Demirbilek, 2005). As older workforce are not preferred in employment, they are forced to be unemployed. This situation worsens the mentioned problems for older people. Working is centre of person's life as being not only an economical action but also a provider of prestige, social status and an active social network (Weiss, 1995). Therefore, lack of employment creates a big gap in a person's life. Old age could mean despair if a person feels unfulfilled (Erikson & Erikson, 1998). Furthermore, if a person does not have the economical means of living a comfortable life in retirement, not having a job may prove to be very hard. In order to tackle these implications, it is imperative to address any solutions on unemployment in old age. Widespread usage of HET will have the power to eliminate the relative disadvantages of the elderly workforce. This situation can cause significant changes in the labour market.

Definition and Classification of Human Enhancement Technologies

Although human enhancement technologies are a newly emerging field, they encompass several areas by definition. Broadly speaking, they include applications that everyone benefits from today, such as mobile phones or medical aesthetics, as well as very new technologies that are rarely encountered in practise, such as brain-computer interfaces and genome therapies. Therefore, it is considered useful to categorise HET under the headings of currently existing technologies, those in the development stage, and speculative technologies believed to exist in the future.

Currently, three types of human enhancement are accepted in the literature: reproductive, physical, and mental human enhancement. Reproductive enhancements include embryo selection through preimplantation genetic diagnosis, cytoplasmic transfer, and in vitro creation of gametes. Physical enhancements encompass cosmetic (plastic surgery and orthodontics), drug-related (doping and performance-enhancing drugs), functional (prosthetics and enhanced exoskeletons), medical (implants like pacemakers and organ replacements like bionic lenses), and strength training (weights like dumbbells and nutritional supplements). For mental enhancement, examples include nootropics, neurostimulation, and supplements that improve mental functions (Lanni et al., 2008). Computers, mobile phones, and the internet can also be used as examples of technologies we use to enhance cognitive activity (Landau, 2012). Wearable electronics (e.g., augmented reality glasses, smartwatches, smart textiles), personal drones, and interconnected Internet of Things (IoT) devices, including body and intra-body nano-networks, are leading significant efforts in the field of human enhancement (Pirmagomedov & Koucheryavy, 2019; Akyildiz et al., 2008). As a developing concept, there are difficulties in defining what an HET is and limitations for what should be accepted as an HET. However, when we focus on the similarities between the definitions in the current literature, three main points step forward; improvement of human capacities, self- improvement and improvement of human nature (Bateman & Gayon, 2012).

Different forms of human-enhancing technologies are either in the development stage or currently being tested and experimented with. Emerging technologies in this field include human genetic engineering (gene therapy), neurotechnology (neural implants and brain-computer interfaces), cyber hardware, designed strategies to prevent ageing, nanomedicine, and 3D bioprinting.

Currently, there are ongoing discussions about some theoretical HETs such as mind uploading, neocortex, and endogenous artificial nutrition. Mind uploading refers to the theoretical process of scanning and mapping a biological brain in detail and then copying its current state to a computer system or another computational device, effectively “transferring” or “uploading” a conscious mind from the brain to a non-biological substrate. The exocortex is defined as a theoretical artificial external information processing system that would augment the brain’s biological higher cognitive processes. Endogenous artificial nutrition refers to a technology that would theoretically allow a person to go without food for weeks by having a radioisotope generator that resynthesizes glucose (similar to photosynthesis), amino acids, and vitamins from breakdown products.

It is also possible to classify human enhancement technologies according to the medical methods used in practise. Gofette (2006) classified HETs under eight headings:

- Performance doping
- Use of psychological stimulants outside therapeutic purposes
- Aesthetic changes beyond reconstructive plastic surgery
- Reproductive control applications outside reproductive disorders
- Interventions in a person’s mood outside therapeutic purposes
- Sex reassignment
- The pursuit of youth or immortality
- Artificial production of humans

Human enhancement technologies can also be classified according to the purposes of the person being intervened upon. In this way, HET can be classified into four different categories: adaptation to environmental conditions, combating disease, ageing, and death, targeting existing or future children, and happiness/mood-based (Blais & Martineau, 2006).

There are many environmental factors that people are exposed to in their daily lives. Moreover, these factors originate from different environments that occupy a person’s life. These factors are related to people’s physical, cognitive, and psychological characteristics and have effects on these characteristics. Due to the rapid changes and increasing expectations in daily life, today’s people live with many pressure elements.

Human enhancement technologies can help individuals better adapt to the expectations of today’s world by intervening in their cognitive, psychological, and physical states (Table 1). Thus, in an environment where personal relationships are becoming increasingly complex, it is possible for people to develop their social skills and meet the ever-increasing expectations of society. In today’s world, where competition and expectations from employees are constantly increasing, it is possible to enhance work skills. In an environment where competition is increasing day by day and academic success expectations are rising, students’ learning abilities can be improved. Additionally, it is possible to reduce the negative psychological effects that inevitably arise in this pressure environment. Whether a professional athlete or a worker earning a living through physical labour, the expected physical performance can be increased using HET. People who are dissatisfied with their physical appearance or sexual life due to societal expectations are provided with the opportunity to make the desired changes to their bodies.

Although the literature states that HET should be distinctly separated from medicine (President’s Council on Bioethics, 2003; Gofette, 2015), it is a fact that these technologies are also beneficial for human health (Table 2). Thanks to HET, it seems possible for people to be much more resistant to diseases and to lead healthier and therefore more satisfying lives. Additionally, it has quite effective methods for reducing the speed and effects of ageing.

Moreover, looking at the roadmap that HET is following, it seems possible that in the future, the effects of ageing can be completely eliminated, ageing can be stopped, and at least natural death can be prevented.

One of the most debated application areas of HET, and perhaps the most controversial, is the technology that can be applied to children and embryos. Using HET, it seems possible to raise a new generation that is healthier, more talented, and has a longer lifespan (Table 3).

One of the most important issues today is the “pursuit of happiness” constantly imposed on society. Moreover, when the pressure to be happy is added to the many existing pressure elements, it becomes difficult for a person to feel good. Perhaps eliminating the sources of pressure that create this situation would be healthier for society, but HET offers solutions that will help people feel better and increase happiness, even if there is no change in this regard (Table 4).

Another four-part classification of HET comes from official institutions in the United States. This classification is similar to that of Blais and Martineau (2006). According to the report of the President’s Council on Bioethics, HET is divided into four categories: better children, happy souls, superior performance, and ageless bodies (President’s Council on Bioethics, 2003).

It is also possible to classify human enhancement technologies according to the methods of application. This type of classification is based on the assumption that there is always an object applied in the HET. This object can vary in size and shape, can be inside or outside the human body, and can range from a simple prosthesis to a gene sequence, but ultimately there is always an object involved (Nouvel, 2015). Human enhancement technologies can be applied to a specific part of the body (such as implants and

Table 1. Interventions aimed at adapting the environment

Sub-categories	Examples of technological interventions and their objectives
Increasing social skills through psychological or cognitive modifications	· Reducing social anxiety, hatefulness, aggressiveness, jealousy and shyness · Improving sociability, agreeableness, conscientiousness, assertiveness, self-confidence, honesty, and fairness · Improving morality · Improving control of emotions, moods, impulsive behaviours · Improving social intelligence
Increasing social acceptability through physical modifications	· Lightening the skin for social acceptability · Modifying morphologies (augmentation mammaplasty, cosmetic height surgery) · Cosmetic surgery
Increasing working skills through psychological, cognitive, or physical modifications	· Reducing fatigue and stress · Improving calmness · Improving strength, speed, stamina, reaction speed, morphologies, productivity, sensory and motor abilities · Reducing fear in people with dangerous jobs · Increasing productivity · Improving concentration, memory storage and working memories, attention, focus, performance on various complex motor learning tasks, proofreading, numerical ability, learning skills, verbal fluency, abstract reasoning, spatial cognition, resistance to sleep deprivation, alertness and wakefulness
Increasing learning skills through cognitive modifications	· Improving learning speed, concentration, memory storage and working memories, attention, focus, proofreading, numerical abilities, learning skills, abstract reasoning, spatial cognition, language learning, alertness and wakefulness
Increasing athletic skills through psychological, cognitive, or physical modifications	· Reducing fatigue and stress · Improving calmness · Improving strength, speed, stamina, reaction speed, morphologies, and sensory and motor abilities · Improving concentration, attention, focus, performance in various complex motor learning tasks, abstract reasoning, spatial cognition, alertness and wakefulness
Increasing sexual skills through psychological or physical modifications	· Improving pleasure and arousal · Correcting erectile dysfunctions · Increasing/reducing breast size · Using hormonal contraception
Increasing seduction skills/appearance through physical modifications	· Improving the physical appearance with cosmetic surgery · Modifying morphologies · Maintaining or recovering a youthful appearance · Reducing the need for exercise to remain physically fit · Choosing colouring, lightening/darkening skin
Increasing combat skills through psychological, cognitive, or physical modifications	· Reducing fear in combatants · Increasing aggressiveness · Erasing the memories of traumatic events · Improving strength, speed, stamina, reaction speed, morphologies, talents, and sensory and motor abilities · Identifying gene markers to distinguish friend from foe between combatants · Improving combatants' cognitive capacities, resistance to sleep deprivation, concentration, attention, focus, ease of skill acquisition, abstract reasoning, spatial cognition, alertness and wakefulness
Fitting into an artificial, fast-changing environment	· Taking charge and modifying human biological development and evolution to better fit into the artificial environment human beings are continuously creating

Note. Adapted from Menuz (2015)

Table 2. Interventions aimed at fighting disease, ageing and death

Sub-categories	Examples of technological interventions and their objectives
Health optimisation	· Improving resistance to disease, manipulating the immune system, and treatment of genetic risk factors · Improving lifestyle, health-wise · Using diagnostic tests · Determining the genetic transmission of disease · Optimising individual lifestyle · Controlling impulses to limit unhealthy food intake
Fighting ageing	· Retarding ageing and age-related medical conditions, increasing health-span · Reversing ageing · Eliminating ageing
Extending lifespan	· Helping people live longer · Seeking an indefinite heath span, quest for immortality

Note. Adapted from Menuz (2015)

prostheses) or can disappear within the body (such as absorbable and injectable substances). Additionally, the effects of these enhancements can be temporary or permanent (Table 5).

It would be helpful to elaborate on the classification mentioned in the table above. Removable prostheses refer to any type of replaceable organ prosthesis, such as the special running prostheses used by the Paralympic athlete Oscar Pistorius. Doping

Table 3. Interventions aimed at modifying existing or future children

Sub-categories	Examples of technological interventions and their objectives
Altering existing or future children	· Choosing certain features/properties of the child · Selecting embryos with pre-implantation genetic diagnosis · Selecting the genetic traits · Selecting embryos for sex (fe. for family balancing) · Selecting a child with superior genes

Note. Adapted from Menuz (2015)

Table 4. Interventions aimed at increasing happiness/well-being

Sub-categories	Examples of technological interventions and their objectives
Increasing happiness/well-being through psychological modifications	· Erasing memories of the shameful conduct of traumatic events · Reducing guilt, depression, anxiety, grief, fear, and stress · Improving calmness, capacities for pleasure, serenity, love, and artistic appreciation · Experiencing novel states of consciousness

Note. Adapted from Menuz (2015)

Table 5. Four classes of enhancement techniques

	Temporary	Definitive
Localised	Removable prothesis	Implanted prothesis or localised genetic modification
De-localised	Doping substance	Germ line genetic modification

Note. From Nouvel, 2015

substances, as the name suggests, are materials like Erythropoietin that allow athletes to exceed their performance limits. Fixed prostheses are implants permanently placed in the body. Regional genetic modifications refer to the placement of genetically modified cell types in a specific area of the body. Germline genetic modification involves a similar process applied at a level that affects all cells in the body. Note that such a procedure has not yet been tested in humans, but given its success in animals, there is a strong prediction that it will be successful in humans as well.

When defining the concept of human enhancement, interventions are often described as being performed through natural or artificial methods. Naturally, this characteristic allows HET to be divided into natural and artificial categories. This distinction is easy to make in temporary and regional applications. However, as the technological intervention area moves away from regionality and becomes permanent, it becomes difficult to understand the difference between natural and artificial. For example, it would be impossible to determine whether the genetic transformation applied to a person whose entire body has been modified at the cellular level is natural or artificial. It would be more beneficial to evaluate such interventions that can imitate nature to an indistinguishable degree in another category (Nouvel, 2015).

As mentioned earlier in this study, although the idea of human enhancement dates back to ancient times, HET is a newly emerging field. However, looking at the history of applications, it is seen that studies in this area began to be conducted from the mid-20th century onwards.

The foundation of human enhancement technologies may have been laid at the Hastings Centre Institute. Founded in 1969, the Institute addressed the need to professionally handle the social impacts of revolutionary changes in the biological sciences. During this period, extraordinary developments such as organ transplants, experiments on humans, prenatal diagnosis of genetic diseases, life extension, and control of human behaviours were occurring, and there was a need to examine all these developments within the framework of ethical concerns and sufficient scientific knowledge. The Institute dedicated itself to bringing together many researchers from around the world working in these areas several times a year, sometimes assigning tasks in between. This group of 75 people conducted studies in four different areas: behaviour control, population control, genetic engineering and guidance, and the process of death and dying (Institute of Society, Ethics and the Life Sciences, 1973).

In conclusion, HET stands as an undeniable reality today. Humanity is rapidly advancing towards a post-human future that surpasses the standard Darwinian concept of evolution with the possibilities of biotechnology (Harris, 2007). Ultimately, technology seems to be leading humans towards a future where ageing can be stopped and even immortality can be achieved (de Grey, 2005).

Ageing and The Increasing Older Workforce: Definitions, Statistics and Impacts

Before delving into the topic of the older workforce, it is useful to discuss the concepts of ageing and old age. In its simplest form, ageing refers to the physiological and psychological changes a person undergoes due to advancing age (Özen & Özbek, 2017). In gerontology, ageing is defined as the regular changes that occur in adult humans as their chronological age progresses

(Baybora, 2007). Ageing refers to the regular changes in an individual's biological, psychological, and social aspects over time, while old age is defined as the period following development and maturation in the lifespan, characterised by the highest level of interaction between genetic structure and the environment, leading to physiological and psychological changes. Thus, ageing reflects a process, whereas old age represents a period, with the beginning of the ageing process preceding the onset of old age (Öktem Özgür, 2021).

The ageing or youthfulness of the workforce is typically considered chronologically based on individuals' birth dates. However, since the concept of ageing includes biological, psychological, and sociological changes, many studies debate whether it is accurate to measure ageing in this way (Atay, 2023). Today, the increased lifespan and the sustainability of productivity during the ageing process are forcing changes in our social definitions (Moulaert & Biggs, 2013). Moreover, even when trying to limit the definition to a chronological sense, there is no consensus in the literature on the minimum age level to be determined. However, for the sake of research validity, there is a need to define the elderly workforce.

In the current literature, the elderly workforce is generally referred to as 40+, 55+, and 65+ (Atay, 2023). Some argue that a person should be considered an elderly worker from the age of 45 (Woods & Ostry, 1962). This view is supported by the correlation between ageing and unemployment, which starts in the 45-65 age range (Axelrad et al., 2013). Workers over the age of 45 face age-related difficulties in re-employment if they lose their jobs for any reason (Marmora & Ritter, 2014). Similarly, workers over the age of 45 are considered elderly by businesses (Axelrad et al., 2013). According to Brown (1990), although the definition of the elderly workforce varies according to various factors, it fundamentally refers to workers aged 50 and over. Some argue that the age limit for defining the elderly workforce chronologically should be over 55 (Morse, 1979). Some researchers even suggest that the elderly workforce should be divided into two categories: elderly workers aged 55-64 and older workers aged 65 and over (Taeuber, 1983). Although the elderly workforce varies depending on the field of work, it generally refers to individuals aged 40 and over up to those aged 75 and over (Kooij, 2010). A study looking at the issue from a perceptual perspective found that the age at which workers begin to be perceived as elderly ranges from 28 to 75, with a median age of 55 (McCarthy et al., 2014). Another definition describes the elderly workforce as those who continue to work contrary to the normative structure of retirement, meaning those who are eligible for retirement but choose not to retire or continue to work despite being retired. Based on this understanding, it can be said that the elderly workforce consists of individuals over the mandatory retirement age of 65 (Öktem Özgür, 2021).

Considering the statistics from the EU, ILO, and OECD, the age range of 55-64 emerges as a basis. In OECD labour studies, the most important factor in choosing this range is the decline in labour force participation in this age range (OECD, 2005). The ILO does not find the chronological definition of the elderly workforce appropriate in terms of performance and defines elderly workers in Recommendation No. 162 as "all workers who may encounter difficulties in employment and occupations due to their advanced age" (ILO, 1980). However, in the tables presented in its reports, the ILO also uses the age range of 55-64 for the elderly workforce (ILO, 2019). The US defines the elderly workforce as those aged 55 and over in official reports (Hardy, 2006). In Türkiye, there is no agreed definition for the elderly workforce, but TÜİK uses the age range of 55-64 when determining the employment rate for the elderly (TÜİK, 2011). Considering all these data, it can be said that those aged 55 and over are generally accepted as the "elderly workforce."

Although there are countries showing a tendency in the opposite direction, the world's population is ageing. Currently, there are 1 billion elderly people worldwide. Globally, the proportion of people aged 60 and over is expected to increase from 12% to 22% between 2015 and 2050. By 2050, the number of people aged 60 and over is projected to double to 2.1 billion. During the same period, the number of people aged 80 and over is expected to be triple to 426 million (World Health Organisation, 2022). For example, in the UK, there are currently around 10 million people aged 65 and over. This number is expected to increase by 50% by 2030 and double by 2050 (Cracknell, 2010). In Türkiye, the population aged 65 and over increased from 6.6 million in 2016 to over 8 million in 2021, showing a 24% increase in five years. The elderly population is not only increasing in number but also in proportion. In 2021, the proportion of elderly people in Türkiye was 9.7%, rising to 10.2% in 2023, and it is expected to exceed 25% by 2060. Moreover, Türkiye ranks below the world average in this statistic, at 68th place (TÜİK, 2022; TÜİK, 2024).

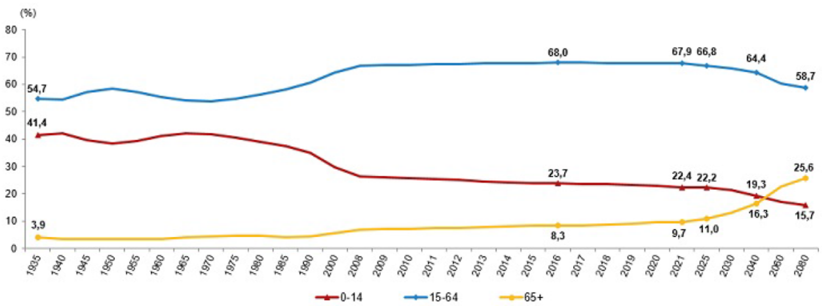

Figure 1. Population ratio by age group

Note. From TÜİK, 2022.

The world's elderly dependency ratio is continuously rising (Figure 2). For example, in Japan, the elderly dependency ratio increased from 19% in 1990 to 60%. Moreover, this ratio is expected to reach 80% by 2060. Similar trends are observed in developed countries such as South Korea, Italy, and Germany (OECD, 2015). All these statistics highlight the potential ageing of the labour market in the future. Perhaps, in the coming years, there may be a need to redefine the working-age population.

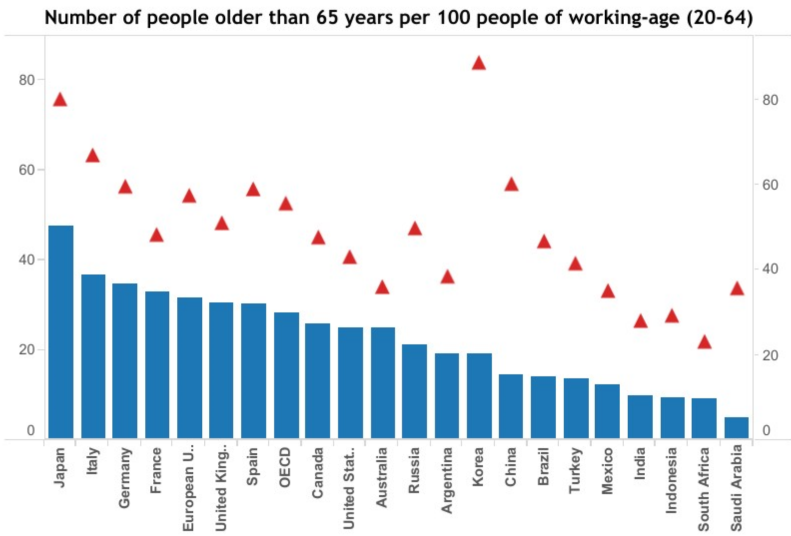

Figure 2. Old-age dependency ratio in the OECD

Note. OECD (2015). https://www.oecd.org/economy/ageing-inclusive-growth/

In Türkiye, the labour force participation rate of the elderly population was 10% in 2020 and 11.3% in 2021. During the same period, the employment rate of the elderly population remained at 9.7%, while the unemployment rate was 2.7% (TÜİK, 2022; TÜİK, 2023). Looking at the OECD as a whole, the labour force aged 60 and over accounts for approximately 5% of the total labour force (OECD, 1998). Given the ageing workforce, it is not difficult to predict that these numbers will not remain this low in the future. For example, Table 6 shows that the proportion of the elderly population in the total labour force in OECD countries is expected to increase and constitute half of the labour force within approximately 25 years.

Table 6. Demographic old-age to working-age ratio: Historical and projected values, 1950-2080

	1950	1960	1990	2020	2050	2080		1950	1960	1990	2020	2050	2080
OECD members													
Australia	14,0	16,0	18,8	27,7	41,6	49,4	Netherlands	13,9	16,8	20,6	34,3	53,3	62,2
Austria	17,3	21,0	24,3	31,3	56,0	60,2	New Zealand	16,3	17,0	19,5	28,3	43,8	57,5
Belgium	18,1	20,3	24,8	33,1	51,3	56,8	Norway	16,0	19,8	28,5	29,6	43,4	53,4
Canada	14,0	15,1	18,4	29,8	44,9	54,0	Poland	9,4	10,5	17,3	30,5	60,3	68,6
Chile	7,2	7,9	10,9	19,7	44,6	67,5	Portugal	13,0	14,8	23,9	38,6	71,4	72,3
Columbia	7,5	7,2	8,4	15,0	36,0	64,3	Slovakia	11,9	12,6	18,2	26,5	54,6	58,1
Costa Rika	6,8	7,1	9,0	16,6	41,6	69,4	Slovenia	12,5	13,7	17,3	34,7	65,0	60,7
Czechia	13,9	16,3	22,0	33,8	55,9	52,8	Spain	12,8	14,6	23,1	32,8	78,4	74,4
Denmark	15,6	19,0	25,9	34,9	44,6	52,4	Sweden	16,8	20,2	30,9	35,9	45,5	53,4
Estonia	19,3	17,7	19,7	34,9	54,9	63,2	Switzerland	15,8	17,6	23,6	31,3	54,4	56,7
Finland	11,9	13,5	22,0	40,1	51,4	65,0	Türkiye	6,5	7,0	9,4	15,2	37,0	58,2
France	19,5	20,8	24,0	37,3	54,5	62,2	United Kingdom	17,9	20,2	26,9	32,0	47,1	55,1
Germany	16,2	19,1	23,5	36,5	58,1	59,5	USA	14,2	17,3	21,6	28,4	40,4	51,1
Greec	12,4	12,2	22,9	37,8	75,0	79,7	**OECD**	**13,6**	**15,0**	**20,0**	**30,4**	**52,7**	**61,1**
Hungary	13,2	15,5	22,9	33,4	52,6	55,4							
Iceland	14,1	16,4	19,0	26,6	46,2	64,5							
Ireland	20,9	22,8	21,6	25,0	50,6	60,0	Argentine	7,5	10,1	17,3	20,2	30,3	45,5
Israel	7,1	9,1	17,8	23,9	31,3	39,9	Brasil	6,5	7,1	8,4	15,5	39,5	63,7
Italy	14,3	16,4	24,3	39,5	74,4	79,6	China	8,5	7,6	10,2	18,5	47,5	60,6
Japan	9,9	10,4	19,3	52,0	80,7	82,9	India	6,4	6,4	7,9	11,3	22,5	40,8
South Korea	6,3	7,6	8,9	23,6	78,8	94,6	Indonasia	8,6	7,6	7,7	10,6	27,3	41,0
Latvia	18,1	17,7	19,9	35,5	53,0	49,9	Russia	8,7	10,5	17,2	25,3	41,7	41,9
Lithuania	17,5	14,0	18,4	34,7	55,7	55,7	Saudi Arabia	7,5	8,4	6,1	5,3	28,2	44,8
Luxembourg	15,8	17,6	21,1	22,3	43,8	50,1	South Africa	8,5	8,4	8,7	9,6	17,4	26,8
Mexico	8,0	8,3	9,6	13,2	28,9	50,9	EU	14,6	16,0	21,6	33,6	56,7	62,0

Note. From OECD, 2021.

On the other hand, the increasing proportion of the elderly workforce in the total labour force should not be assumed to directly and positively affect elderly employment rates. The perception of employers and the society they are in that people in their 50s are old leads to age discrimination against workers at these ages. Therefore, the workforce faces age-related push factors in the market at early ages (Atay, 2023).

The most significant issue that the elderly workforce faces in the job market and working life is age discrimination. Elderly people are often associated with illness, disability (Klein, 2013; Karel et al., 2012), memory loss and cognitive decline, physical weakness, loneliness, and depression (Hehmen & Bugental, 2013). The elderly workforce is thought to have lower motivation compared to the younger workforce (Calo et al., 2013). Additionally, the elderly workforce is seen as slower, less flexible, and less capable of learning new tasks (Ennis et al., 2013), and therefore believed to be less productive (von Hippel et al., 2013). The elderly workforce is found to be more forgetful compared to younger workers (Rosigno, 2010). They are also considered more costly in terms of implementing health and safety standards (Szinovacz, 2011). This results in the elderly workforce being less employed in the job market, having more limited career and educational opportunities, and receiving less social support (Allen et al., 2009; Rosigno, 2010).

Changes in individuals' health and well-being due to ageing affect their employability (Verbrugghe et al., 2016; Baumann, 2016; Nauta, 2005). According to Eurostat data, the third most common main reason for people aged 55-64 to end their active working life is illness or disability (Morschhauser & Sochert, 2006). As age progresses, changes occur in a person's mental and physical well-being due to genetic factors and environmental conditions. With ageing, physical strength loss occurs due to muscle weakening, and people can become more vulnerable to diseases due to a slowing metabolism. All these lead to a decline in a person's physical condition as they age. This physical decline negatively affects individuals' employability (Öktem Özgür, 2021).

Age can indeed affect people's ability to adapt to new technologies. New technologies are often designed with the younger population in mind. Therefore, changes in cognitive, perceptual, and motor skills due to ageing can make interacting with new technologies more challenging (Charness & Boot, 2009). Older workers benefit less from information and communication technologies in the workplace compared to younger workers and face difficulties when trying to use them (De Koning & Gelderblom, 2006). Additionally, there is a positive relationship between age and computer anxiety and a negative relationship between age and computer knowledge (Ellis & Allaire, 1999). As technology continues to develop rapidly and cognitive, perceptual, and physical abilities decline with age, older workers will continue to struggle to adapt to new technologies unless there is a development to counteract this (Charness & Boot, 2009).

One of the significant reasons negatively affecting the employability of the elderly workforce is their outdated skills and qualifications (Hofacker, 2012). The structure of the economy forces businesses to constantly pressure their employees to acquire new skills. Even when businesses are willing to train their employees for the new skills they need, they find the opportunity cost of training their older employees high, making it unattractive for employers to train their older employees (Hofacker, 2010). Consequently, the elderly workforce is deprived of educational opportunities.

Another factor negatively affecting the elderly in the job market is productivity. There is a belief in the job market that productivity decreases as people age, and therefore they should leave the job market. Individuals reach their peak productivity in their 40s, and their productivity gradually decreases after this point (Ilmakunnas et al., 2004; Skirbekk, 2004). Considering the increasing trend in the elderly population, pushing the workforce out of the job market for the reasons mentioned above leads to a significant amount of labour supply potential being unused. Moreover, the elderly workforce has positive qualities that provide significant advantages for businesses. Workers over the age of 40 are experienced, loyal, reliable, have developed communication skills, are conscientious, self-confident, more inclined to act thoughtfully, and more suitable for teamwork (Warr & Pennington, 1993). Additionally, older workers have lower rates of workplace accidents, absenteeism, job turnover, and job searching compared to younger workers (Çilingiroğlu & Demirel, 2004; Hedge et al., 2005). Furthermore, the presence of the elderly workforce is important in professions where experience can make a positive difference, such as teaching, academia, and medicine. Considering all these qualities of the elderly, excluding them from the job market results in the loss of a productive and valuable group. To prevent this loss, efforts are needed to eliminate the problems that hinder the participation of the elderly in the workforce.

Possible Impacts of Human Enhancement Technologies on the Older Workforce

Human enhancement technologies (HET) can eliminate the causes of age discrimination against the elderly in the labour market. HET can address all the above-mentioned issues. As HET becomes widespread, it is expected to increase individuals' productivity, ability to learn a job, chances of employment, and work motivation. It will also enable them to continue working under difficult conditions or at advanced ages, reduce the risks of occupational accidents and diseases, and shorten the time to return to work after illness (The Academy of Medical Sciences et al., 2012).

With the use of HET in working life, it will be possible to enhance individuals' mental and psychological resilience and help them exceed their current potential. For workers in physically demanding jobs, HET can improve their strength, speed, endurance, and various motor skills, thereby increasing their productivity. For workers in mentally demanding jobs, it can enhance social and cognitive abilities such as concentration, memory, attention, focus, learning ability, fluency in speech, and abstract reasoning (Menuz, 2015). This makes it possible to eliminate the gradual loss of physical and mental abilities that inevitably occurs with ageing.

Technologies like exoskeletons and dual-arm power amplifiers, which enhance human physical capacities, have started to emerge (Dollar & Herr, 2008; Young & Ferris, 2017, Gopura et al., 2016; Perry et al., 2007). These devices can easily be used by older people; therefore, they would not be affected in their work life by their deteriorated physical condition. Also, there may be a better solution in the virtual exoskeleton technology where a robot can be operated from afar by its user (Tachi, 2013). Remote control options for older people could be expanded too as gestures can be used. Controlling any machinery by small gestures can be seen to an observer, but it is possible with HET (Agrawal & Gupta, 2016; Bikos et al., 2015; Lee & Lee, 2018).

Cognitive HET will also help address the problems that elderly workers face in adapting to new technologies. Additionally, it can solve the issue of unequal access to educational opportunities experienced by the elderly workforce. Education is the most comprehensive and proven method of cognitive enhancement (The Royal Society, 2011). Even a small competitive advantage makes cognitive enhancers attractive. Even slight increases in cognitive performance can lead to significant improvements in functional outcomes. For example, a mere 10% increase in memory performance can turn a student into a top-performing student (Academy of Medical Sciences, 2008). Another reason for the interest in these drugs is their effect on increasing the pleasure derived from completing a task. Cognitive enhancers like Modafinil have been proven to increase the motivation for routine cognitive activities and the enjoyment derived from completing them (Müller et al., 2012).

Using technology for cognitive training is another method of cognitive enhancement. More efficient learning methods can increase the impact of education by better preparing workers for their jobs and promoting continuous improvement. This is especially important today, as the nature of work is rapidly changing. Digital technology is very suitable for supporting cognitive training due to its fundamental characteristics. Digital technologies are adaptable enough to provide personalised, targeted training, responsive enough to offer instant feedback, and patient enough to allow unlimited repetition of training activities.

Cognitive training studies proceed in two different ways. Commercial brain training targets multiple areas such as memory, executive control, and hand-eye coordination, while laboratory studies focus on improving short-term memory through software (The Academy of Medical Sciences et al., 2012). Research shows that cognitive training also supports cognitive maintenance. Because of cognitive training, people aged 65 and over show improvements in memory, reasoning, and information processing speed (Ball et al., 2002). In another study, participants in the same age group were observed to have indirect improvements in general skills related to attention and memory, even though they did not specifically train for these skills (Smith et al., 2009). Extended memory can be achieved with a centralised network to enable extended cognition (Smart, 2017). Enhanced cognition applications are already being used to monitor health (Reeder et al., 2017), assist patients with mild brain injuries (Stanney et al., 2009), and enhance learning and memory (Palmer & Kobus, 2007; Dingler et al., 2016). New HETs have been developed in the neuroscience area for monitoring, facilitating and modulating human brain functioning (Eaton & Illes, 2007; Shook & Giordano, 2016; White et al., 2015). Implanting electrodes into the brain to restore memory functions is an example of this (Song et al., 2015; Serruya & Kahana, 2008).

The frequency of repetition also has productivity-enhancing effects. Elderly individuals who participated in training games for 15 minutes a day, five days a week, showed improvements in executive functions and information processing speed (Nouchi et al., 2012). Studies with elderly people also show that computer-based training leads to structural changes in areas of the brain that are known to decline with age (Lövdén et al., 2010). Moreover, frequent training increases executive functions transferably for all age groups (Karbach & Kray, 2009).

Hearing loss is associated with ageing and still there are still no known ways on how to prevent age-related hearing loss (National Institute on Deafness and Other Communication Disorders, 2023). But with the help of HET, this could be reversed. Devices are called smart headphones that can be used not only for mitigating hearing loss but also provide super hearing abilities (McGreal, 2018). They can also help filter out noise, discriminate sounds, and transpose the sound frequency to a level that is easier to perceive (Kirchberger & Russo, 2016). This technology can also be used to enhance spatial sense or help focus on the sound from a specific direction (Ricketts, 2001).

Conclusion

In recent decades, improvements in the quality of life and scientific advancements, particularly in health, have significantly increased the human life expectancy compared to previous centuries. Conversely, there is a trend of declining birth rates globally, especially in developed countries. As a result, the average age of the world's population is rising, which inevitably affects the labour market and working life.

As the proportion of the elderly population in the total population increases, so does the proportion of the elderly workforce in the total labour force. Reports in this field estimate that in OECD countries, the elderly workforce will constitute more than half of the total labour force in the next 50 years. In such a future, where the elderly workforce becomes the main labour source, identifying and solving new problems that may arise will become increasingly important.

It should not be assumed that the increase in the number and proportion of the elderly workforce will directly positively impact elderly employment. Currently, it is known that the employment rate and even the labour force participation rate among the elderly population are low. The main reason for this is not personal preference but age discrimination in the labour market.

There are reasons in the labour market that make it difficult for elderly people to keep their jobs or be re-employed if they lose them. Generally, the elderly are associated with illness, disability, memory loss and cognitive decline, physical weakness, loneliness, and depression. The elderly workforce is thought to have lower motivation than the younger workforce. They are seen as slower, less flexible, and less capable of learning new tasks, and therefore are believed to be less productive. The elderly workforce was found to be more forgetful compared to younger workers. Additionally, they are considered more costly in terms of implementing health and safety standards. All these factors result in the elderly workforce being less employed in the job market, having more limited career and educational opportunities, and receiving less social support.

The exclusion of the elderly workforce from the labour market results in the loss of a pool of experienced, loyal, reliable, and communicative individuals who are conscientious, self-confident, more inclined to act thoughtfully, and more suitable for teamwork. They have lower rates of absenteeism, job turnover, and job changes compared with younger workers, and their experience can be beneficial in certain job roles.

Given the increasing number of elderly workers, it is essential to enhance their employability and eliminate the barriers that prevent them from being preferred in the labour market. Human Enhancement Technologies (HET) can address these issues. HET can help mitigate the challenges faced by elderly workers, such as vulnerability to illnesses, physical strength loss, memory loss, cognitive decline, low motivation, slower task performance, difficulty adapting to new technologies, and limited access to educational opportunities.

With developments in HET applications, especially in pharmacology and nanotechnology areas, it seems possible to fortify humans' immune systems beyond current limitations so that older people would take advantage of this to overcome problems rooted from weaker immunity. After physical enhancement drugs and/or exoskeletons become widely available, physical deterioration through ageing wouldn't cause problems for older people. Fast developing fields of application such as cognitive enhancement drugs or digitised education systems, would help overcome any mental and psychological issues that come with age. In a future not far with developments in brain-computer interfaces and brain implants, any cognitive deterioration through ageing could become obsolete.

In conclusion, policies aimed at the elderly workforce should be prioritised. Even if we do not see ourselves as part of this group today, we will be in the future. In societies where the number of elderly people continues to increase, the social security system may not be able to sustain the elderly population excluding themselves from the labour market. Therefore, it is essential to implement all possible measures to eliminate the competition issues faced by the elderly in the labour market. HET can play an effective role in solving these problems. Hence, increasing budgets for research in this area and creating policies to ensure access to these technologies for the elderly when they become widespread is crucial. It should be remembered that protecting people from future problems is as valuable as protecting them from today's issues for social policymakers.

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