

ROBOTICS AND AGEING WELL IN JAPAN:  
THE CHALLENGES AND PROSPECTS FOR A SUPER-AGED SOCIETY



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ROBOTICS AND AGEING WELL IN JAPAN:  
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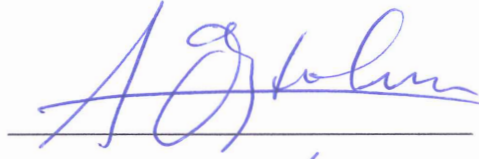
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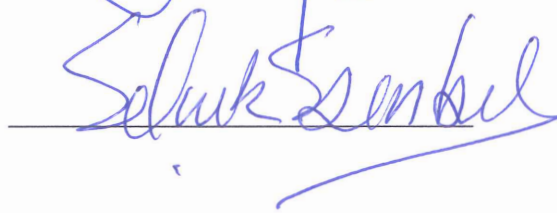
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## ABSTRACT

Robotics and Ageing Well in Japan:

The Challenges and Prospects for a Super-Aged Society

This thesis looks into the question of how the rapid ageing of the population in Japan is affecting the nation, and what are the main solutions the Japanese government has been developing, especially with the use of robotic technologies. In answering this question, the government reports on ageing and technology are taken into consideration. These reports are Annual report on the aging society:2018 by the Cabinet Office, New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan of 2015 and The 5th Science and Technology Basic Plan of 2016. Through an analysis of these reports and corresponding studies, it is seen that rather than solving the issues that are accelerating the population ageing in Japan, mainly decrease in fertility and challenging immigration policies, the Japanese government is planning to utilise new technologies, especially robotic technologies to mitigate the problem. The government's plans also include leading the newly emerging field of medical and nursing robots and creating a favourable environment within the global robotics market for Japanese robots and technology. Through these developments in technology, Japan intends to address the issues born out of population ageing while creating an opportunity for companies and institutions to obtain a large share of the global robotics market.

## ÖZET

Japonya'da Robot Teknolojileri ve İyi Yaşlanma:  
Süper-Yaşlı Toplum için Zorluklar ve Beklentiler

Bu tez Japonya'da hızla yaşlanan nüfusun ulusu nasıl etkilediği ve Japon hükümetinin özellikle robotik teknolojileri kullanarak ne gibi çözümler ürettiği sorusunu incelemektedir. Bu soruyu cevaplarken, yaşlanma ve teknoloji ile ilgili hükümet raporları dikkate alınmıştır. Bunlar Bakanlar Kurulu tarafından hazırlanmış şu raporlardır: Annual report on the aging society:2018; New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan of 2015 ve The 5th Science and Technology Basic Plan of 2016. Bu raporların ve ilgili çalışmaların analizi şunu göstermiştir: doğum oranlarındaki düşüş ve zorlayıcı göç politikaları gibi Japonya'da yaşlanmayı hızlandıran ana konuları çözmek yerine, Japon hükümeti yeni teknolojileri, özellikle robotiği kullanarak problemleri en aza indirmeyi planlamaktadır. Ayrıca hükümetin planları yeni gelişmekte olan tıbbi robotlar ve bakım robotları alanında öncü olmayı; küresel robotik pazarda da Japon robotlarının ve teknolojilerinin iyi bir yere sahip olmasını içermektedir. Teknolojideki bu gelişmeler sayesinde, Japonya nüfusunun yaşlanmasından kaynaklanan sorunları ele alırken küresel robotik pazarda büyük bir pay sahibi olmak için firmalar ve enstitüler için de imkanlar yaratmayı amaçlamaktadır.

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## ABBREVIATIONS

AI: Artificial Intelligence

AIST: National Institute of Advanced Industrial Science and Technology.

ALTs: Assisted Living Technologies

AR: Augmented Reality

ATs: Assistive Technologies

AWS: Autonomous Weapon Systems

CPS: Cyber-Physical Systems

EoL: End of Life

ICT: Information and Communication Technologies

IFR: The International Federation of Robotics

IoT: Internet of Things

ISO: The International Organization for Standardization

ITU: International Telecommunication Union

METI: The Ministry of Economy, Trade and Industry

NEDO: New Energy and Industrial Technology Development Organisation

RRI: Robot Revolution Initiative

SDG: Sustainable Development Goals

UN: The United Nations

UNICRI: United Nations Interregional Crime and Justice Research Institute

VR: Virtual Reality

WHO: The World Health Organization

WRS: World Robot Summit

## INTRODUCTION

The world is ageing at a rapid pace, the number of persons the elderly population consist of is increasing, and even the world's youngest continent Africa will be affected by this change in the near future. The number of elderly in Sub-Saharan Africa by 2050 will be around 163 million, which means, while the ageing rate might still be considered low compared to other continents, the number of elderly to take care of will become significantly higher.<sup>1</sup> As former Director-General of the World Health Organization (WHO) Gro Harlem Brundtland said in a speech in 1999; “Population aging is first and foremost a success story for public health policies as well as social and economic development...”<sup>2</sup> However, it is a story where the consequences as a result of extended lifespans and social development were not foreseen.

Ageing is a natural phenomenon, all living beings experience some kind of change throughout their lifecycle. Human beings are no different, we all grow up, age, get older and pass away. However, different from the individual ageing there is also a new trend of ageing populations. There are growing concerns about the world population ageing and what these changing demographics will bring, socially and economically. The issues that are arising globally and their potential solutions are being discussed by governments, institutions, and academics around the globe. In *Global ageing in the twenty-first century: Challenges, opportunities and implications*, sociologist Zachary Zimmer writes about the vastness of this research topic; “It would truly be impossible

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<sup>1</sup> World Health Organization, “Ageing.”

<sup>2</sup> Leung, *Health, Wellbeing, Competence, and Aging*, 138.

for one book to cover all possible issues related to global population ageing, even if focusing solely on demographic, economic and sociological perspectives...”<sup>3</sup>

Increased life expectancy and declining birth rates have been changing the age distribution toward an older generation around the world, especially in industrialised countries. There are a number of reasons for the demographic ageing of the population but as Zimmer explains it;

Population ageing is primarily a function of reductions in fertility, or a decrease in the number of children that are born. It is secondarily a function of changes in mortality, with a reduction in the rate at which older adults die. But, while the causes are similar, the consequences and challenges that are faced by various countries differ enormously. One of the key factors that contribute to the consequences of population ageing is the speed at which it is taking place. It is extremely rapid in some countries and more modest in others.<sup>4</sup>

When defining the ageing rate of a nation, some classifications used; an ageing rate of 7% means the country is an “ageing society.” When the ageing rate passes 14% it becomes an “aged society.”<sup>5</sup> A country is classified as a “super-aged society” when the ageing rate is 21% or higher.<sup>6</sup> Japan had already crossed over to being a super-aged society in 2007, the first nation to become one and the latest data on the subject gives the current rate of ageing in Japan as 27%, the highest around the world.<sup>7</sup>

The Ministry of Economy, Trade and Industry (METI), supported by Prime Minister Shinzo Abe’s administration, has turned towards robotic technologies to search for a solution, while also aiming to make Japan a world leader in the sector. One issue they are afraid might emerge as explained by Riley Walters is;

METI fears Japanese robotics may succumb to the so-called Galapagos syndrome—the technological phenomenon in Japan whereby electronic devices for the domestic market thrive, while the foreign market is almost non-existent.

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<sup>3</sup> Zimmer, *Global ageing in the twenty-first century: Challenges, opportunities and implications*. 9.

<sup>4</sup> Ibid, 1.

<sup>5</sup> Tahara, “Cardiopulmonary resuscitation in a super-aging society is there an age limit for cardiopulmonary resuscitation?”, 1102-1103.

<sup>6</sup> Arai et al., “Japan as the front-runner of super-aged societies: Perspectives from medicine and medical care in Japan.” 673–687.

<sup>7</sup> Cabinet Office, *Annual report on the aging society:2018*.

To avoid such an eventuality, the ministry is seeking adherence to international standards ... This ought to draw in high-end investment, allow international compliance, and expand Japanese robot exports to world markets that seemingly are becoming less reliant on them.<sup>8</sup>

In 2015 they published the New Robot Strategy, Japan's strategy in order to realise a robot revolution that will reach all layers of society, and not just be limited to the industry. The main aim is the automation of nearly everything; agricultural equipment, automobiles, disaster-relief services, cosmetics, pharmaceuticals industries to even medicine and care services.<sup>9</sup> They also have plans to create *smart factories*, where everything is automated and can operate non-stop.<sup>10</sup>

As it is not possible for any one company to shoulder this robotic revolution, the government's inclusion is unavoidable.<sup>11</sup> The Japanese government is enthusiastic about the subject. It is stated in the New Robot Strategy;

A major innovation in robotics including robot technology and robot utilization system will, once achieved, could serve as an extremely effective tool in the easement of social challenges faced with Japan in the eyes of global robotics trend and the current situation surrounding Japan. Furthermore, such new innovation in robotics can be accelerated by setting and striving to reach a specific and integrated goal. Therefore, Japan has a huge potential of honing itself to become a global hub of robot innovation by capitalizing on its status as a leading nation of challenges, and as a result, Japan will be able to spread across the world its future-oriented system utilizing robots.<sup>12</sup>

The Japanese are not foreign to robots or robotic technologies, many companies like FANUC, Kawasaki Heavy Industries, Sony, and Yaskawa Electric Corporation were active in the robotic development of Japan as the country was in a developmental stage economically. On the subject Todd Schneider writes; "Automation and the integration of

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<sup>8</sup> Walters, "Robotics Answers: Japan Out to Lead The next Industrial Revolution".

<sup>9</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

<sup>10</sup> Ibid, 54.

<sup>11</sup> Walters, "Robotics Answers: Japan Out to Lead The next Industrial Revolution".

<sup>12</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

robotic technology into industrial production have also been an integral part of Japan's postwar economic success. Kawasaki Robotics started commercial production of industrial robots over 40 years ago.”<sup>13</sup>

Demographic ageing of the population is also seen as a societal problem in Japan with possibly critical effects, leading to research in academia as well as in the industries. Some of the research topics include “biomedical aspects (e.g., mechanism of aging, genomics for longevity and health, aging and lifestyle-related disease, brain function) to psychology and social science-related themes (e.g., social participation and community health, prevention of aging and disability, long-term care, and social security).”<sup>14</sup> With the rise of technology aimed at the elderly, gerontechnology is also becoming a prominent research subject.<sup>15</sup> Gerontechnology can be described as;

...an interdisciplinary field of scientific research in which technology is directed towards the aspirations and opportunities for the older persons. Gerontechnology aims at good health, full social participation and independent living up to a high age, be it research, development or design of products and services to increase the quality of life.<sup>16</sup>

In an article co-authored by Naoko Muramatsu, “Japan: Super-aging society preparing for the future”, Japan's relationship with gerontechnology is touched upon; “Engineers with expertise in fields such as robotics and information technology have contributed to the development of assistive technology and aging-friendly environments since the early stage of gerontology in Japan.”<sup>17</sup>

As a consequence of the population ageing, the nursing and care-service fields are experiencing severe shortages, the demand for care workers in the nursing field is already not being met, while an increase in the number of care workers can be

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<sup>13</sup> Schneider et al., “Land of the Rising Robots.”

<sup>14</sup> Muramatsu et al., “Japan: Super-aging society preparing for the future”, 426-427.

<sup>15</sup> Ouchi et al., *Gerontology: Overview and perspectives*.

<sup>16</sup> The Herman Bouma Fund for Gerontechnology Foundation, “What is gerontechnology?”

<sup>17</sup> Muramatsu et al., “Japan: Super-aging society preparing for the future”, 426.

observed, this increase will not be enough and with a shortage estimation of 377,000 by 2025, it will be much more severe in the near future.<sup>18</sup> The rise in elderly population brings with it the rise in people in need of medical care and nursing. The labour shortages will be seen in almost all the fields in the near future, and without necessary steps to combat this Japan will face severe labour shortages. The Japanese government has been trying to create an easier immigration process in recent years, however the reality does not match what is on paper. A new bill was passed on November 27 2018, regarding the immigration issue. The plan targets blue-collar workers and a visa that will allow the workers to stay in Japan for five to 10 years.<sup>19</sup> While this may seem like a solution which will work the number of immigrants that will be accepted into the country will not compensate for the existing shortage, which will worsen in the near future. The criticism regarding this new plan is based on the problems of the existing programs;

There has been growing awareness about the exploitation and mistreatment foreign nationals are experiencing in the Technical Intern Trainee Program that Japan employs. Such abuse manifests itself in considerable overtime work, underpaid foreign employees, and the holding back of contracts or even passports. A similarly unsuccessful situation arose during the final years of the 2000s, when the Japanese government established a program for accepting healthcare professionals, mostly nurses and caretakers, to replenish the dwindling number of workers in the healthcare sector. The applicants in this program had to go through several extensive examinations, but when accepted, the local hospitals and medical institutions restricted their scope of activity, and allowed them to do only simple procedures far below their expertise, or even the tasks during their examinations.<sup>20</sup>

There is also the resistance from the public against possible immigrants to consider, and it can be seen from public interactions with the immigrants in the already existing programmes that a large influx of immigrants is not something the public wants. As such, the Japanese government has been reluctant to develop easier immigration policies and the steps they are taking could be seen as them trying to create the illusion of a more



accommodating Japan. In turn, the Japanese government has been looking at robotic technologies to lessen the pressure that is on the markets because of labour shortages. In its New Robot Strategy, the need for new robotic technologies is stressed and the ways the technologies can be utilised is explained.<sup>21</sup>

There is a great potential in robotics for healthcare and nursing sectors to solve large-scale issues. Moreover, robotic technologies in healthcare are particularly relevant in Japan, having one of the oldest populations and also struggling with issues like labour force shortage as a result of a shrinking population. On this subject Brenda K. Wiederhold writes in the article “Robotic Technology Remains a Necessary Part of Healthcare's Future Editorial”;

Part of the solution may rely on Japan’s historic status as a worldwide leader in robotics: the country’s development of improved robotic technologies has skyrocketed in the past few decades, and the country stands at the forefront of embracing robots into their culture. One such example is Paro, a therapeutic robot that is intended to help patients in hospitals and extended care facilities. Designed to look like a baby harp seal, Paro has been found to improve socialization, stimulate interaction, and reduce stress—which are significant benefits in extended care facilities with elderly patients who are battling dementia.<sup>18</sup>

This study searches for an answer in robots and robotic technologies, to the issues that arise as a consequence of the ageing of populations and changing demographics. The Japanese are at the forefront of this ageing world as they have the highest ageing rate in the world. What solutions have they come up with, as both the government and private companies work in tandem to find solutions to this huge problem, which will soon affect most of the world and not stay contained within developed nations. The Japanese government has turned its face towards technology for possible solutions to the ageing crisis. I share Bryan Pfaffenberger’s view of technology as a “social phenomenon.” He argues that there are two dominant views of technology; technological somnambulism,

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<sup>18</sup> Wiederhold, “Robotic Technology Remains a Necessary Part of Healthcare's Future Editorial,” 511.

portraying technology as “morally and ethically ‘neutral’. It is neither good nor bad, and its ‘impact’ depends on how it is used.”<sup>19</sup> The other view is technological determinism, which views technology as a “powerful and autonomous agent that dictates the patterns of human social and cultural life.” Pfaffenberger counters these views and suggests a view of technology as a social phenomenon.<sup>20</sup> In his article “Social anthropology of technology”, he proposes and defines the concept of sociotechnical system, which according to him refers to; “...the distinctive technological activity that stems from the linkage of techniques and material culture to the social coordination of labor.”<sup>21</sup> He further defines this concept as;

... the sociotechnical system concept puts forward a universal conception of human technological activity, in which complex social structures, nonverbal activity systems, advanced linguistic communication, the ritual coordination of labor, advanced artifact manufacture, the linkage of phenomenally diverse social and nonsocial actors, and the social use of diverse artifacts are all recognized as parts of a single complex that is simultaneously adaptive and expressive.<sup>22</sup>

Because there is a need for technological advancement in a specific area, it develops, and as a result of this technological development societal shifts happen, which at times creates a need for new technological advancement. It is not one or the other, but a connected system where society and social structures affect technological advancements and the resulting developments in technology, in turn, affect society and social structures.

What is currently happening in Japan amidst this Robotic Revolution is similar to this phenomenon. Social changes are urging the technological developments and in the new era to come where robots will be, in theory, commonplace in societies, the society will be affecting the societal structure in ways that we have little chance of knowing.

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<sup>19</sup> Pfaffenberger, “Fetishised objects and humanised nature: towards an anthropology of technology,” 238.

<sup>20</sup> Ibid, 239.

<sup>21</sup> Pfaffenberger, “Social anthropology of technology,” 497.

<sup>22</sup> Ibid, 513.

Especially because the robotic technologies of this new era will not be confined to factories and industrial areas but, exist alongside humans in their daily lives.

Chapter I “Ageing Well,” summarises the ageing phenomenon, its global effects and what the reaction is internationally to this global phenomenon. Chapter II “Japan: Towards a Super-Aged Society,” gives a detailed account of the Japanese experience of the population ageing phenomenon, its social and economic consequences, and the government's response in a general sense. Chapter III “Robots for a Super Smart Society: Society 5.0,” summarises the global development of robots and robotic technologies, the development and advancement of robotic technologies in Japan and what the Japanese government's new societal scheme Society 5.0 entails. Chapter IV, “Robotics and Ageing Well in Japan,” gives an overview of the use of robotic technologies in healthcare and elderly care fields. The challenges and prospects to a heavily automated society and the widespread use of robotic technologies. The last chapter, “Conclusion,” where a final assessment of the use of robotics technologies in society, especially in healthcare and elderly care is made.

## CHAPTER 1

### AGEING WELL

The populations around the world are ageing, and the global age structure is shifting and creating a phenomenon usually referred to as population ageing. This thesis deals with some of the issues caused by this demographic shift, mainly labour shortages in nursing and care sectors, especially in Japan as they are experiencing the most severe population ageing problem around the world. This chapter aims to depict a clear picture of ageing as a phenomenon in a global context. There is an increasing awareness and growing concerns about this demographic shift globally. In Zimmer's words;

...population ageing is a dynamic process wherein a growing proportion of people occupy the older range within an age structure. The definition of the specific age at which a person turns old is unimportant since population ageing is occurring regardless of the criteria that define old age, including criteria that may be cultural, political or practical.<sup>23</sup>

#### 1.1 Ageing - The concept

While it is true that the biological age is not a defining factor when discussing the ageing phenomenon, the United Nations (UN) classifies the elderly as individuals over the age of 60, while the World Health Organization (WHO) sets it at 65 years of age.<sup>24</sup> 65 is also the age when individuals become eligible for social security benefits as senior citizens in most developed countries. "According to the WHO, the proportion of a society's population that is comprised of persons age 65 or older is called the ageing rate. If a society's ageing rate exceeds 7%, it is an ageing society. If the rate surpasses

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<sup>23</sup> Zimmer, *Global ageing in the twenty-first century: Challenges, opportunities and implications*, 1.

<sup>24</sup> World Health Organization, *World report on ageing and health*.

14%, it is an aged society. If it is over 21%, it is a super-aged society.<sup>25</sup> It can be seen in Figure 1 that currently, Japan has the highest ageing rate with 27%, followed by Italy (23%), Portugal (22%), Germany (21%), Finland (21%) and Bulgaria (21%) also as super-aged societies.<sup>26</sup>

Rank	Country	% of population over 65 years old
1	Japan	27
2	Italy	23
3	Portugal	22
4	Germany	21
5	Finland	21
6	Bulgaria	21
7	Greece	20
8	Sweden	20
9	Latvia	20
10	Croatia	20
11	France	20
12	Denmark	20

Figure 1. Countries with an ageing rate of 20% or more

Source: Faraz Haider. “Countries With The Largest Aging Population In The World”

According to the UN's report titled *World Population Ageing*, the elderly population (60 years and over), which was around 200 million in 1950, had gone up to more than 800 million by 2012. By 2030 this number is expected to be around 1.4 billion. By 2050, the number is projected to be more than 2 billion people. All around the globe, the population of the elderly is growing at a faster rate than the entire population. Even in the elderly population, the older age groups are growing at a faster rate, and the fastest-

<sup>25</sup> United Nations, *Sutētomento* ステートメント [Statement].

<sup>26</sup> Faraz Haider, “Countries With The Largest Aging Population In The World.”

growing population of people being the centenarians, people over the age of 100. The UN World Population Ageing Report of 2015 estimates that the elderly population will outnumber the children (0-9 years) by 2030, 1.4 billion to 1.3 billion. By 2050 the elderly population is even projected to outnumber the adolescents and the youth population (10-24 years), 2.1 billion to 2.0 billion.<sup>27</sup> Seeing these numbers, it is clear that the world population is ageing at a rapid pace. But what exactly is ageing?

When talking about this phenomenon it is important to distinguish between demographic ageing and individual ageing. The demographic ageing or population ageing is defined by the UN as “the process whereby older individuals become a proportionately larger share of the total population.” The individual ageing is a far more complex and a multidimensional process involving social, physical and psychological transformations.<sup>28</sup> At a more biological level ageing is the result of a variety of damage, molecular and cellular over a period of time. This damage leads to a progressive deterioration in physical and mental capabilities and also increases the risk of diseases, leading up to death.<sup>29</sup> This transformation is not the same for every individual nor is it a linear process, there can be huge differences between two elderly in the same age; with one being frail and in need of assistance and the other being extremely healthy and able to function by themselves.<sup>30</sup>

We can explain biologically and socially, what happens when people get older but defining what “old” means without context can be a bit of a challenge, as the concept has diverging meanings in societies around the world. Over the last century, there have also been drastic changes in the average lifespan of human beings. The average lifespan

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<sup>27</sup> United Nations, *World Population Ageing*.

<sup>28</sup> United Nations, *Ageing in the twenty-first century: A challenge and a celebration*.

<sup>29</sup> Partridge et al., "Messages from mortality: the evolution of death rates in the old.", 438-440.

<sup>30</sup> Magalhães, "What is aging?"

of humans that was around 45 to 50 years at the beginning of the 20th century is now 80 years in the developed world.<sup>31</sup>

The term lifespan can sometimes be used interchangeably with longevity and while it can mean almost the same thing for humans in developed nations, it can sometimes differ, particularly in underdeveloped parts of the world. Longevity is how long an organism can live under ideal conditions. Lifespan is the period of time when the life events of a species typically happen. Life expectancy is the average of how long an organism is expected to live. Generally speaking, life expectancy, average longevity, and average lifespan have the same meaning.<sup>32</sup> Maximum lifespan and maximum longevity mean the record longevity of the species in question to have been confirmed and is based on actual data. The maximum lifespan for humans has been increasing over the years, it has increased from 103 in 1798 to 110 years in 1898, 115 years in 1990. The maximum longevity for humans, recorded by the late Jeanne Calment of France, as of 1997 is 122 years.<sup>33</sup>

Whether or not this continued increase in life expectancy will go on is a highly debated issue. Various researchers and scholars have been trying to prove or disprove the existence of a natural limit to human lifespan.<sup>34</sup> In 2016 a new debate on the subject was born with the article “Evidence for a limit to human lifespan”<sup>35</sup> claiming a limit to co-authored by Xiao Dong and in response “Questionable evidence for a limit to human lifespan by Adam Lenart and James W. Vaupel was published with the aim of disproving the existence of a limit.” Following the previous discussions in 2018 Elisabetta Barbi states that their studies suggest “...that longevity is continuing to

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<sup>31</sup> United Nations, *Ageing in the twenty-first century: A challenge and a celebration*.

<sup>32</sup> Magalhães, “What is aging?”

<sup>33</sup> Allard, et al., *Jeanne Calment: From Van Gogh's time to ours: 122 extraordinary years*.

<sup>34</sup> Bongaarts et al., “How long do we live?”

<sup>35</sup> Dong et al., “Evidence for a limit to human lifespan.”, 257.

increase over time and that a limit, if any, has not been reached.”<sup>36</sup> Even if this increase continues, there will be a variation between individuals as their genetic predisposition will also play a role and not every individual will be able to reach the maximum lifespan.<sup>37</sup>

However, survival to age 80 is expected to be the norm for everywhere except Africa for young people alive today. 60% of the women and 52% of the men born between the years 2000-2005 are expected to live until 80, compared with less than 40% between the years 1950-1955.<sup>38</sup> There is an enormous increase of 20% in survival rates for women in just 50 years. This increase in life expectancy has created a need to further divide the elderly in to three age groups, the young old (65-74 years), the middle old (75-84 years) and the oldest-old (85 years and older), and the oldest-old age group of the population is the fastest growing segment around the world.<sup>39</sup>

The increasing life expectancy at birth is an important factor that affects the changing demography of populations. However, another factor in this demographic shift is the declining fertility rates around all around the world. This decline in total fertility rates all around the world were not expected until a few decades ago.<sup>40</sup> Total fertility has dropped from 5 children per woman between the years 1950 to 1955, to 2.5 children between the years 2010-2015, and this decrease is expected to continue in the future.<sup>41</sup> Regarding this the 1964 article written by Ansley Cole is still sufficiently describes this structural change, “(w)hether a national population is young or old is mainly determined

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<sup>36</sup> Barbi et al., “The plateau of human mortality: Demography of longevity pioneers”, 1459.

<sup>37</sup> United Nations, *Ageing in the twenty-first century: A challenge and a celebration*.

<sup>38</sup> United Nations, *World Population Ageing*.

<sup>39</sup> Zizza et al., "Total Water Intakes of Community-Living Middle-Old and Oldest-Old Adults," 481-482.

<sup>40</sup> Zimmer. *Global ageing in the twenty-first century: Challenges, opportunities and implications*. 8.

<sup>41</sup> United Nations, *Ageing in the twenty-first century: A challenge and a celebration*.



by the number of children women bear. When women bear many children, the population is young; when they bear few, the population is old.”<sup>42</sup>

Ultimately, the process of ageing is extremely complex. In geriatrics<sup>43</sup>, ageing is defined as “a progressive deterioration of physiological function, an intrinsic age-related process of loss of viability and increase in vulnerability.” This is an accurate interpretation of ageing from a biological perspective, but there are also social, cultural and economic consequences of ageing.

## 1.2 Socio-economy of ageing

Demographic ageing, as well as individual ageing, affects all layers of society. Aside from the biological changes that an individual experiences, ageing people also experience life transitions which have societal and psychological effects, such as death of family and partners.<sup>44</sup> The ageing of the world population is predicted to be one of the most critical transformations of the 21st century. The ramifications will be far-reaching, and there will be changes made or expected to be made virtually in all parts of society. The ageing population will call for multi-sectoral policy reforms and transformation to ensure that the elderly persons actively participate in the economic, social, cultural and political spheres in their societies. There will be changes in the labour market and financial markets, also in the demand for housing, transportation, social protection, and other services and goods. The structure of the family and intergenerational bonds will also be affected. Recognizing the specific population trends will help governments foresee the needs of their elderly population, and proactively carry out new policies and

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<sup>42</sup> Coale, “How a population ages or grows younger,” 48.

<sup>43</sup> Geriatrics, or geriatric medicine is a specialty that focuses on health care of elderly people. It aims to promote health by preventing and treating diseases and disabilities in older adults.

<sup>44</sup> World Health Organization, “Ageing and health.”

programmes to ensure the extensive socio-economic participation and the well-being of its older citizens.<sup>45</sup> Preparing for these changes and dealing with economic and social alterations is crucial for governments to be able to achieve continuous and sustainable development.

There are socially constructed definitions of old usually related to the changing roles in society, such as becoming a grandparent or a retiree.<sup>46</sup> There are social changes that come with ageing and the most drastic of these is retirement, and in some cases relocation as a direct effect of a steep decline in income. Making plans for the growing numbers of the elderly is imperative for the pension systems to be sustainable in the future. Another matter governments ought to take into consideration is the need for alterations in healthcare systems. The governments need to take into account the increasing number of older persons and the pressure this will exert on national healthcare budgets. As life expectancy increases, enacting policies that promote lifelong health and active ageing is becoming more important than ever.<sup>47</sup> There is also the differences in life expectancy at birth to consider, between the developed and developing countries. It is extremely important for governments to contemplate on how this might affect their policy-making, especially because the countries with a lower life expectancy have a higher chance of increasing the life expectancy by as much as 10 years in under a decade.<sup>48</sup> As it can be seen in Figure 2 most of the elderly population across the world will be living in developing countries in the years to come, and with increasing life expectancy at birth for developing countries, this percentage may even increase further, leaving the governments with significant financial burdens.

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<sup>45</sup> United Nations, *World Population Ageing*.

<sup>46</sup> United Nations, *Ageing in the twenty-first century: A challenge and a celebration*.

<sup>47</sup> United Nations, *World Population Ageing*.

<sup>48</sup> Arriaga, "Measuring and Explaining the Change in Life Expectancies," 83.

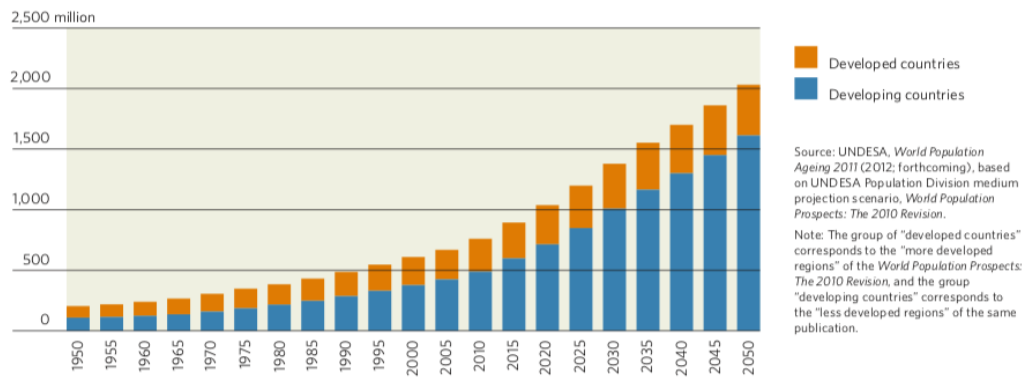


Figure 2. Number of people aged 60 or over: World, developed and developing countries, 1950-2050

Source: Anderson et al., "Population aging: A comparison among industrialized countries.", 196-197.

In addition to pension and healthcare revisions, the governments also need to prepare for long-term care, both facility-based and home-based, to ensure the well being of the elderly population.<sup>49</sup> Government policies in most countries discourage institutionalization, but without further steps to ensure the safety and sustainability of home-based long-term care, the number of senior citizens without adequate nursing care and assistance could escalate, leading to more patients in need of medical care.<sup>50</sup> Home-based long-term care can be examined in two segments; formal home care and informal home care. Formal home care is the provision of healthcare, nursing care and general assistance with daily living by a professional in the patient's house. Informal home care, or 'unpaid long-term care' is the provision of nursing care usually provided by a family member or a relative.<sup>51</sup> The Western style modernisation coupled with high rates of urbanisation has been affecting intergenerational relations, with family sizes getting smaller and intergenerational households becoming sparse. Sociologist Donald O. Cowgill was amongst the first to discuss the effects of modernisation on the elderly

<sup>49</sup> Anderson et al., "Population aging: A comparison among industrialized countries." 196-197.

<sup>50</sup> Jacobzone, *Ageing and Care for Frail Elderly Persons: An Overview of International Perspectives*.

<sup>51</sup> Anderson et al., "Population aging: A comparison among industrialized countries." 196-197.

population in 1974.<sup>52</sup> Since then the effects have become more pronounced and the subject studied. Zimmer explained this challenge quite clearly as, “A demographic perspective certainly makes the obvious point that an ageing population comes hand in hand with smaller family sizes and thus smaller networks upon which older persons can rely when in need.”<sup>53</sup> As the number of elderly who are living alone has been steadily rising, the informal care system seems to have weakened. This change in living arrangements is exacerbating the issue of loneliness in senior populations, which is leading to depression, feelings of social isolation and other mental health problems. The importance of dealing with this issue has been increasingly recognized in international policy and is being recognized more and more as an issue to tackle in national health strategies as well. It is becoming increasingly important to have support systems in place to ensure the social participation of the elderly and improving their mental well-being.<sup>54</sup>

To combat the issues that arise with the ageing of the population, which will increase exponentially as the years go on and the populations age even further, it is crucial for governments to design innovative projects to correctly target the needs of the elderly population.<sup>55</sup> It is also important to keep in mind, that the demographic transformation which is now putting pressure on societies is, in fact a byproduct of efforts to raise the quality of life and the life expectancy of humankind, but the consequences of these improvements had not been predicted. As François Héran eloquently puts it,

Maybe the most striking paradox about determinism and human agency in the field of demography is the way in which the cumulative effects of past human interventions eventually create new constraints, and new inescapable realities, for subsequent generations... Ironically, the free and voluntary actions of all these

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<sup>52</sup> Cowgill, “The aging of populations and societies.”

<sup>53</sup> Zimmer, *Global ageing in the twenty-first century: Challenges, opportunities and implications*. 10.

<sup>54</sup> Cattani et al., “Preventing social isolation and loneliness among older people”, 41-42.

<sup>55</sup> United Nations, *World Population Ageing*.

actors have imposed a new set of unavoidable constraints on upcoming generations.<sup>56</sup>

It is also important for governments to anticipate these demographic transitions in order to execute appropriate policies to adapt and get through without lasting damage. The obvious problems policy-makers are facing also shadow a significant issue ageing persons face; 'ageism'. According to WHO ageism is "...stereotyping, prejudice, and discrimination against people on the basis of their age." Age-related discrimination can lead to older persons being overlooked for employment, being socially marginalised, and being restricted from participating fully in their communities.<sup>57</sup> Even though *ageism* as a term was coined only a year after *sexism* in 1969,<sup>58</sup> it does not have the same kind of universal recognition as sexism. Margaret Morganroth Gullette discusses this issue in her book *Ending Ageism, or How Not to Shoot Old People*, "Unlike all the bigotries now recognized as evils (among them sexism, racism, homophobia), ageism has yet to become an everyday pejorative. But this is not because the reality has ended. It is rarely named and little examined, even in gerontology. (Institutionally, the field started to highlight the lack of study of ageism in 2015)"<sup>59</sup> It is more important than ever to combat age-related discrimination, as the need for elderly citizens participation in labour markets become unavoidable, as the population pyramids around the world become top heavy with the increasing ratio of senior citizens.

There is also a gender imbalance in ageing populations. On average women tend to outlive men at advanced ages. At birth, there are slightly more male babies born than female. However, by 65 years of age, the ratio is roughly nine men for every ten women. By age 75, the ratio is 7.5 men for every ten women. After the age of 80, the ratio

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<sup>56</sup> Héran, "The population ageing process in global perspective," 26-27.

<sup>57</sup> World Health Organization, Ageism.

<sup>58</sup> Gullette, *Ending Ageism, or How Not to Shoot Old People*, 212.

<sup>59</sup> Gullette, *Ending Ageism, or How Not to Shoot Old People*, 1.

declines even further, to roughly five men for every ten women. The proportion of women in the elderly population rises even further with age.

Consequently, women are more likely to be the recipients of retirement programmes, long-term care, healthcare and other support programmes designed for the elderly.<sup>60</sup> This so-called “feminization of ageing,” especially in the oldest-old segment of the elderly population has significant implications for policy. The policies regarding the ageing of men and women differ as they have different patterns of health and death. Usually, women also have lower income but better family support networks.<sup>61</sup>

A factor that has slowed down the population ageing process has been international migration. In countries where a sizeable immigration flow can be seen, the ageing progress can be temporarily slowed down. In her article “The important role of migration for an ageing nation,” Sarah Harper mentions this in “The important role of migration for an ageing nation;”

Migration has a potentially strong and long-lasting impact on population growth and structure through the interaction between the number of migrants, their relatively young age structure and their higher fertility. As a result, immigration has increasingly become perceived as a potential means to prevent population decline, maintain the size of the labour force and thus the support ratio, and slow down structural population ageing.”<sup>62</sup>

Nevertheless, for this solution to be sustainable there would need to be a much larger flow of immigrants than seen in the past. Migration alone does not seem to be a feasible solution to the ageing problem.<sup>63</sup> On the other hand, where this migration process slows down the population ageing in some countries, the countries where these young workers emigrated from, experience an acceleration of population ageing. The countries on the receiving end of this migration process have identified ageing as a “major concern” and

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<sup>60</sup> Anderson et al., “Population aging: A comparison among industrialized countries.”, 194-195.

<sup>61</sup> United Nations, *World Population Ageing*.

<sup>62</sup> Harper, “The important role of migration for an ageing nation,” 184.

<sup>63</sup> United Nations, *Replacement Migration: Is it a Solution to Declining and Ageing Populations?*

one of the main reasons they have increased their immigration rates.<sup>64</sup> The increased rates of migration, while alleviates the issue of the ageing population, it also affects the social structures of the recipient countries with a large influx of young migrants.

### 1.3 Trends

The phenomenon of ageing and ageing populations has been a well-discussed concept throughout the years, beginning as early as the 1980s, the subject has also been an important part of the international discourse. Until a short while ago, the general view and representation of the elderly population, especially in Western societies was negative. The elderly population represented a minority in a society emphasizing the importance of being young and youthfulness.<sup>65</sup> Dorly J.H. Deeg describes this;

If an older individual appeared on television, without exception s/he was living in a nursing home. Grey hair, clothes of a drab color, somber environment, washed-out look. From an older person nothing could be expected that could contribute to society. On the contrary, the slowly but surely increasing number of older individuals was seen as a threat for society, because the cost of care and pensions would reach unsustainable heights. And older persons themselves did nothing to counteract this threat.<sup>66</sup>

This view of the elderly and the ageing phenomenon is indeed becoming a thing of the past. There is now a new, and more positive trend and understanding of the older people, some even depicting the life of retirees as the second adolescence.<sup>67</sup> Deeg further describes this change;

Older people are assumed to go on holiday four times a year, to become internet-wise by following computer courses, and to manage their own care utilization. And of course, older people might as well work a few years longer to

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<sup>64</sup> United Nations, *World Population Ageing*.

<sup>65</sup> Butler, "A disease called ageism."

<sup>66</sup> Deeg, "New Myths about Ageing: The Growth of Medical Knowledge and its Societal Consequences," 139.

<sup>67</sup> Knipscheer, "De tweede adolescentie [The second adolescence]."

compensate for the growth of costs. The representation of older age seems essentially changed.<sup>68</sup>

The increasing percentage of the elderly population all around the world, especially in the developed world, pushed the nations facing the most drastic of this transition to come together in order to come up with an action plan. The first of this was The Vienna International Plan of Action on Ageing. Created in 1982 at the first World Assembly on Ageing. The action plan supplies the governments around the world with a basis for formulating new policies and programmes concerning various aspects of ageing. The plan includes 62 points addressing a range of topics including “research, data collection and analysis, training and education, as well as the following sectoral areas: health and nutrition, protection of elderly consumers, housing and environment, family, social welfare, income security and employment, and education.”<sup>69</sup>

In 1991, following The Vienna International Plan of Action on Ageing, The UN General Assembly approved of the United Nations Principles for Older Persons, supporting 18 points, regarding “independence, participation, care, self-fulfillment and dignity.” for the elderly.<sup>70</sup> The United Nations Principles for Older Persons is mostly about what the rights of the elderly should be, and not what is the best way to ensure that the elderly population achieve those rights. The Proclamation on Ageing created during the follow-up meeting in 1992, goes more into the implementation of the elderly rights specified at the meeting in 1991. The Proclamation on Ageing also recognizes the need to adopt a more holistic approach and accepts that “...ageing is a life-long process and that preparation for old age must begin in childhood and continue throughout the life cycle...” This recognition can also be seen as the starting point for future concepts such

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<sup>68</sup> Deeg, “New Myths about Ageing: The Growth of Medical Knowledge and its Societal Consequences,” 139.

<sup>69</sup> United Nations, *Vienna International Plan of Action on Ageing*.

<sup>70</sup> United Nations, *United Nations Principles for Older Persons*.



as well-ageing and healthy-ageing. The UN General Assembly, subsequent to the conference and also in recognition of “humanity's demographic coming of age”, declared the year 1999, The International Year of Older Persons.<sup>71</sup>

The Second of the World Assembly on Ageing was realized in 2002 in Madrid, 20 years after the first one. The main aim of the assembly was to create new policies on ageing designed for the 21st century. The Political Declaration and the Madrid International Plan of Action on Ageing was adopted. The declaration asked for the eradication of ageism, neglect, violence and abuse against older persons, and also emphasized the significance of international cooperation and assistance. It contains guidance on designing policies and programmes on ageing on regional and national levels. The main concerns that are addressed cover a variety of topics including, equal opportunities in the labour market, provide social protection and security, adequate minimum income for senior citizens. The significance of continued education, and public recognition of senior citizens’ productivity and contributions to society, and their participation in decision-making are also central points made in the recommendations in order to ensure a supportive environment suitable for the well-being of the elderly in advanced ages. The fundamental challenge to be addressed was how to “build a society for all ages.”<sup>72</sup>

Following this, also in 2002, the WHO’s Ageing and Life Course Programme developed Active Ageing: A Policy Framework as a contribution to the Madrid International Plan of Action on Ageing. According to the WHO, active ageing is “...the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age.” The term active in this context, means the continued participation in society in a social, economic, cultural and spiritual meaning

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<sup>71</sup> United Nations, *Proclamation on Ageing*.

<sup>72</sup> United Nations, *Madrid International Plan of Action on Ageing*.

and not just actively participating in the workforce. The elderly who have retired or are ill can continue to have an active role in their families, social communities and countries. The aim of the policies that were developed as a way to promote active ageing was a better quality of life for all people, including the ill, the disabled and those in need of care.<sup>73</sup> WHO describes quality of life as; “An individual’s perception of his or her position in life in the context of the culture and value system where they live, and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept, incorporating in a complex way a person’s physical health, psychological state, level of independence, social relationships, personal beliefs and relationship to salient features in the environment.”<sup>74</sup> As people age, their quality of life is largely determined by their ability to maintain autonomy and independence.

In 2015, in the World Report on ageing and health, the WHO outlines a new policy regarding ageing to replace the previous guideline Active ageing, Healthy Ageing. Healthy Ageing focuses on the work of WHO regarding ageing between the years 2015-2030. The leading point in this new policy framework was the urgent need for a public health action that is both comprehensive and realistic. To realize this transformation, there is a need for a fundamental shift in the collective consciousness about the way societies act and also in the way societies think about ageing itself. Healthy Ageing is a new approach on ageing that is built on the concept of functional ability, it is the process of maintaining functional ability, which in turn allows for well-being in older persons. Functional ability is comprised of both the intrinsic capability<sup>75</sup>

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<sup>73</sup> World Health Organization, *Active Ageing: a policy framework*.

<sup>74</sup> World Health Organization, “WHOQOL: Measuring Quality of Life.”

<sup>75</sup> “Intrinsic capacity comprises all the mental and physical capacities that a person can draw on and includes their ability to walk, think, see, hear and remember. The level of intrinsic capacity is influenced by a number of factors such as the presence of diseases, injuries and age-related changes.” (WHO, *What is Healthy Ageing?*.)

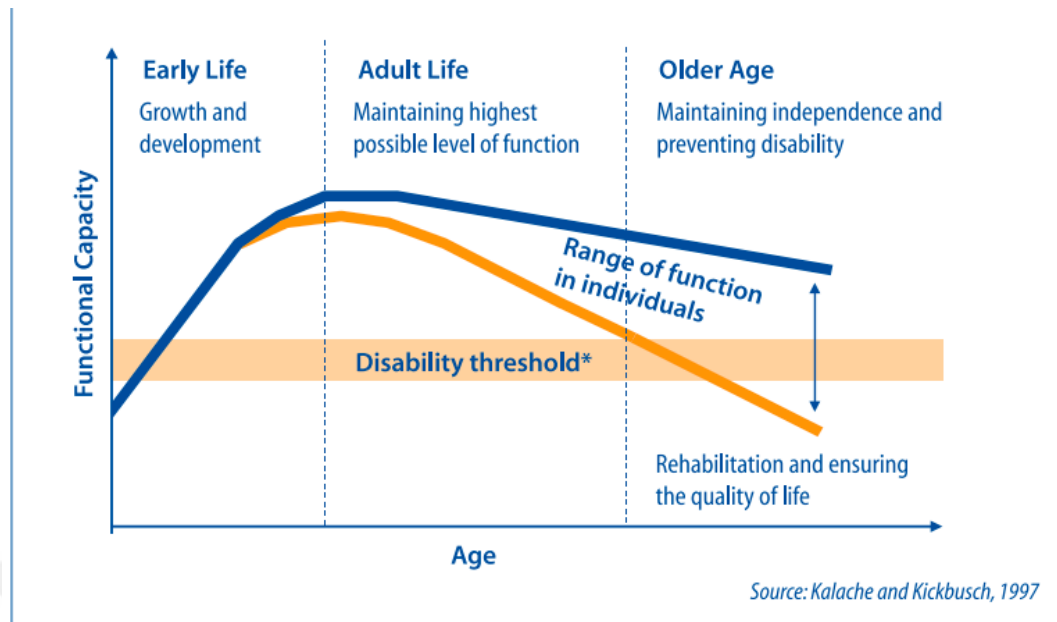
of the individual and also the environmental characteristics<sup>76</sup> that surround the individual. In this context it means “...having the capabilities that enable all people to be and do what they have reason to value.” The ability to meet their basic needs, to continue to learn and grow, to be mobile, to maintain existing relationships and build new ones, and to continue their contribution to society. There is also the life course perspective on ageing developed by the WHO, which accepts the differences in the ageing process and recognizes that the elderly are not homogeneous and as it can be seen in Figure 3 that the individual diversity of functional capacity of people actually increases with age.<sup>77</sup> It is imperative that the governments keep these disparities in mind as enacting broad policies on ageing solely based on the chronological age might be counterproductive in the long run.<sup>78</sup>

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<sup>76</sup> “Environments include the home, community and broader society, and all the factors within them such as the built environment, people and their relationships, attitudes and values, health and social policies, the systems that support them and the services that they implement. Being able to live in environments that support and maintain your intrinsic capacity and functional ability is key to *Healthy Ageing*.” (WHO, *What is Healthy Ageing?*.)

<sup>77</sup> World Health Organization, *What is Healthy Ageing?*.

<sup>78</sup> World Health Organization, *Active Ageing: a policy framework*.



\*Changes in the environment can lower the disability threshold, thus decreasing the number of disabled people in a given community.

Figure 3. Maintaining functional capacity over the life course

Source: World Health Organization, *Active Ageing: a policy framework*

The WHO describes health as “... a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity...”<sup>79</sup> Favouring the definition of health made by the WHO, not being ill or having a disease is not required for Healthy Ageing, as a huge number of older persons have some kind of health condition which is controlled and has little to no influence on their well-being. The most important part in the well-being of the elderly usually come down to basic human rights. In this sense ‘the rights of the elderly’ are but an extension of ‘international human rights’, and the leading reason for categorizing them separately is the overarching discrimination against older persons, from incredibly subtle to outright abuse in some cases.<sup>80</sup>

There is also an innovation-based approach to well-being in advanced ages.

Founded in 2012, Aging 2.0, which is an example for volunteer-based international

<sup>79</sup> World Health Organization, *Constitution*.

<sup>80</sup> World Health Organization, *Active Ageing: a policy framework*.

organizations focused on issues about ageing, in their own words; “..strives to accelerate innovation to address the biggest challenges and opportunities in aging...”<sup>81</sup> There are also organizations and charities focusing more on the societal reforms necessary to accommodate the ageing population. A charity based in the United Kingdom works towards incorporating the older persons in active society by trying to change perceptions in the labour market or creating new opportunities with volunteering without age restrictions to help eliminate discrimination against senior citizens.<sup>82</sup> The international body is moving towards a new phase in managing the ageing population problems, with advancing technologies, and the call for innovative progress is being made all across the globe. The 1st Well Aging Society Summit held in Japan in 2018, illustrates this trend that puts innovation in the centre, with the participation of companies, start-ups, experts and government agencies from all around the world aiming towards a better future for every individual.<sup>83</sup>

Acting upon the need for solid policies and programmes to better approach the ageing problem, international organizations and governments around the globe have been creating new concepts to address their own approach to ageing, such as Well-Aging, Healthy Ageing, Active Ageing, Aging 2.0 to name a few. While their descriptions differ slightly, the main theme in all these new concepts is to minimize the deterioration of health and mental capabilities in the elderly population and have the elderly be a part of society for a longer period of their lives. Every person deserves a chance to live a healthy life, but some factors outside of the hands of individuals such as environmental issues, and access to social-care and health-care affect the quality of the ageing process. And as stated by the WHO “If ageing is to be a positive experience,

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<sup>81</sup> Aging 2.0, “About Aging 2.0.”

<sup>82</sup> Center for Ageing Better, “What We Do.”

<sup>83</sup> Well Aging Society Summit, “1st Well Aging Society Summit Report.”

longer life must be accompanied by continuing opportunities for health, participation and security.”<sup>84</sup>

Globally, especially with more than 2 billion elderly by the year 2050, the population ageing will become an issue that needs to be given the utmost importance. The societal changes to come as a result of an increasing number of elderly will need consideration as well, so will combating age related discriminations. Also without necessary revisions social security systems and the accompanying costs will not be manageable by governments around the world.

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<sup>84</sup> World Health Organization, *Active Ageing: a policy framework*.

## CHAPTER 2

### JAPAN: TOWARDS A SUPER-AGED SOCIETY

All around Japan, the population is ageing at an unprecedented rate. Already, Japan has the highest percentage of the elderly population in the world. Just in two years time, from the year 2015 to 2017 the percentage of the elderly population has risen from 26,6% to 27,7%. The number of people aged 65 or over as of October 2017 was more than 35.15 million.<sup>85</sup> If this trend continues, by 2050 the ageing rate will be 37%, but the total population will go down to around 100 million people.<sup>86</sup>

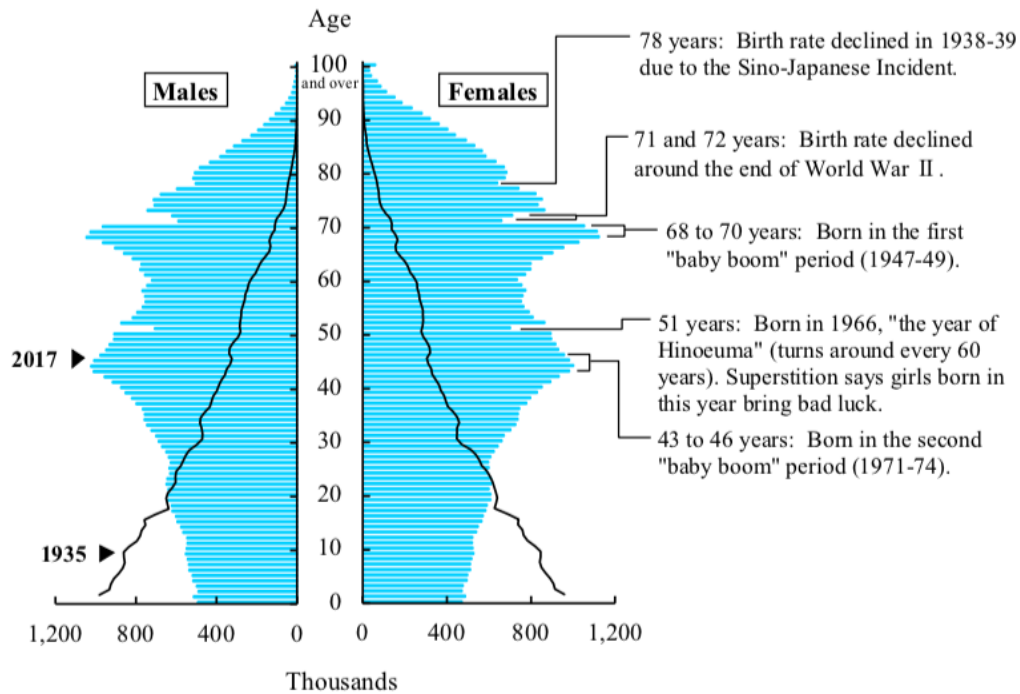
#### 2.1 A dramatic transition

Between the 18th century and the Meiji Restoration in 1868, the population of Japan had stayed the same, around 30 million. The efforts to establish a modern nation-state initiated an expansion in the population and had doubled it by 1929 by reaching 60 million. By 1967 the total population had exceeded 100 million. This growth in population has started to decline, beginning in the 1970s and continued on more drastically from the 1980s with ‘rate of population change’ dropping below 1%. The Japanese population, since peaking in 2010 at 128 million has been steadily declining. Looking at Figure 4 we can see the difference of the population pyramids of Japan in 1935 and 2017.

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<sup>85</sup> Cabinet Office, *Annual report on the aging society:2018*.

<sup>86</sup> Ministry of Internal Affairs and Communication, Statistics Bureau, *Statistical Handbook of Japan 2018*.



Source: Statistics Bureau, MIC.

Figure 4. Population pyramid of Japan (comparing 1935 and 2017)

Source: Ministry of Internal Affairs and Communication, Statistics Bureau, *Statistical Handbook of Japan 2018*

As of October 2017, the total population of Japan was 126.71 million and ranked eleventh as the most populated country. Japan also ranked eleventh in the population density rankings with 340.8 persons per square kilometre. The population decrease is expected to continue and by 2060, the Japanese population is projected to be under 100 million, with 38% of this population consisting of senior citizens.<sup>87</sup> Table 1 shows the current state of ageing in Japan as well as the difference in the ratio of sexes regarding the ageing rate.

<sup>87</sup> Ministry of Internal Affairs and Communication, Statistics Bureau, *Statistical Handbook of Japan 2018*.



Table 1. State of ageing in Japan as of October 2017

Units: 10,000 people (Population), % (Composition ratio)

		October 1, 2017		
		Total	Male	Female
Population (Units of 10,000 people)	Total population	12,671	6,166	6,505
	65 years old and over population	3,515	1,526	1,989
	65-74 years old population	1,767	843	924
	75 years old and over population	1,748	684	1,065
	15-64 years old population	7,596	3,841	3,755
	Population aged under 15	1,559	798	761
Composition Ratio (%)	Total population	100.0	100.0	100.0
	Population aged 65 and over (rate of ageing)	27.7	24.8	30.6
	65-74 years old population	13.9	13.7	14.2
	75 years old and over population	13.8	11.1	16.4
	15-64 years old population	60.0	62.3	57.7
	Population aged under 15	12.3	12.9	11.7

Source: Ministry of Internal Affairs and Communications “Population Estimates (final estimates as of October 1, 2017)”

(Note) “Sex ratio” is the male population against a female population of 100 people

Source: Cabinet Office, *Annual report on the aging society:2018*

A society with an ageing rate of 7% is considered an “ageing society”. If the rate of ageing is 14% or higher it becomes an “aged society”.<sup>88</sup> When this rate exceeds 21%, a society is classified as a “super-aged society”.<sup>89</sup> Japan became the first “super-aged society” in 2007 when the ageing rate exceeded 21%. According to the Annual report on the aging society 2018 by the Cabinet Office, the population of the elderly has surpassed 27% in Japan which is the highest rate to this date around the world,<sup>90</sup> and the number of elderly citizens is increasing by around 30,000 per month.<sup>91</sup> This rapid pace also stands out when compared with other developed countries, Figure 5 shows information regarding the time it took for the percentage of the elderly (65 years or older) in the

<sup>88</sup> Tahara, “Cardiopulmonary resuscitation in a super-aging society is there an age limit for cardiopulmonary resuscitation?” 1102-1103.

<sup>89</sup> Arai et al., “Japan as the front-runner of super-aged societies: Perspectives from medicine and medical care in Japan.” 673–687.

<sup>90</sup> Cabinet Office, *Annual report on the aging society:2018*.

<sup>91</sup> Fukuyama, “From elderly to 'superelderly': Japan wrestles with demography.”

population to go from 7% to 14%. While it took 115 years (1864-1979) in France, in Sweden 85 years (1887-1972), in Germany 40 years (1932-1972), in Japan it only took 24 years (1970-1994) for the elderly population to double.<sup>92</sup>

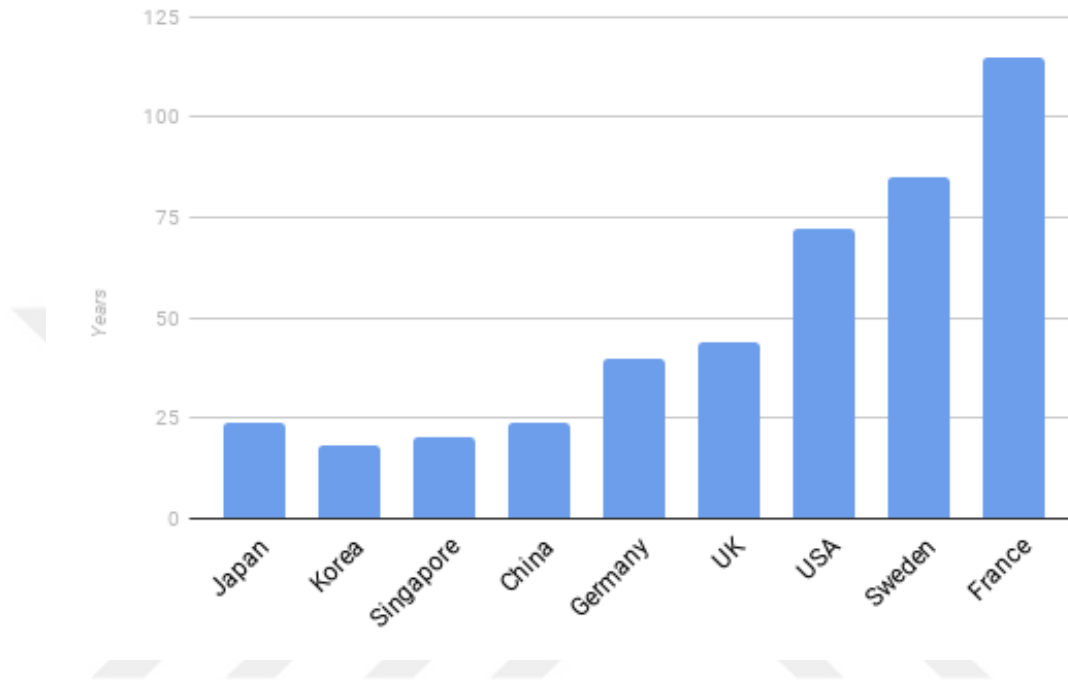


Figure 5. Years for the proportion of the elderly (65 years or older) to go from 7% to 14%

Source: Annual Report on the Aging Society 2017

Japan, having passed the 7% ageing rate in the 70s,<sup>93</sup> which made the nation an ageing society, meant that they have been researching the phenomenon for some time now at various institutions, both public and private. The study of the ageing process and individuals as they grow and become elders is Gerontology. It includes “the study of physical, mental, and social changes”, “the investigation of the changes in society”.

Another term that can be confused with gerontology is, Geriatrics, which is “the study of

<sup>92</sup> Cabinet Office, *Annual report on the aging society:2017*.

<sup>93</sup> Ministry of Internal Affairs and Communication, Statistics Bureau, *Statistical Handbook of Japan 2018*.

health and disease in later life” and “the comprehensive health care of older persons and the well-being of their informal caregiver”<sup>94</sup>

One of the first institutes established that was specializing in gerontology was the Japan Gerontological Society in 1959 in partnership with the Japan Geriatrics Society and the Japan Socio-Gerontological Society, later joined by The Japan Society for Biomedical Gerontology, Japanese Society of Gerodontology, Japanese Psychogeriatric Society, Japan Society of Care Management, and Japan Academy of Gerontological Nursing. The first aim of the Society is to educate the public on various topics regarding the elderly, while also giving recommendations to policy-makers about the subject. They also hold the Biennial Meeting of the Japan Gerontological Society, which brings together more than 10,000 scholars and healthcare professionals.<sup>95</sup>

Following this in 1972, Tokyo Metropolitan Institute of Gerontology was established, in order to promote interdisciplinary research on topics relating to ageing and older persons. As of 2015, in the Institute, “...approximately 200 researchers, including 84 full-time employees, part-time employees, and graduate students, are engaged in research activities based on the medium-term goals approved by the Tokyo Metropolitan Assembly.” The research goals include, "research to support medicine and care for the elderly," "research aiming to maintain and advance the elderly's health and improve their vitality." "the early detection of dementia and the development of a system to train doctors and nurses"<sup>96</sup> The National Center for Geriatrics and Gerontology, founded in 2004, “...is composed of the National Hospital for Geriatric

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<sup>94</sup> Academy for Gerontology in Higher Education. “Gerontology/Geriatrics Definitions”.

<sup>95</sup> Arai, “About us”.

<sup>96</sup> Kyo, “From the President”.

Medicine and the Research Institute, is one of the six national centers for advanced and specialized medicine in Japan.”<sup>97</sup>

Another research institute regarding gerontology in Tokyo is the Institute of Gerontology at the University of Tokyo. Junichiro Okata the director of the Institute explained their aim as, “... projects are being put together using interdisciplinary team which are able to engage effectively and flexibly in research concerning the various challenges for an aging society. The very fact that Japan is the country with the greatest longevity means that we will take the lead as we aim to gather multi-disciplinary knowledge about the important emerging challenges facing the aging society, and work to promote gerontology, a discipline still in its formative stages, as well as submitting evidence-based proposals for policy and measures.”<sup>98</sup>

In Figure 6 the rate of growth of the elderly population (65 years or older) in Japan can be examined. From the 1920s when the elderly population consisted of about 5% of the population to 2020s, where the elderly population is projected to be about 25% of the population. As this upward trend is likely to continue in the near future, by 2055 the elderly population is projected to be nearly 40 % of the population. On the other end of the spectrum, the working age population (15-64 years) has had a downward trend since the beginning of the millennium. By 2055 the working age population is projected to be only half of the total population.<sup>99</sup> The ratio of the elderly population to the working age population is swiftly rising.<sup>100</sup>

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<sup>97</sup> National Center for Geriatrics and Gerontology. “The Word from the President.”

<sup>98</sup> Okata, “About us”.

<sup>99</sup> Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing].

<sup>100</sup> Muramatsu et al., “Japan: Super-aging society preparing for the future”, 426-427.

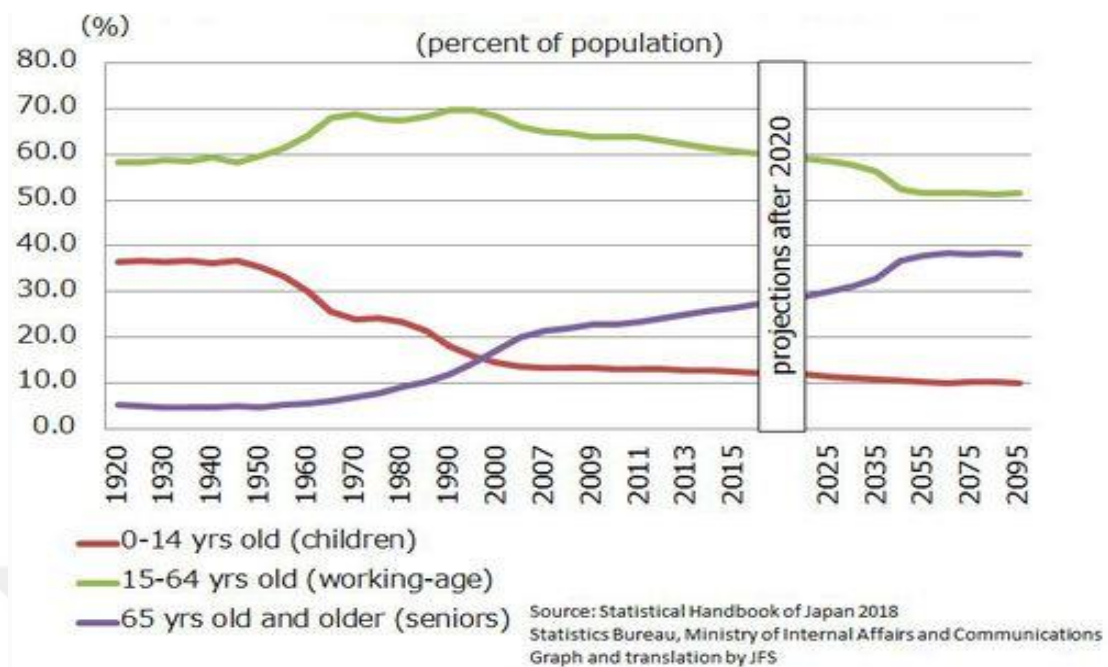


Figure 6. Population trends in Japan

Source: Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 (The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing)

The decline in population starting from the 1980s, gradually created a top-heavy population pyramid, as the life expectancy at birth increased and the fertility rates started dropping with more women entering the workforce and as a consequence marrying later. After World War II triggered the first baby-boom, the birth-rates started falling after reaching the highest point in 1950. After the second baby-boom in the 1970s, the birth-rates have been steadily declining. The total fertility, also been declining since the 1950s, from 3.65 to 1.43 in 2013.<sup>101</sup> According to professor of economics Naohiro Yashiro;

A major factor behind the fertility decline since the mid 1970s is its association with the falling marriage rate. In Japan, where only one per cent of births occur outside marriage, the lower marriage rate leads directly to fewer children, even with the average number of children per married couple unchanged at two.<sup>102</sup>

<sup>101</sup>Japanese Nursing Association, *Nursing in Japan*.

<sup>102</sup>Yashiro, "Social implications of demographic change in Japan," 298.

Women are having fewer babies, and they are having them later. Figure 7 shows the the change in the total fertility rate in Japan between the years 1950 to 2013. The change in the average of mothers age can also attest to this, as the age which was 25.7 years in 1965 has risen to 30.4 years in 2013.<sup>103</sup>

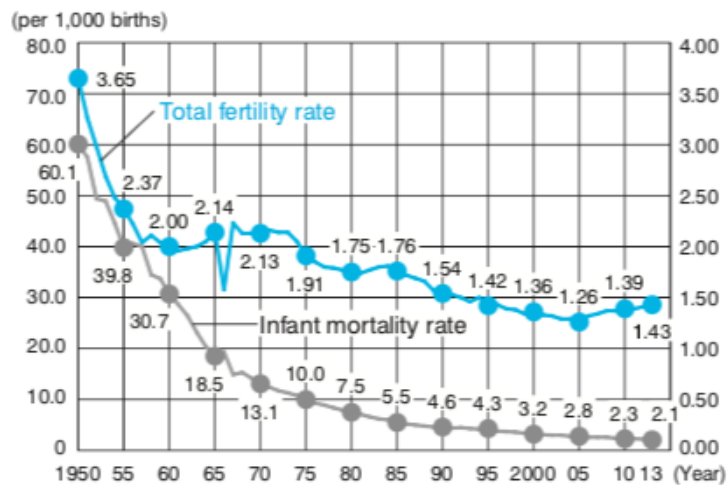


Figure 7. Transition of infant mortality rates and total fertility rates  
Source : Japanese Nursing Association, *Nursing in Japan*

By 2020, an elderly will be supported by only two working-age persons, by 2050, the number will go down to 1,5 working-age persons supporting an elderly person. When we compare it to 11.2 in 1960 and 3.9 in 2002, the rapid decline is apparent.<sup>104</sup> Figure 8 shows the change in the number of working age persons supporting an elderly citizen. The increasing elderly population will continue to exhaust public spending, especially on health and nursing care. It has become exceedingly important for Japan to regulate social benefits and ensure its fairness and continued affordability.<sup>105</sup>

<sup>103</sup> Japanese Nursing Association, *Nursing in Japan*.

<sup>104</sup> National Institute of Population and Social Security Research, *Population Projections for Japan: 2001-2050*.

<sup>105</sup> Organisation for Economic Co-operation and Development, *Better Policies Japan: Promoting Inclusive Growth for an Ageing Society*.

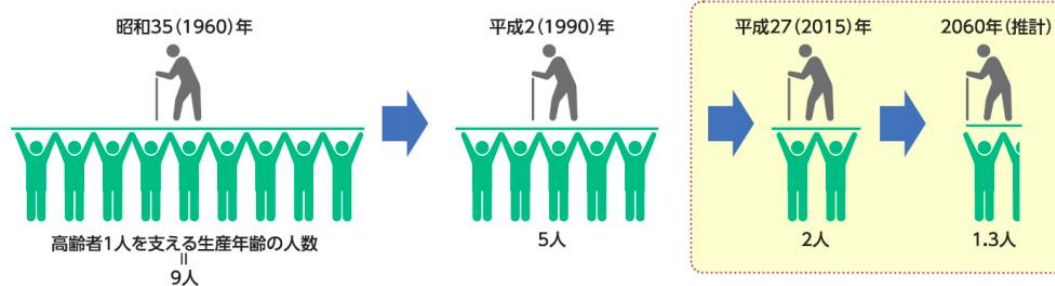


Figure 8. The number of working-age persons to support an elderly

Source: Hiroshima Keizai Dōyuukai, 人口回復に向けた広島経済同友会の取り組み Jinkō Kaifuku ni Muketa Hiroshima Keizai Dōyuukai no Torikumi (The Approach of Hiroshima Economic Association for Population Recovery )

The population ageing phenomenon will continue to worsen as the average life expectancy rises. As seen in Figure 9 by 2065 the average life expectancy at birth, which is 80.98 years for males and 87.14 years for females as of 2016, will be 84.95 years for males and 91.35 years for females, exceeding 90 years for the female population.<sup>106</sup> To understand this increase in the elderly female population is critical for the government to form appropriate policies and programmes. The ageing of the population affects all layers of society, albeit in different ways and levels. There is an undeniable impact of the ageing phenomenon in societies, creating big impacts in both social and economic dimensions.

<sup>106</sup> Cabinet Office, *Annual report on the aging society:2018*.

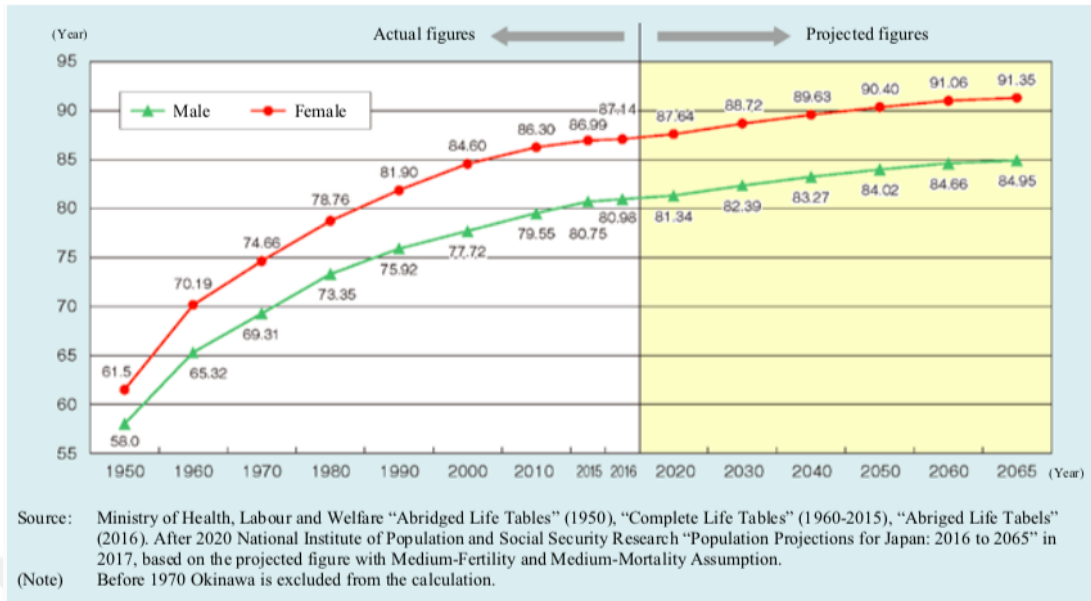


Figure 9. Trends and future projections of life expectancy at birth  
 Source: Cabinet Office, *Annual report on the ageing society:2018*

## 2.2 Emerging challenges

This considerable shrinkage in the working-age population to the elderly population is forcing the Japanese government to create new plans to utilize all capable and available population to deal with the upcoming labour shortages in the markets. For a smooth transition, the government must create superior conditions in workplaces for young people. Have better incentives for the senior population to become active participants of the labour market, and also promote the involvement of women.<sup>107</sup>

This unprecedented rise in the elderly population and a shrinkage in the working-age population has also started to impact the nursing care services. The number of care workers is starting to fall short of the demand and this leads to shortages in the nursing care services. As this demographic situation worsens the shortages will only become more severe, as a result of increases in insurance premiums and taxes, the economic

<sup>107</sup> OECD, *Better Policies Japan: Promoting Inclusive Growth for an Ageing Society*.



burden individual Japanese carries will also be worsening.<sup>108</sup> The labour shortage issue is also aggravated as young people are not keen to work in the nursing care services or health care industry in general, as the education period is longer than most other professions, but the salaries are not attractive enough to compensate for neither the training period nor the long working hours. The general trend of having fewer workers and more retirees in the developed world raises the question of how will these societies handle the financial and resource-based problems that arise as the need for long term care for the elderly population increase.<sup>109</sup>

As a result of the shortages in nursing and care services, many of the senior citizens are being cared for by another family member, usually another elder, at home. This leads to the deterioration of health of the elder who is acting as the caregiver. This situation creates a burden for the families, and has become a social problem in Japan and will continue to worsen in the near future. The Japanese government estimates that by 2025 there will be a shortage of 377,000 care-workers.<sup>110</sup> One solution the government has been looking into is, utilizing technological developments, in fields such as Robotics, Artificial Intelligence (AI) and Virtual Reality (VR). To use the technological advancements in order to counter the issues that come with an ageing population, at least to some degree.<sup>111</sup>

The transition of the population pyramid is owed to a lot of factors, including fertility rates. As more women take part in the work-force for a longer time and have children later in life, if at all, the birth-rates are declining, people prefer to live alone

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<sup>108</sup> Ministry of Economy, Trade and Industry., *Report by the Study Group on the Provision of Nursing Care Services in Response to Future Nursing Care Demand.*

<sup>109</sup> World Health Organization, *Preparatory meeting for the Third Global Forum on HRH.*

<sup>110</sup> Ministry of Health, Labour and Welfare. *2025 Nen ni Muketa Kaigo Jinzai ni Kakaru Jukyū Suikei (Kakuteichi) ni Tsuite. 2025年に向けた介護人材にかかる需給推計（確定値）について.* [Supply and Demand Estimation for Care Workers in 2025 (Final Value)]

<sup>111</sup> Ministry of Economy, Trade and Industry., *Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン—* [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

longer as well. The times when the whole family from grandparents to grandchildren lived together are behind us. The compositions of households have been changing rapidly and into one-person households or nuclear-family household, which can be seen in Figure 10 and in just 15 years time from 2000 to 2015, the one-person households that were around 27% increased to about 34% with the rest comprising of mostly nuclear-family households.<sup>112</sup>

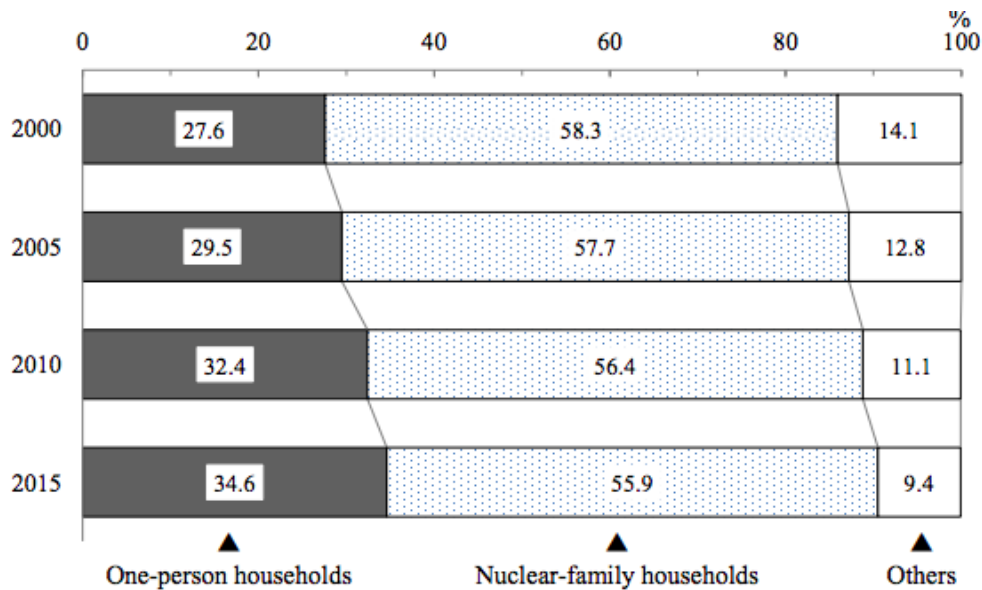


Figure 10. Changes in household composition  
Source: Statistics Bureau, *Statistical Handbook of Japan 2018*

One group highly affected by this transformation of the structure of the households are the elderly. Table 2 shows that the proportion of elderly living with an elderly spouse or by themselves is continuously increasing, while the number of elderly living together with children or relatives is decreasing. The number of elderly households<sup>113</sup> in 2015 was accounting for 40% of the total number of private households with 21.71 million households. There are now almost 6 million one-person elderly households, with two

<sup>112</sup> Statistics Bureau, *Statistical Handbook of Japan 2018*.

<sup>113</sup> Private households with household members 65 years of age or over.

times many of these comprising of elderly women.<sup>114</sup> This leads to issues with long-term care for the elderly. Institutionalization or facility-based long-term care is now socially more acceptable, but there is still a certain level of reluctance for both the caretaker and the family. And even if this was not the case, there are not enough care workers in the country to deal with the growing number of elders. Traditionally in Japanese society, the wife of the oldest son would be in charge of taking care of the elderly parents. But with the Japanese society changing this cannot be thought of as the norm anymore.<sup>115</sup>

Table 2. Trends in elderly households<sup>116</sup>

Type of households	(Thousands)				
	1995	2000	2005	2010	2015
Private households .....	43,900	46,782	49,063	51,842	53,332
Elderly households .....	12,790	15,057	17,220	19,338	21,713
(percentage) .....	29.1	32.2	35.1	37.3	40.7
One-person households .....	2,202	3,032	3,865	4,791	5,928
Males .....	460	742	1,051	1,386	1,924
Females .....	1,742	2,290	2,814	3,405	4,003
Aged-couple households <sup>1)</sup> .....	2,763	3,661	4,487	5,251	6,079

1) Consisting of a husband 65 years of age and over and his wife 60 years of age and over.  
Source: Statistics Bureau, MIC.

Source: Statistics Bureau, *Statistical Handbook of Japan 2018*

Following this, an increasing number of elderly express that they actually prefer their daughters, rather than their daughters-in-law to be their caregivers.<sup>117</sup> On the other end of this, married women also have reported to prefer taking care of their own parents rather than their in-laws. The changes in societal structure and women entering the workforce in large numbers have created diversity in familial-care-givers, while still

<sup>114</sup> Statistics Bureau, *Statistical Handbook of Japan 2018*.

<sup>115</sup> Muramatsu et al., "Japan: Super-aging society preparing for the future", 429.

<sup>116</sup> Household Size and Household Composition The Population Census shows that Japan had 53.33 million private households (excluding "institutional households" such as students in school dormitories) in 2015, showing a consistent increase since the initiation of the Census. Of that total, 55.9 percent were nuclear-family households, and 34.6 percent were one-person households.

<sup>117</sup> Long, *Family change and the life course in Japan*.

short in numbers, husbands and sons are also being asked to be caregivers. There is also the psychological pressure on the caregiver, as a survey done in 1994, when the ageing rate of the Japanese population was around 14% “...Japanese women providing care found that 33.6% of wives, 30% of daughters and 46.2% of daughters in law, felt hatred towards the person they were caring for.”<sup>118</sup> Elder abuse, ranging from physical, psychological to economic can also be observed in some Japanese households. However, in a survey conducted by the Ministry of Health, Labor and Welfare in the 1990s reports “...in Japan, sons were the most common offenders and that one out of two abusers did not realize that what they were doing constituted abuse. It also revealed that 90% of nursing care managers found it difficult to effectively deal with cases of abuse after they had been identified.”<sup>119</sup> A legal framework to combat elder abuse, the Elder Abuse Prevention and Caregiver Support Law was enacted in 2005. “This law makes the reporting of elder abuse mandatory if the life or health of an older person (who is believed to have been abused or neglected) appear to be in great danger. The person who discovers such an older person must report the incidence to the municipal office.”<sup>120</sup>

In some cases, both the care-giver and the care-taker might be elderly citizens; a seventy-year-old woman looking after her ninety-year-old mother is ceasing to be an exception to the norm.<sup>121</sup> Consequently, as the population ageing worsens in the future, the problem of “elderly care by elderly” will become even more widespread, as well as elderly living by themselves. Leading to an increase in the news of *kodokush* 孤独死 (lonely death) making them more prevalent than ever.<sup>122</sup> *Kodokushi* or lonely death

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<sup>118</sup> Centre for Policy on Ageing, *Long term care insurance in Japan*.

<sup>119</sup> Tsuno et al., “Ageing in Asia—the Japan experience,” 5.

<sup>120</sup> *Ibid*, 5-6.

<sup>121</sup> Kawano, *Nature's embrace: Japan's aging urbanites and new death rites*, 36-40.

<sup>122</sup> Niitsu, *Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu*, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing].

refers to a Japanese phenomenon of death of people living alone, and not being found for a period of time. This phenomenon was first introduced in the 1980s, but since then it has become increasingly common, partly because of economic reasons and partly as a result of the ageing population. Takako Sodei, a gerontologist at the Ochanomizu University comments on the loneliness of the elderly, "There is a kind of myth that older people in Japan are living in three-generational families, but that's not so anymore..."<sup>123</sup>

There is also the wishes of the elderly to consider. According to a recent survey, 90% of the elderly want to die naturally, and over half of the elderly wish to be able to remain at home during their final moments.<sup>124</sup> Kazumasa Yamada writes about this and the issues that might arise in his article "An Acquaintance with An Aging Society;"

Therefore, their houses must serve the functions needed at the End of Life (EoL). The problem is that how the elderly person *wants* to spend their EoL is not always compatible with the ability to build an environment that respects those intentions. In other words, it is necessary for the elderly to select their treatment at the terminal stage. The ways and means of a person's EoL depend on their selections; so it is important that, while they are still of sound mind and able to communicate, they have discussions, even documentation, of their wishes regarding EoL interventions and assistance such as cardiopulmonary resuscitation, endotracheal intubation, artificial respiration, and procedures such as tracheotomies, gastrostomy, and so on. Their ability to talk or eat and the functions required of the space are all affected by these selections.<sup>125</sup>

Nationwide population ageing is an issue the government must tackle as its effects are far-reaching, but for some time now the depopulation of rural areas in Japan has also been having this issue, as young people leave for metropolitan areas in search of schools or jobs, the rural population has been ageing and shrinking rapidly. The villages in question have been trying to get young people to move to rural areas with *mura okoshi* 村おこし (village revitalization) projects. This problem is something most Japanese are

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<sup>123</sup> Nobel, "Japan: 'Lonely Deaths' Rise Among Unemployed, Elderly"

<sup>124</sup> Cabinet Office, Heisei 29 Nenban Kōrei Shakai Hakusho 平成29年版高齢社会白書 [2017 Ageing Society White Paper].

<sup>125</sup> Yamada, "An Acquaintance with An Aging Society," 18.

familiar with as it was widely announced through all kinds of media, it even has a place in popular culture mediums like manga and anime<sup>126</sup>. The population of Japan is shrinking in size and ageing at the same time. In recent years, however, this problem has ceased to be an issue that is contained in the rural areas. The metropolitan areas where the young people are supposedly moving to are also faced with the ageing of the population.<sup>127</sup> The ageing of the population is not uniform across Japan and different patterns can be observed in the rural areas and in the urban areas.<sup>128</sup> Looking only at the percentages of senior citizens in Table 3 it is clear that every prefecture of Japan will experience an increase in the elderly population. The ratio of the elderly population is projected to be the highest in Akita prefecture by 2035 with 42% and lowest in Okinawa with 28%. By 2035 the elderly population in Tokyo is projected to be around 29%, which is, in fact a lower number than the ratio of senior citizens in Akita in 2015. Only looking at the percentages, this number might seem manageable. However, once we look at the actual number of senior citizens, rather than just the percentages, it becomes obvious that Tokyo will face a more drastic increase in its elderly population than Akita prefecture, which is projected to have the highest ratio of elderly in Japan. By 2035, Akita prefecture is expected to have a lower number of senior citizens than in 2015, the elderly population is expected to be around 20,000 lower. The senior population in the Tokyo will increase to around 750,000 by 2035. It can be seen clearly

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<sup>126</sup> Examples include: ‘Sakura Quest’, ‘Futsuu no Joshikousei ga [Locodol] Yatteremita’. Also by creating anime pilgrimage sites in rural areas, thereby creating a new kind of anime tourism.

<sup>127</sup> Muramatsu et al., “Japan: Super-ageing society preparing for the future”, 426-427.

<sup>128</sup> Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing].

that the expected increase in the number of senior citizens in Tokyo and neighbouring prefectures is quite high.<sup>129</sup>

Table 3. Trends and future projections for the elderly population

Total population (persons) in 2015 in parentheses	Ratio of seniors (2015) (age 65 and over)	Ratio of seniors (2025) (projected)	Ratio of seniors (2035) (projected)	Increase in seniors 2015 to 2025 (persons, projected)	Increase in seniors 2015 to 2035 (persons, projected)
Yamanashi (834,930)	28.4%	32.5%	36.4%	17,913	22,135
Gunma (1,973,115)	27.6%	31.3%	34.1%	41,660	42,585
Ibaraki (2,916,976)	26.8%	31.2%	33.9%	90,370	91,369
Tochigi (1,974,255)	25.9%	30.8%	33.7%	67,085	72,744
Chiba (6,222,666)	25.9%	30.0%	33.5%	213,346	286,533
Saitama (7,266,534)	24.8%	28.4%	31.8%	193,761	297,677
Kanagawa (9,126,214)	23.9%	27.2%	31.7%	289,747	567,581
Tokyo (13,515,271)	22.7%	25.2%	29.8%	316,963	764,753
Akita (1,023,119)	33.8%	39.5%	42.1%	9,276	-22,208
Okinawa (1,433,566)	19.6%	25.0%	28.1%	75,042	112,781

Source: Data compiled from "Population Census Report" (Ministry of Internal Affairs and Communications) for 2015, and "Regional Population Projection for Japan: 2010-2040 (March 2013)" (Institute of Population and Social Security Research) for 2025 and 2035.

Source: Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing]

The biggest obstacle to clear, especially in Tokyo and other urban areas will be shortages of hospitals, care facilities and housing for the elderly. One might assume that Tokyo would not face shortages of medical facilities given its size, but the actual number of hospital beds per person is actually one of the worst in the country.

According to a survey made by the Ministry of Health, Labour and Welfare, the number of beds per 100,000 people is the highest in Kochi prefecture with 2,522.4 beds per 100,000 people, compared to 948,3 in Tokyo, 943,3 in Chiba, 853,8 in Saitama, and

<sup>129</sup> Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing].

810,5 in Kanagawa, all places where the number of senior citizens are expected to be the highest.<sup>130</sup>

In order to deal with the rising senior citizens, Tokyo Metropolitan Government has addressed some solutions to this issue in the Comprehensive Strategy of 2015. The Comprehensive Strategy states that by 2025, they plan to add “...intensive-care seniors' housing for 60,000 people, health-care facilities with nursing care for 30,000 seniors, and group homes for 20,000 seniors with dementia, plus 28,000 units of housing with services for seniors.” The number of elderly utilizing the ‘housing with services for seniors’<sup>131</sup> as it will depend on whether or not it will become a single-person household or, be occupied by two or more persons. The new project plans to create housing for more than 140.000 elderly citizens residing in Tokyo. Unfortunately, this number still leaves a housing shortage of about 150.000, as the population of elderly in Tokyo is expected to be around 300.000 by 2025, and even passing 700.000 by 2035. Nonetheless, this project is expected to have a favourable impact on the housing problem.<sup>132</sup>

Solving the housing crisis, that is coming with the increasing number of elderly citizens is important in order to create a better environment for the elderly, but there is also the issue of lowered income in elderly-households. The income average of elderly-

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<sup>130</sup> Ministry of Health, Labour and Welfare, Heisei 27 Nen Iryō Shisetsu (Dōtai) Chōsa, Byōin Hōkoku no Gaikyō. 平成27年(2015)医療施設（動態）調査・病院報告の概況 [2015 Survey of Medical Facilities (Dynamic), The Overview of Hospital Reports]

<sup>131</sup> Housing with services refers to housing offered by private operators who are required, in principle, to offer safety confirmation and wellbeing consultation services, for persons aged 60 and over. Basically this category is aimed at seniors who do not yet need nursing care, but the services the residents can get may vary significantly among facilities. (Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu. 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing]).

<sup>132</sup> Niitsu, Shutoken no Kōreika Mondai: Mikake ijō ni fueru Kōreishasuu, 首都圏の高齢化問題：見かけ以上に増える高齢者数 [The Population Ageing Problem in Urban Areas: The Elderly Population That is Silently Growing].



households<sup>133</sup> is JPY 3 million (US\$27,850), which is almost half of other households at around JPY 6,5 million (US\$59,500) . According to a survey conducted by the government, the percentage of elderly who do not worry about their livelihood is around 65%. This trend might explain the increase of elderly in work-force. In 2017, the total labour force was around 67 million people. The elderly in Japan, while having less in terms of pension when compared to some European countries, are usually better off at least to some degree, as a number of Japanese continue their employment even after becoming eligible for retirement.<sup>134</sup> The population of people aged 65 to 69 was 4.54 million and those over 70 years of age was 3.67 million. The percentage of elderly; aged 65 years or over in the workforce, which was around 5% in the 1980s had surpassed 12% in 2017. Almost half of the men continue to work until their late 60s, the ratio falls to around 35% for the women.<sup>135</sup> The high rate of continued employment which can be seen in Figure 11 means that the elderly are able to lead an active life, which is a goal governments with ageing populations wish for, but at the same time it also means that people are not comfortable retiring early and feel the need for a higher income, although most workers are enthusiastic at the chance of working beyond retirement.<sup>136</sup>

This demographic shift, while creates a lot of disadvantages, there are also ways to this around, as a lot of companies have started doing with senior-oriented marketing. The elderly, previously thought as savers are now spending more freely than ever, and companies varying from markets to cell-phone carriers are hoping to be on the receiving end of this cash flow.<sup>137</sup>

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<sup>133</sup> Consists of people aged 65 and over only or with unmarried member(s) under 18 years old.

<sup>134</sup> Tamiya et al., "Population ageing and wellbeing: lessons from Japan's long-term care insurance policy."

<sup>135</sup> Cabinet Office, *Annual report on the aging society:2018*.

<sup>136</sup> Ranasinghe, "Can Japan's elderly become its growth engine?"

<sup>137</sup> Ranasinghe, "Can Japan's elderly become its growth engine?"

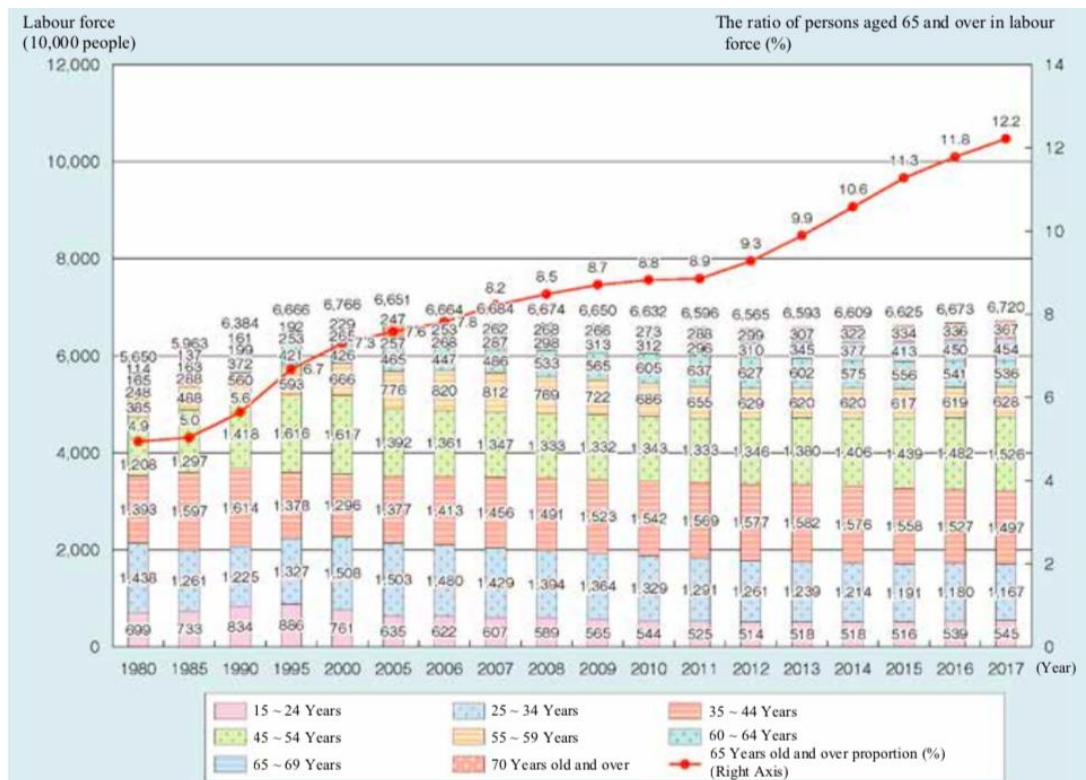


Figure 11. Trends in the labour force<sup>138</sup>

Source: Ministry of Internal Affairs and Communication, Statistics Bureau, *Labour Force Survey*

An example of this can be observed with NTT DoCoMo, a mobile phone carrier have designed a new phone with a simpler interface, larger fonts and easy to use camera.<sup>139</sup>

Another sector that has been growing as a consequence of elderly spending is the market for commercially prepared foods, as more and more elderly prefer to buy rather than cook their meals at home. Cafes and restaurants have also started to adapt to this shift, with senior courses or special offers for the elderly. Komeda coffee shop chain has adapted by changing their opening hours for early-rising senior citizens, with special offers for the elderly.<sup>140</sup> The families, the general society along with companies and the government are trying to adapt to this demographic shift. The Japanese government, besides looking for feasible solutions to the issues arising from the ageing population, is

<sup>138</sup> *Labour force* refers to an aggregate of employed people and unemployed people for the age group of 15 years old and over.

<sup>139</sup> Ozasa, "DoCoMo Looks for Growth Among Japan's Elderly."

<sup>140</sup> Hiroyuki, "Tapping the Potential of Japan's Senior Consumers."

also working towards making Japan a leader in the ageing topic, in both societal side of the issue and the technological and business side.

### 2.3 Government's leading role

The continuous decline in population and the ageing trend is not only worrisome regarding Japan's future as a country but also for the economy as the top-heavy population pyramid puts economic pressure to the rest of the population. This kind of top-heavy structure cannot be sustainable in the long run, unless the governments design and enact new policies to improve the situation and lighten both the economic and psychological burdens that puts pressure on the society.<sup>141</sup>

The rise in elderly populations around the globe has led to a widespread acceptance of the role of the environment the older people live in, and their role in older persons being active. The streets, the parks, the public transportation systems all play a part in creating a supportive surrounding which is favourable for healthy and active ageing. Still, not much is known on how to create environments to favourable influence the super-aged societies to have more active lifestyles. There is still much to be researched on the subject, but as Japan has already become a super-aged society, physical activity and having the elderly be more active has become a major target for public health agencies. To promote overall health in the nation, the government has devised a new plan, Health Japan 21.<sup>142</sup> The targets set by the plan include; “achieving extension of healthy life expectancy and reduction of health disparities”, “the prevention of onset and progression of life-style related diseases”, “maintenance and improvement of functions necessary for engaging in social life”, “putting in place a social

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<sup>141</sup> Weil, The economics of population aging, 968-970.

<sup>142</sup> Ministry of Health Labor and Welfare, *Health Japan 21*.

environment to support and protect health”, and “improvement of everyday habits and social environment relating to nutrition and dietary habits, physical activity and exercise, rest, alcohol, smoking, and dental and oral health”. The plan is not only for the benefit of the elderly, but a more holistic approach to national health, which in turn would have positive effects in the future, when the elderly ratio increase even further.<sup>143</sup>

Another solution, for the improvement of health and daily lives of the elderly, are the Silver Human Resource Center's. Silver Human Resource Centers, or Silver Centers for short are a government-backed programme for the senior citizens to find work after retirement. The first centre was opened in Tokyo in 1974, and with the amendment of the Act Concerning Stabilization of Employment of Older Persons<sup>144</sup> in 1986 the programme continued to expand. Today there are more than 1600 centres all around Japan. The aim of the centres is “...to create dynamic communities and to support meaningful and fulfilling lifestyles for older persons through the provision of appropriate work opportunities for people generally age 60 or over who desire to participate in society through a work style that suits them.”<sup>145</sup> Each of these centres is usually tied to a municipality and receive work from companies, environmental agencies, public organizations, and even private households. The work centres accept

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<sup>143</sup> Koohsari et al., Activity-Friendly Built Environments in a Super-Aged Society, Japan: Current Challenges and toward a Research Agenda, 2-3.

<sup>144</sup> “The Act on Stabilization of Employment of Older Persons developed out of the Act for Promoting Employment of Middle-aged and Older Persons, Etc., which was enacted in 1971. At a time when the Act for Promoting Employment of Middle-aged and Older Persons, Etc. was enacted in 1971, it was provided for as a regulation for setting targets on the percentage of middle-aged and older employees of age 45 and over in each job category. Later, the system of setting targets in each job category was abolished in 1976, and, instead, employers were obligated to meet the uniform target of 6% or more as a percentage of older employees of ages between 60 and 65 among all employees. In 1986 the Act for Promoting Employment of Middle-aged and Older Persons, Etc. was amended and became the Act on Stabilization of Employment of Older Persons. At this time, the act provided for an obligation of firms to make an effort to set the mandatory retirement age at 60, in addition to the target on the percentage of older employees. In the amendment of 1994, the mandatory retirement age of 60 became an obligation for employers, and as of April 1998, it became illegal to set the mandatory retirement age at below 60.” (Fujimoto. Employment of older people after the amendment of the act concerning stabilization of employment of older persons: current state of affairs and challenges.)

<sup>145</sup> International Longevity Center Japan, Japan's Silver Human Resources Centers: Undertaking an Increasingly Diverse Range of Work.

varies; from general indoor and outdoor work to facility administration and office work<sup>146</sup>. The work is then allocated to registered members, members receive around JPY 50.000 to 60.000 (US\$450-550) a month based on the content and frequency of the work. The senior citizens that take part in this programme do so partly to earn money and partly to stay healthy and socialize with people their age.<sup>147</sup> For now, the economy in general has not suffered drastically as the senior citizens, in general are relatively active and, they are spending money as almost half on Japan's personal consumption is made by people aged 60 years and over. Peter S. Heller, the former Deputy Director of the Fiscal Affairs Department of the International Monetary Fund (IMF), touches upon this issue in an article titled "The challenge of an aged and shrinking population: Lessons to be drawn from Japan's experience;" "The next 10-15 years are Japan's last obvious window for important policy gains from reform. The baby boomers are still the "young old" and can participate in the labor force. The prospects for reducing the public debt are still plausible and many in the business sector as well as scholars and policy makers accept the need to revitalize the economy."<sup>148</sup>

However as the population ages further, more and more of the government's budget will go to elderly care; nursing-care, health-care and long-term care. The fastest growing demographic group, the oldest-old require the most care; as only 3% of senior citizens require nursing-care, but this percentage jumps to 23% for the oldest-old. The

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<sup>146</sup> "Park cleanup, weeding, building janitorial work, product control, poster hanging, flyer distribution. Parking lot administration, bicycle control, administration of schools, community centers, and buildings. Bookkeeping, translation, editing, driving, computer operation, instruction of cram classes. Plant pruning, painting, carpentry work, air conditioner repair, repapering of sliding screens (fusuma and shoji). General office work, reception work, survey work, hand-writing of addresses using pens, copying of documents using brushes. Pamphlet distribution, payment collection, pickup and delivery service, sales, reading of water and gas meters. Traffic control, housekeeping assistance, distribution of city newsletters, etc." (International Longevity Center Japan, Japan's Silver Human Resources Centers: Undertaking an Increasingly Diverse Range of Work.)

<sup>147</sup> International Longevity Center Japan, "Japan's Silver Human Resources Centers: Undertaking an Increasingly Diverse Range of Work."

<sup>148</sup> Heller, "The challenge of an aged and shrinking population: Lessons to be drawn from Japan's experience," 14.

same trend can be seen for dementia patients as well; a study backed by the Ministry of Health, Labor and Welfare shows; for people in their 60s dementia can be seen in around 2% of the population. This number goes up to 5% for the early 70s and 10% for late 70s. The economic dimension of this trend is, people aged 70 and over hold many “securities, and as Takata Hajime, chief economist of Mizuho Research Institute puts it, “...people with dementia, rather than the Bank of Japan or pension funds, could become the largest holders of securities.” By Takata’s estimation around JPY 150 trillion (US\$1,4 trillion) of securities will be owned by people with dementia, presumably whose accounts will be frozen, and with restricted money flow, the economy suffers even more.<sup>149</sup> To deal, at least to some degree with the ballooning social welfare costs with the increasing number of welfare recipients, the government has been gradually increasing the consumption taxes. The rate, which is 8% since the rise from 5% in 2014, is planned to be increased again in October 2019 to 10%.<sup>150</sup>

The medical sector is also affected noticeably as a consequence of population ageing, and it can be seen from the government's attempts to create a healthier and more active elderly population. Figure 12 shows the percentage of each age groups medical expenses. A large percentage of medical expenses in 2015 was spent on the elderly with the oldest old taking the biggest share; for a person aged 75 to 79 around JPY 793,000 (US\$7300), for those of the population aged 80 to 84 about JPY 940,000 (US\$8700) while for an older person aged 65 to 69 the spending was JPY 469,000 (US\$4300). The respective shares different age groups of the elderly population spend makes it clear that it is not feasible to think of the elderly as a homogeneous group of people. Between the youngest age group of the elderly (65-69) and the oldest (100+), there is nearly a

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<sup>149</sup> Fukuyama, “From elderly to 'superelderly': Japan wrestles with demography.”

<sup>150</sup> JETRO, *Overview of Consumption Tax*.

threefold difference in medical expenditures, which is more than the difference between the working-age population and population of the 65 to 69 age bracket.<sup>151</sup>

The Japanese healthcare system is very hospital-oriented, the average stay at hospitals in 2010 was 18,2 days. “In the past, when families were unable to cope with the provision of care at home, older family members were often admitted to hospital. This social hospitalisation led in 1980 to an estimated 4% of the population aged 65 and over “living” in hospital with an average stay of 103 days.”<sup>152</sup> Preventing the elderly from being hospitalized in the first place can play an important role in keeping the medical expenses down. To achieve this, the Japanese government has drafted a guide for both doctors and pharmacists about the appropriate use of medicine for the elderly, to prevent excessive use of medications, which are harmful to the elderly and curb the cost as well. Ministry of Health, Labour and Welfare drafted the first guideline on September 2017, and continuing its work on the subject on January 2019, drafted the 7th guideline.<sup>153</sup>

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<sup>151</sup> Cabinet Office, *Annual report on the aging society:2018*.

<sup>152</sup> Centre for Policy on Ageing, *Long term care insurance in Japan*.

<sup>153</sup> Ministry of Health, Labour and Welfare. Kōreisha Iyakuhin Tekisei Shiyō Gaidorain Sakusei Wākingu Gurūpu. 高齢者医薬品適正使用ガイドライン作成ワーキンググループ [The Working Group for The Appropriate Use of Medicine for The Elderly].

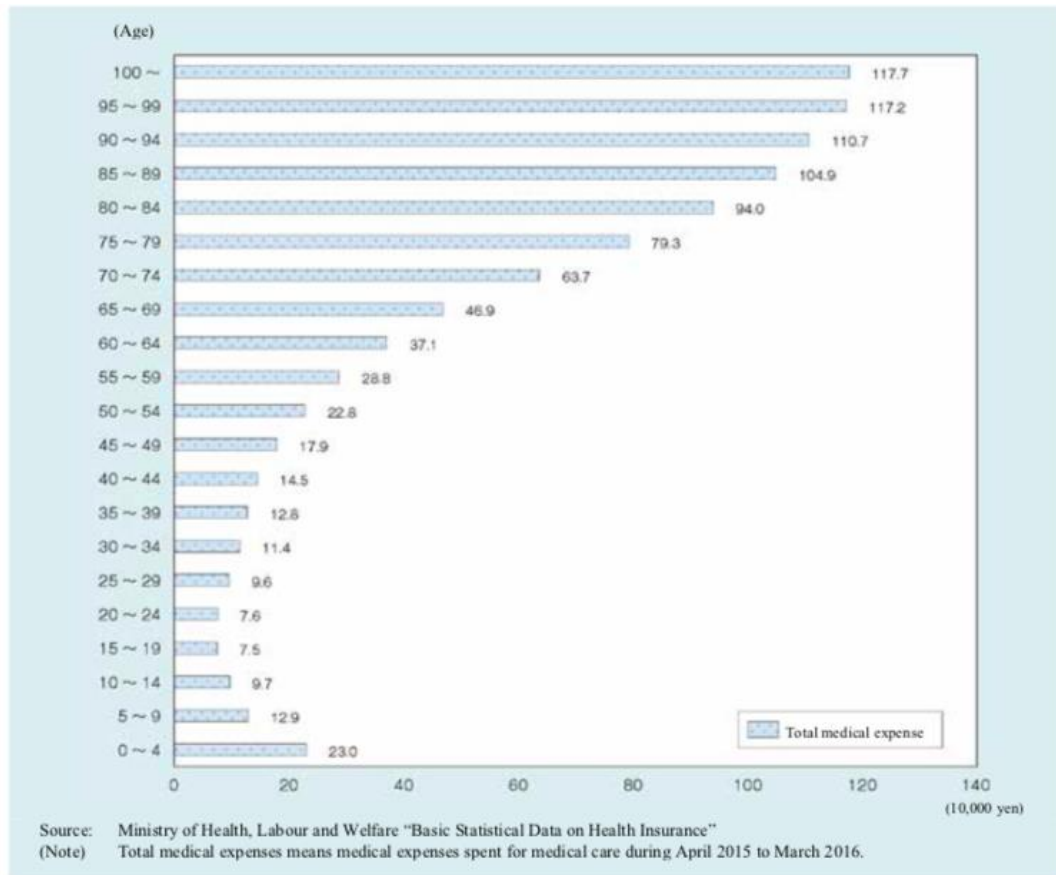


Figure 12. Medical expense (2015) per person by age group in health insurance system  
 Source: Cabinet Office, *Annual report on the aging society:2018*

If preventive measures are not taken, the demographic ageing of a country can have various consequences, most severely to a nation's economy. The main economic problem that also has wide social ramifications is the funding of social welfare systems. The percentage of the working-age population which creates revenue falls while the elderly population which rely on social welfare increases, consequently this situation makes it extremely hard to create continued funding to social welfare systems. And this upward trend the social security system faces can be seen in Figure 13. In 2015 the social benefits costs including pension, healthcare and welfare were the highest ever to be recorded and were recorded to be JPY 114.8596 trillion (US\$1 trillion). Again in 2015, 67% of the social welfare funds, JPY 77.6386 trillion (US\$715 billion) was used



on the elderly population.<sup>154</sup> The government is searching for solutions to overcome this financial disaster; even considering to give people a choice of delaying until they are aged 70 or over to start receiving their pensions, but a change of this degree will not be easy to make. Another consideration to make according to pension economist Takayama Noriyuki from *Research Institute for Policies on Pension and Aging* is “...adjusting benefits across the health care, nursing care and pension frameworks, such as reducing payments to those in public nursing homes.” He believes that without this adjustment is not possible to stop the costs of welfare systems from ballooning.<sup>155</sup>

Japan has had universal health insurance since 1961. In the 1960s, when the ageing rate was around 6%, the government has also begun developing welfare policies for its senior citizens. In 1963, with the Enactment of the Act on Social Welfare for the Elderly, intensive care homes were created and there was legislation on home care-workers for the elderly as well. In the 1970s, it was decided that there would be free healthcare for the elderly aged 70 and over. Subsequently in the 1980s, “bedridden elderly” were now becoming social problems.<sup>156</sup>

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<sup>154</sup> Cabinet Office, *Annual report on the aging society:2018*.

<sup>155</sup> Fukuyama, “From elderly to 'superelderly': Japan wrestles with demography.”

<sup>156</sup> Ministry of Health, Labour and Welfare, *Heisei 28 Nendo Kaigo Hoken Jigyō Jōkyō Hōkoku (Nenpo)*. 平成28年度 介護保険事業状況報告（年報）[2016 Situation Report for Long-Term Care Insurance (annual)].

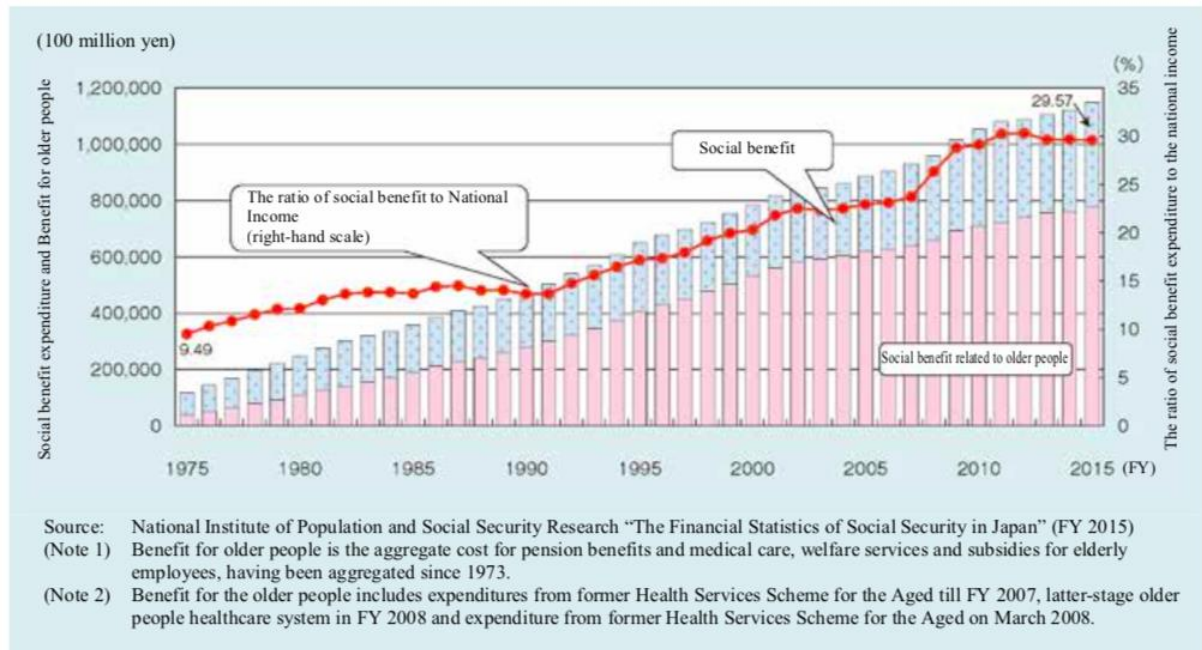


Figure 13. Japanese social benefit trends

Source: Cabinet Office, *Annual report on the aging society:2018*

In 1982, Enactment of the Health and Medical Services Act for the Aged, which meant that healthcare for people aged 70 and over and bedridden elderly aged 65 and over would be financed 30% by public funds and 70% by health insurance, with a small co-payment. And in 1989, the establishment of the Gold Plan; a 10-year plan designed for the amelioration of health and welfare of senior citizens, promoting the much needed formation of facilities and in-home welfare services. In the 1990s, where the ageing rate had gone up to 12%, a new Gold Plan had been established, this time promoting the amelioration of in-home long-term elderly care. Following this in 1997, when the ageing rate was now around 15%, with the enactment of the Long-Term Care Insurance Act, one of the social issues of the ageing phenomenon was addressed and in the year 2000, the Long-Term Care Insurance System<sup>157</sup> was enforced, with the slogan “from care by

<sup>157</sup> There is a variety of “Long-Term Care Insurance Services”, the elderly can benefit from their home, and from long-term care facilities. For the senior citizens living at their private homes, the services include; “Home-visit Care, Home-visit Nursing, Home-Visit Bathing Long-Term Care, In-Home Long-Term Care Support”. Day services, including outpatient rehabilitation, and short-stay services like daily-life long term care are also covered. For in-facility services “Facility Covered by Public Aid Providing

family to care by society”, providing facility-based care, home-based health services and also community-based healthcare services for citizens aged 65 and over, and also for citizens aged 40 to 64 who suffer from ageing related issues.<sup>158</sup> As Muramatsu put it, “This historic policy has made a variety of home, community-based, and institutional services, a universal entitlement for every Japanese person aged 65+ years based strictly on physical and mental status, regardless of family availability and economic status.”<sup>159</sup> However, while the Gold Plan has been praised for providing healthcare for the elderly, it has also been criticized because of the burden its expense put on the national economy. Recognizing the importance of continued family-care for the elderly, in 2001, the Japanese government has started to provide “payments for providing care to the most needy older relatives”<sup>160</sup> By the 2010s, the ageing rate had gone up to 23%. In 2012, the Community-based Integrated Care System was established, for the betterment of “community-based care and integrated clinical-care and welfare services.”<sup>161</sup>

The government is also enthusiastic about the notion of using technological advancements to help with the issues of ageing, and also developing a lucrative field of robotics and AI for the elderly, nursing and care-work surrounding the ageing population. The Japanese government is willing to work towards becoming a world leader in technologies for senior citizens as the world population is also ageing rapidly. The government has addressed these issues and future projects in its New Robot

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Long- Term Care to the Elderly and Long-Term Care Health Facility” are covered by the insurance. (Ministry of Health, Labour and Welfare, *Situation Report for Long-Term Care Insurance.*)

<sup>158</sup> Tsutsui et al, “Japan’s universal long-term care system reform of 2005: Containing costs and realizing a vision”, 1458-1459.

<sup>159</sup> Muramatsu et al., “Japan: Super-ageing society preparing for the future”, 426-427.

<sup>160</sup> Tsuno et al., “Ageing in Asia—the Japan experience,” 7.

<sup>161</sup> Sudo, et al., “Japan’s healthcare policy for the elderly through the concepts of self-help (Ji-jo), mutual aid (Go-jo), social solidarity care (Kyo-jo), and governmental care (Ko-jo)”, 2.

Strategy report in 2015 and wants to create a Robot Revolution to help Japanese society and economy in the near future.<sup>162</sup>



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<sup>162</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

## CHAPTER 3

### ROBOTS FOR A SUPER SMART SOCIETY: SOCIETY 5.0

The population of Japan is ageing rapidly and by the year 2050, 40% of the population in Japan will be consisting of elderly citizens. To combat the resulting labour shortages the Japanese government is searching for answers in robotic technologies. The government plans to create a smart society, Society 5.0, where technological advancements reach every layer of society, while alleviating the labour shortages most industries will face.

#### 3.1 Global trends in robotics

What constitutes as a robot? “The word itself comes from a Czech play from the 1920s, entitled *R.U.R.* (Rossum’s Universal Robots), by Karel Čapek.<sup>163</sup> In the play, the “robots” are artificial humans used as slave labour in a factory (roboti in Czech translates to “serf labor,” with the associated connotations of servitude and drudgery).”<sup>164</sup> Before the word robot began to spread, the word ‘automat’ was being used to define these machines. The idea of robots, automats and “mechanized human-like figures” goes back thousands of years to Ancient Greece and also to China.<sup>165</sup>

The word ‘robot’ itself went through many metamorphoses with the result that a generally accepted definition does not exist. It is generally agreed that a robotic system

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<sup>163</sup> Karel Čapek, *R.U.R. Rossum’s Universal Robots* (1920).

<sup>164</sup> Calo et al, *Robot law*, 5.

<sup>165</sup> de Solla Price, “Automata and the origins of mechanism and mechanistic philosophy.”

is a machine with a degree of autonomous function.”<sup>166</sup> The modern robotics relies on advancements in computers and mechatronics, still, the main aspect is the ‘automation of physical work’. Another function the modern robots are expected to possess is an intelligent communication with its surroundings. When we think of robots, what we usually imagine is not robots on a micro scale. However, “systems on a micrometer or nanometer scale are also included in the area of robotics, provided that they perform all three essential functions defining a robot: 1) acting on environmental stimuli in combination with 2) sensing and 3) logical reasoning.”<sup>167</sup> The definition of robots and robotic systems will likely change even more and acquire additional sub-sectors in the near future.

Presently, the robot industry is generally separated into two fields; industrial robots and service robots. The International Organization for Standardization (ISO) defines industrial robots as “automatically controlled, reprogrammable, multipurpose manipulator<sup>168</sup>, programmable in three or more axes<sup>169</sup>, which can be either fixed in place or mobile for use in industrial automation applications”<sup>170</sup>. Some examples of industrial robots being utilized are; “automobile manufacturing robots; electrical/electronic appliance manufacturing robots; cargo/transportation robots; arc & spot welding robots; single axis and cartesian robots; electric slide and tabletop robot; palletizing & take out robots; transfer and wafer transfer robots”. Nowadays, industrial robots are able to lift hundreds of kilograms and position that load “with accuracy to a

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<sup>166</sup> Pohl, “A Comparison of Websites by Robot Manufacturers in Germany and Japan: The Ethical Relationship Between ‘Robot’ and ‘Human Body’ as a Management Challenge,” 28

<sup>167</sup> Butter et al, *Robotics for Healthcare*, 4.

<sup>168</sup> Machine in which the mechanism usually consists of a series of segments, jointed or sliding relative to one another, for the purpose of grasping and/or moving objects (pieces or tools) usually in several degrees of freedom. (ISO. Robots and robotic devices.)

<sup>169</sup> Direction used to specify the robot motion in a linear or rotary mode. (ISO. Robots and robotic devices.)

<sup>170</sup> The International Organization for Standardization, *Robots and robotic devices*.

fraction of a millimetre”. Highly advanced algorithms are utilised in order to correctly perform the tasks assigned to the robotic systems.<sup>171</sup>

A Service robot<sup>172</sup> is a “robot that performs useful tasks for humans or equipment excluding industrial automation applications”.<sup>173</sup> To put it plainly; service robots aid humans by completing tasks that are too dirty, repetitive or dangerous for human beings. Usually they are autonomous or they are operated by a previously installed control mechanism, they typically contain a manual override option as well.<sup>174</sup> There are personal service robots and professional service robots; a personal service robot is “...used for a non-commercial task, usually by lay persons. Examples are domestic servant robot, automated wheelchair, and personal mobility assist robot.” While a professional service robot is “...used for a commercial task, usually operated by a properly trained operator.”<sup>175</sup> Examples are cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot and surgery robot in hospitals.”<sup>176</sup> In the robotics market aside from industrial robots and service robots there is also the field of Robotech. Industrial robots are used in the manufacturing industry, whereas service robots can be for both industrial use and personal use. Robotech is the field that makes the robots, or the components for the robot industry.<sup>177</sup>

While the main field is divided into two categories, as Robotech is not usually considered as a field onto itself, the lines are not always so clear cut. One example being robots in healthcare, “ a clear distinction for a robotic system in healthcare is not given.

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<sup>171</sup> Weeën, *Robotics in Japan*.

<sup>172</sup> While articulated robots (An articulated robot is a robot with rotary joints) used in production lines are industrial robots, similar articulated robots used for serving food are service robot. (ISO. Robots and robotic devices.)

<sup>173</sup> The International Organization for Standardization, *Robots and robotic devices*.

<sup>174</sup> Weeën, *Robotics in Japan*.

<sup>175</sup> In this context, an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system. (ISO. Robots and robotic devices.)

<sup>176</sup> The International Organization for Standardization, *Robots and robotic devices*.

<sup>177</sup> Weeën, *Robotics in Japan*.

Some robots used in healthcare are categorized as service robots, however, some healthcare related robotic systems such as those used in logistics do not fall into that criteria either.”<sup>178</sup> Butter describes in the report *Robotics for Healthcare*, “Robotics for medicine and healthcare is considered the domain of systems able to perform coordinated mechatronic actions (force or movement exertions) on the basis of processing of information acquired through sensor technology, with the aim to support the functioning of impaired individuals, rehabilitation of patients and also to support individuals in prevention programs”.<sup>179</sup>

A similar issue emerges in the field of social robots. Here, it is important to distinguish between societal robots and social robots. Brian R. Duffy distinguishes them as, “The former represents the integration of robotic entities into the human environment or society, while the latter deals specifically with the social empowerment of robots permitting opportunistic goal solution with fellow agents.”<sup>180</sup> While societal robots are generally categorized as service robots, the same can not be said for social robots. The term “socially intelligent agents” is used for service robots,<sup>181</sup> but Duffy argues that, this “...represents an example of societal robotics where robots are introduced into society with degrees of required functionality to act as aides to people.”<sup>182</sup>

When discussing social robots, the meaning of social intelligence becomes important, and it is argued by Bruce Edmonds, “social intelligence is not merely intelligence plus interaction but should allow for individual relationships to develop between agents. This means that, at least, agents must be able to distinguish, identify, model and address other agents, either individually or in groups; in other words that

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<sup>178</sup> Pohl, “Robotic Systems in Healthcare with Particular Reference to Innovation in the ‘Fourth Industrial Revolution’,” 18.

<sup>179</sup> Butter et al, *Robotics for Healthcare*, 12.

<sup>180</sup> Duffy et al., “What is a Social Robot?”

<sup>181</sup> Wilkes et al. “Hudl, a design philosophy for socially intelligent service robots,”

<sup>182</sup> Duffy et al., “What is a Social Robot?”



purely heterogeneous interaction is insufficient.”<sup>183</sup> Also on the same subject, in an article co-authored by Duffy, the concept of being social is defined, “Sociality implies the existence of interactive relationships. An agent capable of interactive, communicative behaviour is considered social. The simple existence of two autonomous robots in the same environment forces aspects of social contact, be it direct or indirect.”<sup>184</sup>

“The social intelligence hypothesis, or the Machiavellian intelligence hypothesis promotes the theory that in order to achieve a degree of intelligent behaviour from an agent, the agent must be both embodied in a physical environment and embodied in a social environment.” Kerstin Dautenhahn and Thomas Christaller believe that, the agent must be in real-world situations with real interactions in order to be able to develop as an intelligent agent.<sup>185</sup> “One perspective is that one should be aware of their mental states (i.e. motives, beliefs, desires, and intentions) and be able to attribute mental states to others, which allows one to predict and analyse the behaviours of both oneself and others.” This ability would enable one to deal effectively with complexity in social relations and also the ability for abstract thought in social situations.<sup>186</sup> According to Dorothy L. Cheney and Robert M. Seyfarth the origin of primate intelligence was “to solve social problems and was only later extended to problems outside the social domain.”<sup>187</sup>

The robotics industry is advancing at a rapid pace, a variety of new robotic technologies are being developed all around the world. This increasingly rapid pace of advancement makes the standardization of robots crucial for a worldwide network of

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<sup>183</sup> Edmonds, “Modelling Socially Intelligent Agents in Organisations,”

<sup>184</sup> Duffy et al., “What is a Social Robot?”

<sup>185</sup> Dautenhahn et al, “Remembering, rehearsal and empathy-towards a social and embodied cognitive psychology for artifacts”

<sup>186</sup> Duffy et al., “What is a Social Robot?”

<sup>187</sup> Cheney et al., “Précis of How monkeys see the world,” 145-146.

robots to be a reality. The standardisation period is still in its infancy but as the field grows further so will the globalisation of robotic technologies, making standardisation even more important. Currently, the standards applicable to robots are “ISO 10218, which is applicable to industrial robots and robot-related devices and ISO 13482, a recently established safety-related standard for service robots. Other examples of standards under discussion include a standard for robotic vacuum cleaners, IEC<sup>188</sup> TC59/WG5, a safety standard for cooperating robots, ISO TC184/SC2, a safety standard for robotic devices for nursing care, and modularization of software and hardware for robots that move on wheels. In Japan we should be prepared to commit to these standards guided by a defined strategy or actively promote the universal application of these standards.”<sup>189</sup>

### 3.2 Society 5.0

In Japan, the biggest societal change in recent history is their rapidly ageing population, as such the government has been designing a remedy to help lighten the burden on the society. One of the solutions to combat this issue is the newly introduced societal structure, Society 5.0. The concept for Society 5.0 or Super Smart Society was proposed by the Council for Science, Technology and Innovation in 2016 in its 5th Science and Technology Plan. One definition given for Society 5.0 initiative is "A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space.”<sup>190</sup>

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<sup>188</sup> International Electrotechnical Commission.

<sup>189</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>190</sup> Cabinet Office, *Society 5.0*.

The Japanese lay a roadmap starting it with the hunter-gatherer (society 1.0), agrarian (society 2.0), industrial (society 3.0), and the information (society 4.0) which we currently reside in and finally Society 5.0, creating systems of information and connectivity on both physical and informational level.<sup>191</sup> This initiatives main objective is to create a sustainable society, in which the individuals from different age groups and generations are able to live comfortably and in harmony.<sup>192</sup> The discussion about the best method to integrate the new technologies based on AI, IoT and Robotics into our daily lives, is at the moment an important topic in Japanese policy-makers agendas, as advancements in science and technology fields are improving all facets of businesses and society, especially through innovation.<sup>193</sup> The aim of Society 5.0 is “...creating a society where we can resolve various social challenges by incorporating the innovations of the fourth industrial revolution (e.g. IoT, big data, artificial intelligence (AI), robot, and the sharing economy) into every industry and social life.”<sup>194</sup>

To support the government in its endeavour to create Society 5.0, the Advisory Board on Artificial Intelligence and Human Society was created in 2016 as a part of Science and Technology Policy with the aim of advancing research and development as well as spreading the use of AI technologies. “AI technology is one of the most significant technologies that facilitates the realization of Society 5.0. The Advisory Board has worked especially to clarify benefits, issues, challenges, and future directions with special attention to AI technologies that exist or will be realized in the near future and a society in which such technologies prevail.”<sup>195</sup> The world around us is changing at

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<sup>191</sup> Cabinet Office, Dai Go Ki Kagaku Gijutsu Kihon Keikaku 第5期科学技術基本計画 [The 5th Science and Technology Basic Plan].

<sup>192</sup> Shiroishi et al., “Society 5.0: For Human Security and Well-Being.”, 91–95.

<sup>193</sup> Harayama., “Society 5.0: Aiming for a New Human-centered Society”, 8-13.

<sup>194</sup> Cabinet Office, *Society 5.0*.

<sup>195</sup> Advisory Board on Artificial Intelligence and Human Society, *Report on Artificial Intelligence and Human Society*.

an incredibly fast pace, sometimes in places where we can not perceive it in a concretely, especially the change that is happening in the digital world. The digital transformation that awaits us will revolutionize not only the industry but also impact social infrastructures around the world as well. The digital transformation in the industrial sector, especially in manufacturing has accelerated throughout the world, with programmes such as Germany's Industry 4.0, China's Made in China 2025, and Advanced Manufacturing Partnership in the United States.<sup>196</sup>

Similar to the roadmap for societal advancements, there is also a one for the progression of industrial revolutions throughout history. Starting in the 18th century with advancements with the utilisation of steam and mechanisation of production in light industry, the First Industrial Revolution. Followed by advancements in heavy and chemical industry in the 19th century which is classified as the Second Industrial Revolution. In the 20th century, this is succeeded by the developments in computers and the creation of the internet, the Third Industrial Revolution. The Fourth Industrial Revolution was brought upon by a digital transformation and developments in the fields of AI, IoT, blockchain and their utilisation in the industry.<sup>197</sup>

The next step to follow the 4th Industrial Revolution that we currently reside in is the creation of systems that use the things or manufactured goods that were handled separately to become connected with the digital revolution to come. The systems of various fields that already exist separately in our current society will be able to collaborate more easily and freely as the coordination of such connectivity will be much smoother with further digitalization of industry and social infrastructures. This transformation is expected to create change throughout society by structurally changing industries and as a consequence, altering the way people live and work. The societal

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<sup>196</sup> Li, "China's manufacturing locus in 2025," 66-74.

<sup>197</sup> Stearns, *The industrial revolution in world history*.

changes to come are especially important for countries such as Japan, that are impacted by an ageing population where the quality of life cannot be sustained by the current means and structural transformation is impertinent in both industry and also society to keep and improve the current quality of life.<sup>198</sup>

The Information Society in which we are assumed to be living in already uses information in volumes never been seen before, and recent developments in the technology field, together with some structural changes in the society due to the advances in information and communication technologies (ICT) has created an environment for information exchanges in very large volumes.<sup>199</sup> The concept of information society was proposed to define the post-industrial society in which the prominent factor becomes information. Since its first use as a term in the 1960s in Japan as Johou Shakai 情報社会 or Johouka Shakai 情報化社会 (information society) in the social sciences field, there has not been a general agreement on one concrete definition. There are five main characterizations used for the information society: technological, economic, occupational (sociological), spatial, and cultural. While they cannot agree upon a concrete definition, what they agree upon is, the fundamental description of information society, that it utilises incredible amounts of information, like never been seen before by previous generations.<sup>200</sup>

Society 5.0, which is thought to be the next step in the evolution of society is planned as a more inclusive and highly connective system that will cater to the needs of all its citizens regardless of age, sex, region, language or any other factors. This is a human-centric concept, the main focus being to create equal opportunities for everyone

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<sup>198</sup> Fukuyama., “Society 5.0: Aiming for a New Human-Centered Society” ,47–50.

<sup>199</sup> Nath, “The Information Society,” 19-29.

<sup>200</sup> Webster, *Theories of the Information Society*, 8-14.

to indulge in an active life and also having a high-quality life.<sup>201</sup> The central objective is to provide all the necessary services and products to all its citizens equally. The main factor in realizing this next step is to further integrate cyberspace and physical space successfully to create more quality data.<sup>202</sup> This is a central difference between Society 4.0 and 5.0 in how the data is analyzed. In Society 4.0, the data is usually stored in cloud databases in cyberspace, where people could access the data and analyze it. In Society 5.0, the information is again stored in cyberspace, but the fundamental distinction is, the data is analyzed by AI, which is connected to all systems in cyberspace, and afterwards the analyzed data is brought back to humans in the physical world. This new practice is expected to bring new values to both the industry and society in various ways.<sup>203</sup>

With Society 5.0 the Japanese government aims to realize a new societal infrastructure to combat issues that are mainly created by its ageing population. The main subjects they wish to address are; healthcare, mobility, infrastructure<sup>204</sup> and fintech<sup>205</sup>. Being one of the first countries to face these issues, and search for answers to the problems which will in near future affect more countries Japan is sharing its answers and help create global solutions with Society 5.0.<sup>206</sup> Its universal appeal seems to have prompted scholars from countries ranging from Lithuania<sup>207</sup>, Russia<sup>208</sup> to even China<sup>209</sup> to adopt the term. This concept will be using the technological advancements from the ongoing industrial revolution, Industry 4.0 and create an environment that will ensure a

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<sup>201</sup> Shiroishi et al., “Society 5.0: For Human Security and Well-Being.” 91–95.

<sup>202</sup> Hitachi, “Realizing Society 5.0 through ‘Habitat Innovation’,” 3-5.

<sup>203</sup> Harayama, “Society 5.0: Aiming for a New Human-centered Society”, 8-13.

<sup>204</sup> The reduction in population will lead to less dense areas, where the basic infrastructure services such as water, energy, education and medical services will need to be provided to large and sparsely populated areas, resulting in higher service costs. (Harayama, 2017)

<sup>205</sup> Financial Technology. Products and companies that employ newly developed digital and online technologies in the banking and financial services industries.

<sup>206</sup> Fukuyama, “Society 5.0: Aiming for a New Human-Centered Society”, 47–50.

<sup>207</sup> Savanevičienė et al., “Individual innovativeness of different generations in the context of the forthcoming society 5.0 in lithuania”, 211-222.

<sup>208</sup> Salimova et al., “From industry 4.0 to society 5.0: Challenges for sustainable competitiveness of russian industry”, 1-7.

<sup>209</sup> Wang et al., “Societies 5.0: A new paradigm for computational social systems research”, 2-8.

sustainable future. Industry 4.0, in essence, is the integration of industrial and technical systems to cyber-physical systems (CPS<sup>210</sup>). This connectivity is what the Japanese government aims to create in the everyday world outside of the industrial processes.

The Japanese government also expressed its wish to comply with the sustainable development goals (SDGs)<sup>211</sup> set by the United Nations Development Programme (UNDP) in 2015 in its 5th Science and Technology Basic Plan, by incorporating them into its Society 5.0 scheme.<sup>212</sup> This means that while the Society 5.0 project is a development system for Japan, it is by no means restricted to Japanese society. The difficulties Japan currently faces as a result of its demographic changes will appear in different nations in the near future around the world as well. By finding solutions to these problems, Japan will be able to help settle these comparative issues worldwide and help accomplish the SDGs.<sup>213</sup>

AI will also be playing a major role in realizing Japan's vision for the future and has been gaining popularity as technological advancements create a superior playground for it. But the story of AI had already started in the 1950s, more precisely in the summer of 1956, at the Dartmouth Summer Research Project (Dartmouth Conference) at Dartmouth College, when John McCarthy, a mathematics professor coined the phrase artificial intelligence. The field of thinking machines or AI, as we now call it was launched by a vision shared by the scientists attending the conference. Although they were not in complete agreement on the choice of problems, the general theory or the methodology, they all believed that computers could be able to do intelligent tasks. Their vision, as it was clearly stated in the proposal of the conference; "The study is to proceed

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<sup>210</sup> A broad concept that collects data from sensors installed in the real world (physical space) in the cloud (cyberspace) via the internet, and feeds the results of analysis back into the real world.

<sup>211</sup> United Nations, "Sustainable Development Goals."

<sup>212</sup> Cabinet Office, Dai Go Ki Kagaku Gijutsu Kihon Keikaku 第5期科学技術基本計画 [The 5th Science and Technology Basic Plan].

<sup>213</sup> Harayama., "Society 5.0: Aiming for a New Human-centered Society", 8-13.

on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.” A lot has happened in the field of AI during the 60 years that have passed since the conference and even though AI has enjoyed success, disagreements remain. One such fundamental disagreement being, whether AI has to be probability based or logic based. These disagreements and obstacles can, of course, be tackled. But first, the situation as Marvin Minsky<sup>214</sup> expressed has to be changed. His main concerns being; projects being chosen on the basis of popularity and only success stories being published in the field. He also argued that for AI to be considered as a scientific field failures would also have to be published and shared.<sup>215</sup>

The transformation of the society as a consequence of advancements in AI is now coming closer to becoming a reality. Technological advancements have paved the way for research in replacing some purely intellectual activities; perception, recognition, reasoning, learning, decision making to name just a few. AI will be transforming It will be supporting humanity, enhancing daily activities and even decision making. AI will be creating new business opportunities, services, new standards in welfare, but this reality will hugely depend on the way it is implemented in real socioeconomic structures. The main difference AI has to earlier technologies is its ability to do things that were previously accepted to be only doable by humans.<sup>216</sup>

Another fundamental technology for the enhancement of the society is the Internet of Things (IoT). In the Merriam-Webster Dictionary, it is defined as “the networking capability that allows information to be sent to and received from objects

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<sup>214</sup> Marvin Lee Minsky (August 9, 1927 – January 24, 2016) was an American cognitive scientist concerned largely with research of AI, also co-founder of the Massachusetts Institute of Technology's AI laboratory.

<sup>215</sup> Moor, “The Dartmouth College artificial intelligence conference: The next fifty years,” 87–91.

<sup>216</sup> Cabinet Office, *Report on Artificial Intelligence and Human Society*.



and devices using the Internet.” The term first appeared at the beginning of the new millennium. In the beginning, it was used as a term to indicate a device able to connect to the internet, but in the last 20 years, since its inception, the term is becoming difficult to define as it has come to mean several things at once. At its core it is the technology that enables *things* to be part of the connection made available by the use of the internet, as such, it is called the Internet of Things. The International Telecommunication Union (ITU)<sup>217</sup> report of 2005 further discusses the possible development of IoT “...most of the traffic will flow between devices and all kinds of “things”, thereby creating a much wider and more complex “Internet of Things” ... if “things” become active internet users on behalf of humans, then the number of active connections could be measured in terms of tens or hundreds of billions. By connecting the world’s things, the internet would truly achieve ubiquity in every sense of the word.”<sup>218</sup> This is precisely what the Japanese plan to do; to connect ‘things’, people, and systems in cyberspace to obtain optimal results with the use of AI technologies. In this new digital era, some of the ‘things’ in IoT will obviously be robots or robotic machines,<sup>219</sup> and as they start being used in medical fields as well, their value for a society such as Japan, where the population ages and shrinks rapidly are immeasurable.

### 3.3 Japan’s “Robotic Revolution”

The swift decline in population, particularly in the working-age population coupled with the limited number of immigrants has pushed Japan to look for answers in automation, leading the way for a number of nations around the world, and in a way becoming a

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<sup>217</sup> ITU is the United Nations specialized agency for information and communication technologies – ICTs.

<sup>218</sup> The International Telecommunication Union, *The Internet of Things*.

<sup>219</sup> Fleisch, “What is the Internet of Things? An Economic Perspective.” , 125-157.

social laboratory to research what the future of work might look like.<sup>220</sup> When we talk about robots and robotics, the first place that comes to mind is Japan. Japan has been named Robotics Superpower, Robot Nation and has even been called The Land of Rising Robots<sup>221</sup> and the Japanese government means to profit from these depictions.<sup>222</sup>

Culture has of course been influencing Japan on its drive to become a ‘Robotic Power’, but more importantly, the economic reasons for this development cannot be ignored. The most important factor in this is the rapid growth of the Japanese automobile industry in the 1980s when Japan became one of the largest automotive manufacturers in the world. The automotive industry in Japan had already begun using industrial robots in the late 1970s, and this adaptation picked up pace in the 1980s with advancing robotic technologies. The robot manufacturers in Japan also began competing domestically with the increase in demand from the automakers, leading the robot manufacturers to also occupy a dominant position in global robot markets.<sup>223</sup> On a more historical and cultural note, Japan’s relationship with robotics can also be associated with its *monozukuri* (ものづくり) culture. Monozukuri is a term that is being used to describe Japan’s manufacturing industry, the *creation of things* to be precise. In recent years, the monozukuri culture has started being used when mentioning the robotic manufacturing industry as well.<sup>224</sup>

The concrete steps the Japanese government has started to take are in a way a built upon a cultural engineering that has been linking the historical popularity of automation machines like *Karakuri Ningyō* (からくり人形) of the Edo Period to the

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<sup>220</sup> The University of Tokyo, “Japan: The Land of Rising Robotics. Japan: The World’s Leading “Robot Nation.”

<sup>221</sup> The expression "Land of the Rising Sun" is used for Japan in most countries.

<sup>222</sup> Schneider et al, “Land of the Rising Robots.”

<sup>223</sup> Fujiwara, “Why Japan leads industrial robot production”.

<sup>224</sup> Kovacic, “The making of national robot history in japan: Monozukuri, enculturation and cultural lineage of robots,” 572 - 590.

present popularity of robots in Japan.<sup>225</sup> Another example of this attempt to normalize robotics technology can be seen in popular culture, when nationwide celebrations were prepared for the classic anime *Astro Boy*<sup>226</sup> in 2003. This, in some ways forced celebration was interpreted by historian Kenji Itō as an attempt to rekindle the “extreme optimism of science and technology” depicted in *Astro Boy*, in the postwar period of Japan.<sup>227</sup>

In the global market, Japanese companies such as Mitsubishi Electric Corporation<sup>228</sup>, Nachi- Fujikoshi Corp<sup>229</sup>, Fanuc Corp<sup>230</sup>, Kawasaki Heavy Industries<sup>231</sup>, Yaskawa Electric Corp<sup>232</sup>, Honda Motor Co.Ltd<sup>233</sup> and many more are playing key roles in the development of robotic technologies. However for Japan to deliver their robotic products all around the globe, it is imperative that their robotic technologies are part of an interconnected system with compatible software and hardware. The Japanese government is also adamant that there is a necessity for “internationally compatible regulations and a framework” in order to make it possible for widespread use of Japanese robots worldwide once the domestic requirements are fulfilled as the government states in its New Robot Strategy, “...we should take the lead to promote internationally accepted standards based on the strength of our technology and at the same time advocate further domestic standards to promote the use of robots in Japan.”<sup>234</sup>

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<sup>225</sup> Karakuri puppets are incredibly sophisticated traditional Japanese mechanized puppets or automata, originally made between the 17th century and the 19th century.

<sup>226</sup> *Astro Boy* known natively in Japanese as *Tetsuwan Atom* is a 1952 manga series written by Osamu Tezuka and was published by Kobunsha serialized in *Shonen* from April 3, 1952 until March 12, 1968.

<sup>227</sup> Ito, “Astroboy’s birthday: robotics and culture in contemporary Japanese society.”

<sup>228</sup> Mitsubishi Electric, “Factory Automation.”

<sup>229</sup> Nachi- Fujikoshi Corp, “Robots.”

<sup>230</sup> Fanuc Corp, “Robot.”

<sup>231</sup> Kawasaki Heavy Industries, “Kawasaki Robotics.”

<sup>232</sup> Yaskawa Electric, “Robotics.”

<sup>233</sup> Honda, “Honda Robotics.”

<sup>234</sup> Ministry of Economy, Trade and Industry, *Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン—* [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

The robots besides the industrial robots have not gained enough popularity as of yet, as a result of high prices and complicated maintenance. The government describes one way of solving these problems in its New Robot Strategy, as “...a strategy to promote modularization, the utilization of middleware or operating systems for robots, international standardization, and the creation of a common platform.” Traditionally the hardware and software are built specifically for that robot only, and are not reusable. This pushes the cost up for both the hardware and software as well as for the robot in question. If common parts could be used for a wide range of robots and robotic systems, the robots could be manufactured at a much lower cost, thus lowering their sale price. In order to achieve this, “standardization and commonization of interfaces between components both software and hardware” for all developers and manufacturers are crucial. “In the past, the de facto standard established by a handful of dominant corporations prevailed. However, de jure standards such as the ISO have gained ever more importance as the level of technological complexity has progressed. This has made de facto standards more difficult to establish as interest in the creation of international standards has grown in the rest of the world.” In the past, the standards were established after the product was already in the market, nowadays, especially in Europe, the companies incorporate standardization into their planning phase, cooperating with the academia, research institutions and other corporations as well. “Europe provides a case in point in that it is no longer sufficient to merely improve common parts accessibility, but to establish a national strategic perspective of securing the international competitiveness of our corporations involved in robotics and to lay a foundation that will lead the robotics industry into the next generation. As in Europe, it is important that

Japan tackle the issue of standardization that is integrated to and in parallel with its R&D efforts.”<sup>235</sup>

Global markets are expanding at an incredible rate, especially in the industry. According to the data that can be seen in Figure 14 of the International Federation of Robotics (IFR), the global industrial robot sales have doubled in just five years, between the years 2013 to 2017.<sup>236</sup> Meanwhile, Japan is worthy of being called the industry leader in the field of robotics as it continues to maintain a top place as an exporter in the world. As of 2012, Japan’s shipment of robotics approximated to around JPY 340 billion (US\$3,2 billion), accounting for nearly half of all global market share in robotics. The number of robotic units in operation in 2012 was near 300,000, which accounts for almost 25% of the overall market share.<sup>237</sup>

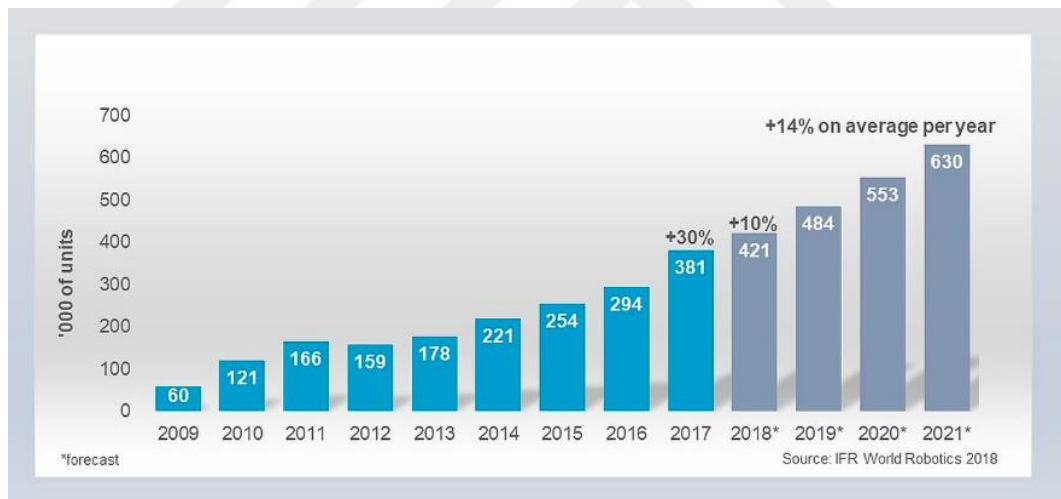


Figure 14. Estimated annual worldwide supply of industrial robots 2009-2017 and 2018-2021

Source: The International Federation of Robotics, “Robots: Japan delivers 52 percent of global supply.”

<sup>235</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>236</sup> The International Federation of Robotics, “Global industrial robot sales doubled over the past five years.”

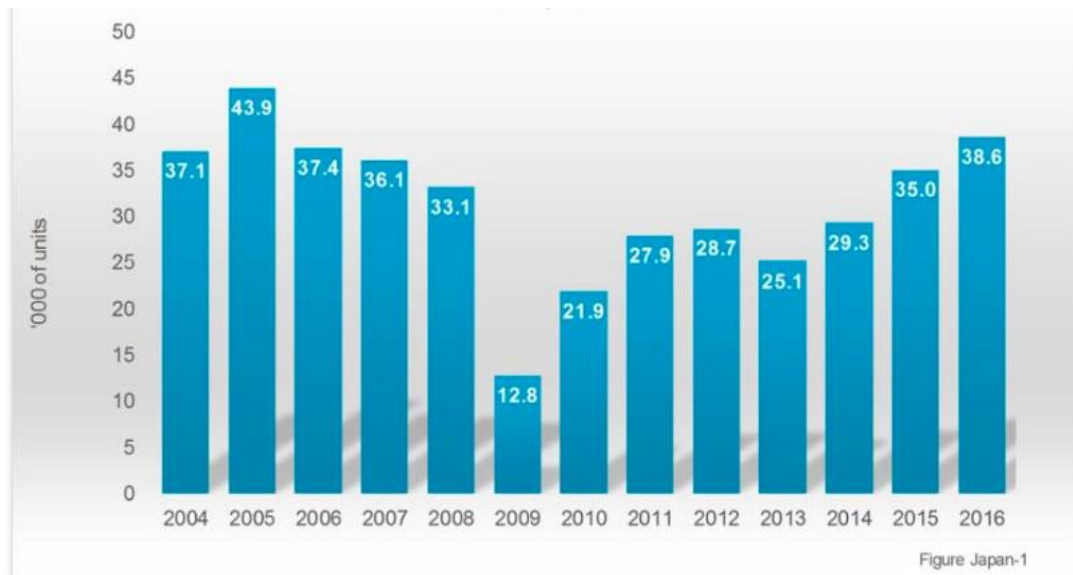
<sup>237</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

In 2016, the production capacity of robotic units by the suppliers in Japan had reached 153,000 units, the highest capacity ever to be recorded, as we can see in Figure 15. The same year Japan exported JPY 309 billion (US\$2,8 billion) worth of robotic machines, which was the highest volume of export for one year. The export rate also increased from %72 to %75 between the years 2011 to 2016. While the imports were only about %1 with foreign suppliers of robots not enjoying high sales in Japan. According to IFR, currently the Japanese are enjoying a leadership position regarding robotic technology with manufacturers with Japan supplying 52% of the global share in 2016 and increasing it to 56% in 2017.<sup>238</sup> Domestically as well, in 2016 robot sales in Japan has reached their highest for the last ten years. Japan takes great pride in being an industry leader, and the government has also realized the need to take concrete steps in order to preserve this position. As the President of the International Federation of Robotics (IFR) Joe Gemma describes it, “Japan is a highly robotized country where even robots are assembled by robots”<sup>239</sup>

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<sup>238</sup> The International Federation of Robotics, “Global industrial robot sales doubled over the past five years.”

<sup>239</sup> The International Federation of Robotics, “Robots: Japan delivers 52 percent of global supply.”



Robot sales in Japan reaching the highest level since 2006

Figure 15. Estimated annual supply of industrial robots in Japan.

Source: The International Federation of Robotics, “Robots: Japan delivers 52 percent of global supply.”

This financial leadership in robotics was something the Japanese have enjoyed for some time, but at the beginning of the 2010s, US’s newly created National Robotics Initiative<sup>240</sup>, and also new developments in Europe and China has made the Japanese government realize that this leading role in robotics is not for granted, has made the government to take action, making concrete plans and create new strategies to hold onto their position as the industry leader.<sup>241</sup> The need for improvement in robotic technologies was touched upon in the Priority Policy Program reports made by the Cabinet as early as 2006. In 2008, the Council for Science and Technology Policy created a road-map for a “project to accelerate the translation of research and development results into society.” The details of the project is a part of the Innovation

<sup>240</sup> Manufacturing USA. “National Robotics Initiative.”

<sup>241</sup> Robot Revolution Initiative, *Setsuritsu no shui to ikisatsu* 設立の趣意と経緯. (The Background and Purpose of Establishment.)

25 report.<sup>242</sup> Before this initiative, private companies handled the developments in medical technologies. “...the potential market for innovative solutions in ICT and robotic technologies for active ageing would be crucial for the Japanese economy and for other ageing societies.”<sup>243</sup> In these reports the emphasis is on how the robotic technologies can ameliorate the situation caused by the ageing of the population.<sup>244</sup> The frequency of robotic technologies being an important part of future plans for the government seem to have slowly increased. Until the process which is termed the ‘robotic revolution’ as it were, was started with the statement of Prime Minister Shinzō Abe in 2014 at the Organisation for Economic Co-operation and Development (OECD) Ministerial Council Meeting.<sup>245</sup> This was followed by the establishment of the Robot Revolution Realization Council on September 2014, in order to work towards the goal of realizing a New Industrial Revolution Driven by Robots, which was decided in the Japan Revitalization Strategy also in 2014.<sup>246</sup> By 2015, the Japanese government had published the report New Robot Strategy.<sup>247</sup> This was again followed by the establishment of Robot Revolution Initiative(RRI)<sup>248</sup> on May the same year, with 226 members at the time composed of associations, companies and individuals. By the end of 2017, the member count was close to 500.<sup>249</sup> In July 2015, the *Robotics Policy Office* was established by the Ministry of Economy, Trade and Industry (METI), in the Industrial Machinery

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<sup>242</sup> ““Innovation 25” is one of the promises made in the policy speech of the Abe administration. It is a long-term strategy initiative for the creation of innovation contributing to the growth with an eye on the year 2025. In order for the government to intensively promote the decision of “Innovation 25”, a minister in charge of innovation was established and Sanae Takaichi, the Minister of State was appointed as in charge, and the “Innovation 25 Special Mission” was set up within the Cabinet Office.” (Source: Cabinet Office, “Innovation 25”.)

<sup>243</sup> Tsuno et al., “Ageing in Asia—the Japan experience,” 12.

<sup>244</sup> Cabinet Office, *Priority Policy Program 2006*.

<sup>245</sup> Cabinet Office, “OECD Ministerial Council Meeting - Keynote Speech by Prime Minister Abe.”

<sup>246</sup> Cabinet Office, “Robot Revolution Realization Council.”

<sup>247</sup> Ministry of Economy, Trade and Industry, *Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン—* [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>248</sup> Robotto Kakumei Inushiatibu Kyougikai ロボット革命イニシアティブ協議会 . [Robot Revolution Initiative].

<sup>249</sup> Robot Revolution Initiative, *Gaiyō* 概要 (Outline).



Division of the Manufacturing Industries Bureau in their words to “...promote the proactive use of robots in various fields including the service field, and to drive the promotion of the robot industry.” The Robotics Policy Office was also launched for a supervisory role regarding the use of robots, international standardisation, and for establishing new rules.<sup>250</sup> In 2017 New Energy and Industrial Technology Development Organisation (NEDO) held the Strategic Advancement of Multi-Purpose Ultra-Human Robot and Artificial Intelligence Technologies (SAMURAI) Workshop. SAMURAI was based on the New Robot Strategy. The event was used to “...promote development of promising technologies for practical use, the event provided business matching opportunities for project contractors and companies that agreed to sign non-disclosure agreements.”<sup>251</sup>

There is also a radical transformation that is taking place in the global arena of robotics, and the Japanese government wishes to take advantage of. The days when robots were mindless automated machines, doing only routine and simple tasks are coming to an end. They are becoming “autonomous” with self-learning capabilities, initiative and creating interconnected networks with the advancements in Artificial Intelligence (AI) technologies and Internet of Things (IoT).<sup>252</sup>

The global trends are to increasingly use robotic technologies outside of manufacturing. Japan has also begun to follow this trend, and robotic technologies are now being used

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<sup>250</sup> Ministry of Economy, Trade and Industry, “Robotics Policy Office is to be Established in METI.”

<sup>251</sup> New Energy and Industrial Technology Development Organisation, “NEDO Held “Strategic Advancement of Multi-Purpose Ultra-Human Robot and Artificial Intelligence Technologies (SAMURAI) ” Workshop - Business Matching - Event.”

<sup>252</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

in various fields, such as aeronautics,<sup>253</sup> space exploration, medicine, nursing, welfare, disaster investigation, disaster mitigation and rescue.<sup>254</sup>

The Japanese robotics market is currently still dominated by robots made for industrial use, but the data in Figure 16 shows that by 2025 service robots will have taken over, and have the largest share in the robotics market.<sup>255</sup>

The start of using robots in varying fields in Japan, is a direct consequence of the labour shortages the country faces caused by the ageing and shrinking population.

Introducing robots to the sectors that are suffering from labour shortages is thought to be one way to alleviate the problem. Automation and the introduction of robotic technologies were never seen to be a threat to the Japanese employees, as most companies employed a lifelong employment scheme and even with rapid automation it was understood that the employees would retain their jobs.<sup>256</sup>

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<sup>253</sup> A science dealing with the operation of aircrafts.

<sup>254</sup> The University of Tokyo. “Japan: The Land of Rising Robotics. Japan: The World’s Leading “Robot Nation.”

<sup>255</sup> Orange Labs Tokyo, *Robot market overview*.

<sup>256</sup> Hornyak. *Loving the machine: the art and science of Japanese robotics*.

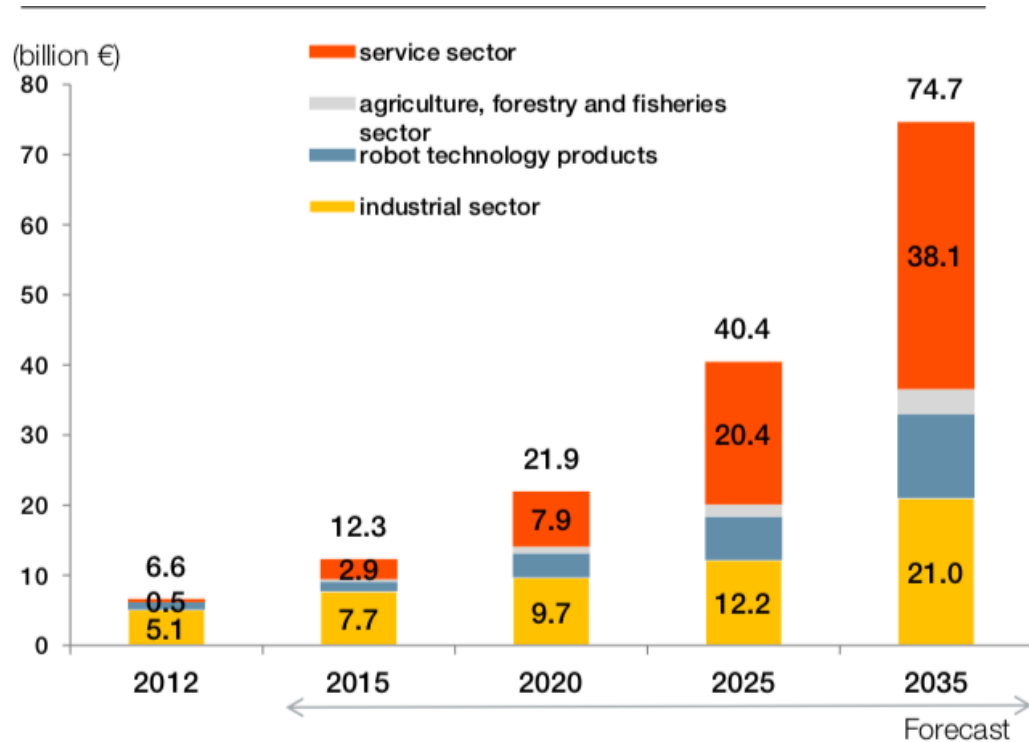


Figure 16. The robot market in Japan  
 Source: Orange Labs Tokyo, *Robot market overview*

The sectors which have the highest demand for robotic technologies are medical and nursing care, agriculture, logistics, service and non-manufacturing sectors. The food industry is also swiftly moving towards adopting robots. The stage of the utilisation of robots in these sectors varies, with some sectors such as logistics, having adopted robotics more easily than others. The automation of these sectors will require time, with some sectors achieving this automation more rapidly. The ease these sectors adopt automation and robotics is in some ways a product of the attitude the Japanese take towards robots, with most people thinking of them as partners. In the 2015 report, the New Robot Strategy the Japanese government has set clear goals on how to speedily adopt robotic technologies in sectors with low productivity with emphasis on nursing, agriculture and construction of infrastructure. The strategy to better adopt robots in a

variety of sectors also acts as a boost to the development of the domestic robot industry.<sup>257</sup>

The Japanese government has set some goals to be achieved by the Robot Revolution mentioned in the New Robot Strategy, the three main goals mentioned are; the transformation of daily items such as household appliances, automobiles and housing itself into robots with advanced sensors and AI technologies, secondly better utilisation of robots in manufacturing, as well as daily life, and lastly creating a societal environment where global competitiveness is reinforced in manufacturing and service fields. The government has also a set of objectives for the realization of the robot revolution, the first objective is to transform Japan into a global base for robot innovation, the second objective is to normalize the use of robots in daily life and become the best “society of robot utilization”, and the third objective is the “global development and expansion of the robot revolution” with the aim of acquiring international standards. The government also wishes to reform the machines with robotic capabilities used in daily life in accordance with the second objective and make them more “easy-to-use” for everybody. In order to accomplish this, the need for technological innovations, developments and environmental transformations are necessary to create next-generation robots fused with AI and easily used platforms that connect singular robots within an interconnected system. The creation of a “robot

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<sup>257</sup> Fujiwara, “Why Japan leads industrial robot production”.

barrier-free society”<sup>258</sup> society will also be crucial for a future where humans can coexist with robots in their daily lives.<sup>259</sup>

The Japanese are also attempting to create an environment where innovation is in the centre, and various opportunities are given to innovators, engineers and students. One such environment is the World Robot Summit (WRS), detailed in the *New Robot Strategy* held in Tokyo in 2018 as a pre-competition for the main event to be held in Aichi and Fukushima in 2020. WRS is promoted as a setting where the latest development in robots can be shown and helping the development of robotic technologies in sectors that have not adapted to the transition so well. The main theme for the WRS is “collaboration between humans and robots”. The competition attracted more than 1000 entries from more than 20 countries.<sup>260</sup> Moreover there are plans to expand the “Robot Award”, which has been implemented since 2006.<sup>261</sup> Currently there are five categories for the award; industry robot area,<sup>262</sup> service robot area,<sup>263</sup> public and special environment area,<sup>264</sup> parts and software area,<sup>265</sup> and robot business/social implementation area.<sup>266</sup> The government plans to evaluate the existing categories, and

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<sup>258</sup> “Despite rapid advancement of robots, some point out that there is a huge limit in what robots can do as compared to what a human can do to recognize and cope with diverse situations and therefore we should not expect a dramatic leap in robotics in mid-term. Having said that, it is crucial to meet the requirements for a society where humans and robots can coexist and cooperate on a daily basis for the maximization of robot capacities. Such kind of society can be called “robot barrier-free society” (New Robot Strategy)

<sup>259</sup> Ministry of Economy, Trade and Industry, *Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン—* [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>260</sup> Fujiwara, “Why Japan leads industrial robot production”.

<sup>261</sup> Co-hosted by the Ministry of Economy, Trade and Industry and the Japan Machinery Federation.

<sup>262</sup> “Robot and system that are used in production sites such as factories.” (New Robot Strategy)

<sup>263</sup> “Robot and system that provide various service at office, home, public space.” (New Robot Strategy)

<sup>264</sup> “Robot and system that operate under public and special environment, such as search and restoration in disasters and research in the sea.” (New Robot Strategy)

<sup>265</sup> “Parts, materials, or software that constitute part of robots.” (New Robot Strategy)

<sup>266</sup> “Manufacturers, businesses, and system integrators who have introduced and use robots to realize the service and social implementation of robots, or human resources that played a central role in such cases.” (New Robot Strategy)

add new categories if necessary, and redevelop it into an award which will be backed up by the government as a whole and not just relevant ministries.<sup>267</sup>

In addition to creating new competitions and award, the government is also taking a more direct approach with the creation of a robot project worth JPY 100 billion (US\$900 million) through both government and the private sector while providing readiness of the system and the environment by regulatory reform, and at the same time expanding the robot market.<sup>268</sup> Furthermore, to establish an area for field testing robots and drones the government is building a test field in Fukushima, which has partly opened in 2018 as the world's first test field for robots.<sup>269</sup> The Japanese government will also be increasing its support to companies that mainly work on care-robots for nursing purposes, as the labour shortages in the sector are becoming unmanageable with no solution on the horizon. Utilizing robots for helping the elderly or the disabled to walk, to bathe, or go to the toilet will aid the caregivers tremendously while easing the pressure from the labour shortage.<sup>270</sup>

We are on the brink of a new era, one that will be dominated by robotics and AI. The increase in robotisation is not confined in the manufacturing or industry anymore. The robots and the accompanying technologies are increasingly becoming part of our daily lives.<sup>271</sup> In order to cope with the possible problems that might arise, Robot Law is a rapidly developing field, as a new legal framework is needed to deal with any legal issues that might arise with the advent of this new era. In essence, robot law relates to robots and robotic technologies, algorithms, drones, robots used for surveillance

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<sup>267</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

<sup>268</sup> Ibid.

<sup>269</sup> Ministry of Economy, Trade and Industry, "Part of Fukushima Robot Test Field to Open."

<sup>270</sup> Japan Times, "Japan to increase support for firms developing caregiver robots."

<sup>271</sup> Danaher, "Robots, law and the retribution gap," 299.

purposes, driverless or intelligent cars, virtual reality<sup>272</sup> (VR) and augmented reality<sup>273</sup> (AR). The main issues robot law deals with are both legal questions and ethical questions concerning robots. Some pressing issues regarding this are, what will be the legal status of robots and will they have rights, who will be liable in the case of defective robots, protecting intellectual property, privacy protection issues with robots processing personal information.<sup>274</sup>

Robots are already handling a large amount of work, previously done by humans behind the scenes, they are manufacturing products, managing warehouses, and fighting wars. In the near future they will be doing deliveries, cooking meals and doing what are thought to be human activities.<sup>275</sup> These changes our societies are facing will have enormous social consequences along with moral and legal implications. The legal issues and potential repercussions of robots being a part of daily life have been contemplated by legal theorists as well as philosophers for some time now. There have been studies to identify the possible inadequacies the law may face with the rise of the robots. Most frequently these questions focus on liability; who should be held responsible in the case of a robot harming or injuring a human being.<sup>276</sup> And from time to time, more philosophical questions such as, should a robot be legally and morally responsible are asked.<sup>277</sup>

The laws regarding robots and AI technologies are newly developing, and as Nicolas Petit puts it, there can be an “...inconsistency between an innovation-adverse

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<sup>272</sup> An artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment. (definition taken from Merriam-Webster Dictionary)

<sup>273</sup> An enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera). (definition taken from Merriam-Webster Dictionary)

<sup>274</sup> Michalsons, “Robot Law is an emerging field of law.”

<sup>275</sup> Kaplan, *Humans need not apply*.

<sup>276</sup> Calo et al., *Robot law*.

<sup>277</sup> Purves, et al., “Autonomous machines, moral judgment, and acting for the right reasons.”

rule of strict liability on AI programmers on the one hand and an innovation-friendly legal framework that encourages computer scientists to work on AI through the allocation of subsidies, intellectual property (“IP”) rights and tax benefits on the other hand. Or consider a statute that confers dignity rights to robots. As part of such rights, a prohibition of torture would prevent to test how a robot reacts in stressful circumstances, and in turn undermine experimental research on the design of safer robots.”<sup>278</sup>

At times, the law takes some time to catch up with the technological advancements that have taken place, but in the end it does. The law takes some time to get used to new ideas, and how to incorporate them into existing laws. A similar period was experienced in the 1990s with the Internet becoming more and more mainstream. There were now unanswerable questions about jurisdiction, ownership and control, what ‘net neutrality’ should mean and of course privacy. To find solutions to these problems, legal academics rose to the challenge and developed *cyberlaw*. Robot technologies are on their way to create the new transformation, and with a main difference from the Internet, the robots are merging the question of information and privacy with the capability to cause harm physically.<sup>279</sup>

When approaching the regulation of robots and AI, two dominant patterns emerge. Legalistic and technological.<sup>280</sup> The first route begins within the legal system and draws a list of issues within the legal system which could be affected by robots and AI; privacy, cybersecurity, liability, etc.<sup>281</sup> The second route tries to predict legal issues that might arise from the application of new technologies; intelligent cars, social robots,

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<sup>278</sup> Petit, “Law and Regulation of Artificial Intelligence and Robots,” “2.

<sup>279</sup> Calo, “Robotics and the lessons of cyberlaw,” 514-515.

<sup>280</sup> Petit, “Law and Regulation of Artificial Intelligence and Robots,” 2.

<sup>281</sup> De Cock Buning et al., “Mapping the Legal Framework for the introduction into Society of Robots as Autonomous Intelligent Systems.”



exoskeletons, etc.<sup>282</sup> A third approach to regulating the laws about robots and AI, differentiates between robolaw and robot ethics. Robot ethics mainly focuses on the appropriateness of their utilisation, in some ways like the three laws of robotics; “A robot may not injure a human being or, through inaction, allow a human being to come to harm. A robot must obey orders given it by human beings except where such orders would conflict with the First Law. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.” created by Isaac Asimov.<sup>283</sup>

Whereas robolaw mainly focuses on the external implications of robots’ actions, the execution stage once robots are brought in into society<sup>284</sup>.<sup>285</sup> There is another field of ethics in robotics; machine ethics. It is a more speculative field, as it considers the actual behaviour of advanced robots. The future where the robots might have self awareness and the capability for moral judgement, thus can be judged according to their actions.<sup>286</sup>

There is a need to create a legal system that is not too lenient nor too restrictive, so as not to slow down the innovation processes. An additional problem that comes out when creating a legal framework about robots is the issue of retribution. Humans crave retribution when they or people close to them are harmed.<sup>287</sup> The robotization of society will make it likely that robots will be responsible for harming humans, but they will not meet the conditions for retribution. The retribution gap might generate social and legal ramifications, which the legal academics should keep in mind when creating the laws on robotics.<sup>288</sup>

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<sup>282</sup> Palmerini et al., “RoboLaw: Towards a European framework for robotics regulation.”

<sup>283</sup> Asimov, "Runaround", Astounding Science Fiction 1942.

<sup>284</sup> There also seems to be some sociological ramifications. Where Robolaw seems primarily a field populated by lawyers, robot ethics also consists of philosophers, ethicist, psychologists, computer scientists and novelists.

<sup>285</sup> Petit, “Law and Regulation of Artificial Intelligence and Robots.”

<sup>286</sup> Anderson et al., “Machine Ethics: Creating an Ethical Intelligent Agent.”

<sup>287</sup> Jensen, “Punishment and spite: The dark side of cooperation.”

<sup>288</sup> Danaher, “Robots, law and the retribution gap,” 299.

The UN has also joined in on the development of a legal framework concerning AI and robotics, as they agree that along with the beneficial developments these new technologies will bring, they also raise some concerns about safety and security. The technologies themselves, especially robotics have the innate capability for physical harm, but there are also considerations about the using of force autonomously, algorithm bias,<sup>289</sup> black boxes in decision making,<sup>290</sup> privacy issues and certainly the danger of criminals or terrorist misusing the technology. To approach these issues in 2015, the United Nations Interregional Crime and Justice Research Institute (UNICRI) commenced its programme on robotics and AI, to educate the people in the field, and especially the policy makers. Following this in 2017, with the assistance of the Municipality of the Hague and the Ministry of Foreign Affairs of the Netherlands UNICRI opened the Centre for Artificial Intelligence and Robotics. The centre is mainly committed to recognizing, focusing on and educating about the dangers and advantages of AI and robotics, in the context of crime and security. To achieve success UNICRI has created a vast international network.<sup>291</sup>

It is universally acknowledged that, for mainstream acceptance of robotic technologies and AI in general society and to safely include them in daily life, one main problem to consider is the legal issues regarding the clarification of responsibility. One frequently used example is the problem of autonomous cars. While the use of autonomous cars, or intelligent cars, lead to a decrease in traffic accidents, the problem emerges if and when one such car creates an accident. To whom does the responsibility belong to when such an accident occurs. For a wider implementation of smart cars,

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<sup>289</sup> Algorithm bias, also known as machine learning bias or AI bias, is a phenomenon that occurs when an algorithm produces results that are systematically prejudiced due to erroneous assumptions in the machine learning process.

<sup>290</sup> When AI makes decisions that humans can not understand, or follow the thought process.

<sup>291</sup> United Nations Interregional Crime and Justice Research Institute, “Artificial Intelligence and Robotics.”

robotic technologies and AI in general into a society; there has to be a clear understanding of the placement of responsibility for accidents, risks, privacy and rights issues, as well as achievements and benefits. This will also be crucial in helping businesses to not overreact or become intimidated because of risks to their reputation or economic burdens.<sup>292</sup>

Another heatedly debated topic concerning responsibility is the issue of autonomous weapon systems (AWS), which will in the near future, with advancements in AI technologies will have the capability to decide on matters of life and death ‘on their own’. The main argument is, AWS or robots in general cannot reproduce ‘human moral judgement’. In the article “Autonomous machines, moral judgment, and acting for the right reasons” moral judgement is defined as “...(it) requires either the ability to engage in wide reflective equilibrium, the ability to perceive certain facts as moral considerations, moral imagination, or the ability to have moral experiences with a particular phenomenological character.” As robots do not possess these characteristics, it is not morally acceptable to deploy the AWS’s. Following the responsibility argument, the deployment of AWS would bring about what is called the *responsibility gaps*.<sup>293</sup> An example of this issue was argued by Robert Sparrow, where he argues, if an AWS makes a mistake in the battlefield and kills a civilian, to whom does the blame go to, as no one could be legally held responsible; not the robot, the commander, the programmers, etc. Which would result in a responsibility gap, making the deployment of AWS morally dubious. Following through with this objection, it is important to distinguish between weaponized and non-weaponized autonomous technologies, such as autonomous cars, so as not to obstruct the advancements in technology and innovation.<sup>294</sup>

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<sup>292</sup> Cabinet Office. *Report on Artificial Intelligence and Human Society*.

<sup>293</sup> Purves, et al., “Autonomous machines, moral judgment, and acting for the right reasons.”

<sup>294</sup> Sparrow, “Killer robots.”

Another significant issue in the legal arena is privacy protection. As the advancements made in the AI field and consequently in the robotics field are highly reliant on data. Their usefulness relies on their ability to exploit and use big data. To avoid what may feel like an invasion of privacy, it is imperative to create institutional frameworks. Access rights of personal data, portability of data, and security issues related to international corporations are some of the main concerns around privacy. And the use of this technology boosts the creation of high-value and high-profit products. It is important to recognize the issue of ownership, to whom does the property rights belong to a creation or a model made by AI. Moreover, to utilize and facilitate further development, there have to be clear guidelines to protect developers and users of algorithm, and also data providers as the protection of the creative rights is another issue the legal frameworks on AI and robotics are working on.<sup>295</sup>

The global policies are moving forward with trying to solve the issues created by the new technologies of AI and robotics. Japan, named as a Robotics Superpower, is also transforming its policies to create a more technology friendly legal system. Examples like the Radio Act<sup>296</sup>, Road Traffic Act and Road Transport Vehicle Act<sup>297</sup> clearly shows that the Japanese are eager to solve possible legal issues that might arise, and create solutions with new introductions to technology. There are also changes made in order to make it easier for the use of new technologies in the medical field. The Act on Securing Quality, Efficacy and Safety of Pharmaceuticals, Medical Devices, Regenerative and

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<sup>295</sup> Cabinet Office. *Report on Artificial Intelligence and Human Society*.

<sup>296</sup> The establishment of rules aimed at robot utilization such as frequency allocation and regulate maximum permitted power.

<sup>297</sup> The sorting-out of legal position of vehicles equipped with robotic functions.

Cellular Therapy Products, Gene Therapy Products, and Cosmetics is one example of this new transformation.<sup>298</sup>

The future that the Japanese government wishes to achieve is deeply connected to the new societal scheme, called Society 5.0, where technological advancements will relieve humans from routine daily tasks and make way for a higher quality of life. This will be notably significant in nursing and medicine sectors, as the population ages and labour-shortages become even more prevalent due to decreased fertility. The routine tasks being managed by the robots and robotic technologies will allow for better quality nursing-care and advanced medical-care for every individual.<sup>299</sup> And this future will only be made possible if the necessary legal adjustments are made, and the system as a whole becomes more innovation friendly.

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<sup>298</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

<sup>299</sup> Ibid.

## CHAPTER 4

### ROBOTICS AND AGEING WELL IN JAPAN

Around the globe, the utilisation of robotic technologies in the medical field and the development of said technologies is rapidly going forward. The Japanese government has also expressed its intention of supporting the development of robotics in the medical field as well.<sup>300</sup>

#### 4.1 Robots in healthcare

There are some robotic technologies which are being used at the moment in hospitals and other medical institutions. The technologies include; robot assisted surgery, actuated and sensory prostheses for amputees,<sup>301</sup> endoscopy-bots for easier procedures, exoskeletons, targeted therapy micro-robots for tumours, disinfectant bots, clinical training bots, robotic nurses for relieving human nurses of menial tasks, antibacterial nanorobots and many more.<sup>302</sup>

Japan has also been researching robotic technologies in the context of healthcare and the medical field. Mitsubishi Harada Laboratory affiliated with the University of Tokyo, has a list of one of the most versatile research projects in Japan. Their projects include; Cutting Tools for Biocompatible Bone-Cutting, Robot assisted repositioning of bone fractures, Robot assisted hand surgery, Microsurgical Robotic System for

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<sup>300</sup> The University of Tokyo, "Japan: The Land of Rising Robotics."

<sup>301</sup> "At the MIT Biomechatronics lab, researchers have created gyroscopically actuated robotic limbs that are capable of tracking their own position in three-dimensional space and adjusting their joints upwards of 750 times per second." ( Tomlinson, "15 Medical Robots That Are Changing the World.")

<sup>302</sup> Tomlinson, "15 Medical Robots That Are Changing the World."

Neurosurgery, Eye Surgical Robotic Systems, Surgical Robotic System for Minimally Invasive Knee Arthroplasty and Tele-operative Laparoscopic Surgical System.<sup>303</sup>

Particularly, the widespread use of minimally invasive “precise-motion surgical robots” and similar technologies such as surgical assistants will be lessening the burden on the patient, and especially on older patients and hasten their recovery.<sup>304</sup> Contrary to traditional surgery, where large incisions are made to operate on the patient, in minimally invasive surgeries can be completed with small incisions. While this type of surgery lessens the burdens on the patients, it is much more difficult than a conventional surgery for the doctors as they have to work within a smaller area thus puts more pressure on the doctors.<sup>305</sup> These surgical robots are being utilised in a number of medical institutions but the government aims to further spread the use of such technologies.<sup>306</sup> To ensure the swift utilisation of these technologies the Japanese government states in its New Robot Strategy;

Technical evaluation indexes, etc., utilized at the time of review of novel medical device that is needed at many medical sites and is very feasible will be formulated and publicized in advance in order to enhance the efficiency of product development and shorten the time required for approval review. At the same time, the pre-market approval review of brand-new medical device, including that utilizing robot technology will be smoothly conducted. The targets of standard total review period from the receipt of application of brand-new medical device to its approval are to become 14 and 10 months for normal review item and priority review item, respectively.<sup>307</sup>

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<sup>303</sup> Mitsubishi Harada Laboratory. “Research Topics.”

<sup>304</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>305</sup> The University of Tokyo, “Japan: The Land of Rising Robotics.”

<sup>306</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>307</sup><sup>307</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

In accordance with the government's 2020 goals, the Japanese startup company Riverfield is aiming to develop a cheaper robotic surgeon than the industry leader American company Intuitive Surgical.<sup>308</sup> Figure 17 shows the robotic surgeon Emaro, developed by Riverfield.



Figure 17. Riverfield’s robotic surgeon Emaro  
Source: Riverfield Inc, 空気圧駆動型 内視鏡ホルダロボット EMARO Kūkiatsu kudō-gata naishikyō horudarobotto [EMARO Pneumatic Endoscope Manipulator Robot]

The future holds even more advanced robotic technologies which will enable “high precision and high accuracy” surgeries for areas difficult or sometimes even impossible for human hands to access, or on tissue areas behind organs and remotely performed surgery; tele-surgery. The manufacturing of medical robotic technologies utilises

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<sup>308</sup> Nomura, “Japanese firm's robotic surgeon to hit market by 2020.”



“manufacturing engineering, robotics and AI technology”. There is continued research in the sector in fields such as “neurosurgery in deep parts of the brain and for eye surgery, for tele-surgery system, for joint replacement system, and for HIFU (high intensity focused ultrasound) system.”<sup>309</sup>

There are also advancements in the use of robotic technologies in rehabilitation. In a paper co-authored by Kenneth Lo in 2019, the economic costs of utilisation of robotic technologies on stroke patients to reduce disabilities was studied. Their study shows that, while the benefits are clear, there is still the economic cost to consider;

Our review indicated that robotic therapy had a better economic outcome than conventional therapy. For patients with severe disability from significant stroke, a moderate dominance favoring robotic therapy for health benefit was found, and a strong dominance for robotic therapy for cost benefit was found ... Key sensitivity factors affecting robotic therapy were the number of patients who could be treated per robotic session and the time therapists spent with patients during a robotic session. Robotic therapy could be prescribed primarily for patients with severe impairment after stroke. To maximize the cost economics, hospital providers may wish to organize their robotic therapy programs based on cost-sensitivity factors.<sup>310</sup>

#### 4.2 Robots in elderly care

The estimated shortage of nurses and care-workers by 2025 in Japan is 377,000.<sup>311</sup>

While other independent researchers give an even higher number at 500,000.<sup>312</sup> While there has been an increase in their number as it can be observed in Figure 18, this

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<sup>309</sup> Mitsuishi, “Medical Robotic System.”

<sup>310</sup> Lo et al., “The economic cost of robotic rehabilitation for adult stroke patients: a systematic review”

<sup>311</sup> Ministry of Health, Labour and Welfare. 2025 Nen ni Muketa Kaigo Jinzai ni Kakaru Jukyū Suikei (Kakuteichi) ni Tsuite. 2025年に向けた介護人材にかかる需給推計（確定値）について。 [Supply and Demand Estimation for Care Workers in 2025 (Final Value)].

<sup>312</sup> Emont, “Japan Prefers Robot Bears to Foreign Nurses.”

increase will not be enough to deal with the increase in the number of elderly in need of care.<sup>313</sup>

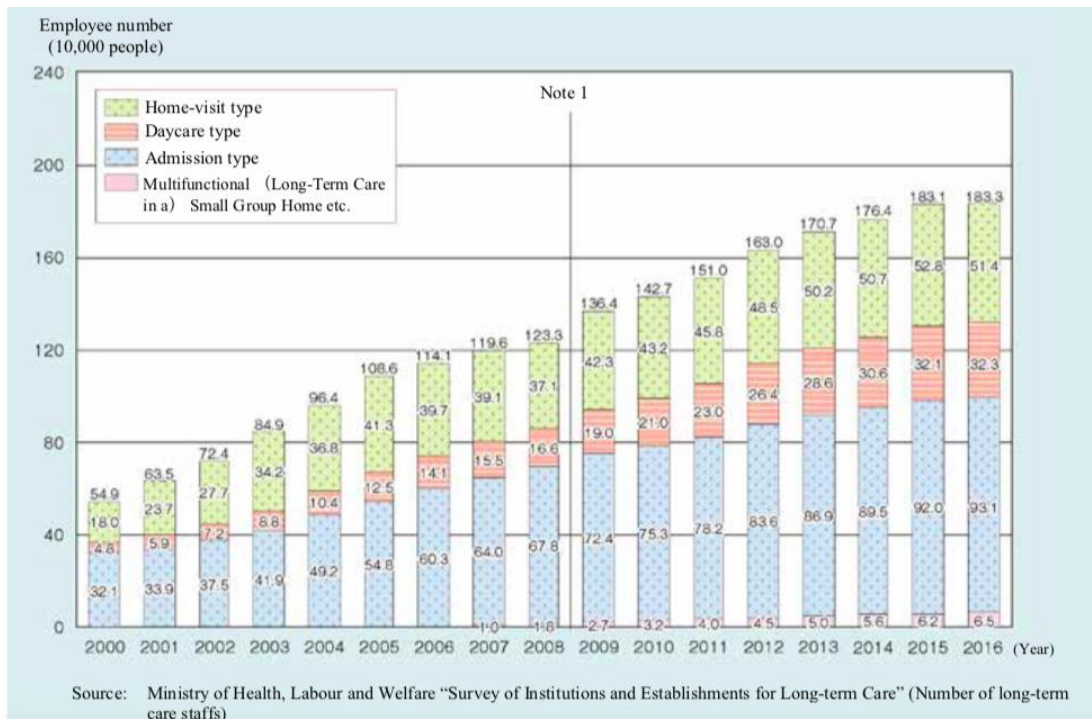


Figure 18. Changes in the number of long-term care staff  
Source: Cabinet Office, *Annual report on the aging society:2018*

In its New Robot Strategy, the Japanese government expressed the basic policy regarding the nursing and medical field as “Creating safe and stable work environments will be pushed forward by using robots that aid the aged to lead self-sustaining lives by helping them move around when they go out so that they can live in a region to which they are accustomed, even though they need care, and by introducing to medical sites the nursing robots that mitigate the physical burdens of care workers by making it easy for those who they look after to transfer.”<sup>314</sup> It is clear that the government has realised that the manpower is not enough to take care of the steep increase in the elderly without

<sup>313</sup> Ministry of Health, Labour and Welfare. 2025 Nen ni Muketa Kaigo Jinzai ni Kakaru Jukyū Suikei (Kakuteichi) ni Tsuite. 2025年に向けた介護人材にかかる需給推計（確定値）について。[Supply and Demand Estimation for Care Workers in 2025 (Final Value)].

<sup>314</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

outside help and as a result of the immigration policies in Japan, they are turning to the only viable solution to this problem, robotic technologies.

The robots in the nursing field are, to some degree to replace the foreign labour; which is not plenty to begin with as a result of strict policies, restrictions and difficult exams to pass to work in the nursing field in Japan. There have been guest-worker programmes to allow nurses and care-workers from Indonesia and the Philippines, but these cannot resolve the shortage as very few are allowed. This situation has led the Japanese government to demand faster results for nursing technologies. To further incentivize the companies the government is offering up to JPY 2.4 billion (US\$22 million) in assistance to developers who aim to reduce the price of care robots; with per robot.<sup>315</sup>

The potential benefits to mixing human care workers with robotic technologies are great, not only will they be able to help with the shortages, but the technologies will also provide assistance and share the burden of the care workers and nurses who are currently under pressure as a result of the stressful nature of their work coupled with insufficient human capital. As Perry Share expresses it, “...the technologisation of care is on the agenda for policy and practice.”<sup>316</sup> There are Assistive Technologies (ATs), which are mostly used in managerial and administrative works, such as mobile technologies, screen readers.<sup>317</sup> Assisted Living Technologies (ALTs) are usually more sophisticated than ATs, consisting of telecare, telehealth, smart houses, and even social

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<sup>315</sup> Weeën, *Robotics in Japan*.

<sup>316</sup> Share, et al. Preparing for a robot future? Social professions, social robotics and the challenges ahead.

<sup>317</sup> Wynne et al., *Assistive Technology/Equipment in Supporting the Education of Children with Special Educational Needs—What Works Best?*

robots.<sup>318</sup> With examples like meal assistance robots, such as My Spoon developed by Secom ALTs will be helping the elderly more and more in the future.<sup>319</sup>

ALTs such as telecare, telehealth and “digital participation services” are designed for people living at home. David Lewin express the purpose for such technologies as, “Deliver better and more cost effective social and health care into the homes of older and disabled people – enabling them to live at home longer.”<sup>320</sup> These technologies have created a self-monitoring trend based on the new health and daily life monitoring tech available and have led to what Deborah Lupton calls “the quantified self” in sociological studies.<sup>321</sup>

The technologies, some of which are brand new and some that have been used for some time, but the implications of a tech-heavy care-sector is not yet fully understood nor is everybody clear on its potential,<sup>322</sup> or effects the technological developments will have on the psychology of the elderly or on their daily lives.<sup>323</sup>

There is also a new kind of healthcare system that has been proposed by Yoshihiko Takahashi for health monitoring, by utilizing a simplified robot face with categorized facial expressions. The new system is described in their paper:

Patient’s health care data can be stored in a personal computer and a robotic system can take many actions depending on the stored data. It can tell a patient what time to take his/her medication and warn them if they fail to take their medication at the appropriate time. The robotic system can communicate with a patient using facial expressions, a voice communication system and a personal computer monitor. The robot face was designed using simple mechanisms in order to achieve a low-cost system.<sup>324</sup>

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<sup>318</sup> Wigfield et al., “Assisted Living Technology in social care: workforce development implications”

<sup>319</sup> Secom. Mai Supūn Shokuji Shien Robotto マイスプーン食事支援ロボット[My Spoon Meal Assistance Robot], For the related image, see Appendix, Figure A1.

<sup>320</sup> Lewin, et al., “Assisted living technologies for older and disabled people in 2030,” 2.

<sup>321</sup> Lupton, *The quantified self: Sociology of self-tracking*.

<sup>322</sup> Wada et al., “Living with seal robots—its socio psychological and physiological influences on the elderly at a care house.”

<sup>323</sup> Obayashi et al., “Socially Assistive Robots and Their Potential in Enhancing Older People's Activity and Social Participation.”

<sup>324</sup> Takahashi, “Facial expressions of simplified robot face for health care system,” 163.

It is clear that robotic technologies will make monitoring the health and well-being of the elderly patient easier, while decreasing the strain on the caregiver. As Costantino Grasso puts it; “Robots can be extremely helpful in continuous monitoring of patient and data collection for emergency cases like heart failure and diabetes and then relay such data to a human nurse or doctor for action to be taken.”<sup>325</sup>

In 2011, the Ministry of Health, Labor and Welfare conducted a survey Project for Helping Putting Welfare Equipment and Nursing Robots into Practice, in order to find the needs of nursing facilities and care-workers. 220 nursing facility managers and care-workers were contacted and, the ministry decided on the most important fields to enhance and which problems could be solved with robotic technologies.<sup>326</sup> By 2017, the nursing-care homes which were testing robots for nursing purposes had gone up to 5000.<sup>327</sup> The important fields in need of development and pursued in order to solve the problems in nursing fields were selected as “...transfer support (wearing type), transfer support (non-wearing type), transfer support (outdoors), transfer support (indoors), excretion support, watching over those who have dementia (for institution), watching over those who have dementia (for home), bathing support.” The care-workers needed help with transferring and baths, with watching over elderly with dementia, and just helping the elderly live their daily lives as, 70% of nursing care-workers reported to suffer from backaches.<sup>328</sup>

The forecasts of Japanese robotics markets are similar for both the NEDO and METI, both report that while the current market is still dominated by industrial robots,

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<sup>325</sup> Grasso, “Challenges and advantages of robotic nursing care: a social and ethical analysis.”

<sup>326</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

<sup>327</sup> The Economist, “Japan is embracing nursing-care robots”

<sup>328</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

there is expected to be an increase in utilizing robotics in the fields of nursing care and welfare. Upon observing Table 4 it is possible to see the projected increase in the demand for nursing care robots, with a projected market share of JPY 404,3 billion (US\$3,7 billion) by 2035.

For further development of the robotic technologies to be used in the nursing field, specific requirements will be determined to develop better suited technology, and research into the field will be continued to be supported by the government. Concerning the continued research and development of robotic technologies in nursing the field, as stated in the New Robot Strategy, “a study of items covered by the nursing-care insurance system will flexibly be promoted in order to keep abreast with the technological innovation of nursing robots and smoothly alleviate the workload of home health care.” The care-robots will also be utilized to prevent people from needing care in the first place and in the rehabilitation field.<sup>329</sup>

Table 4. Sales value of service robots meant for nursing care and human assistance from 2015 to 2035 in JPY billion

<b>Nursing care robot for</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2035</b>
Independence support	JPY 13.4 bn	JPY 39.7 bn	JPY 82.5 bn	JPY 220.6 bn
Care and assistance	JPY 3.3 bn	JPY 14.6 bn	JPY 41.4 bn	JPY 183.7 bn
<b>Service robots for</b>				
Movement support (professional use)	JPY 5.0 bn	JPY 116.2 bn	JPY 619.0 bn	JPY 675.9 bn
Movement support (personal use)	JPY 2.1 bn	JPY 49.8 bn	JPY 265.3 bn	JPY 289.7 bn
Watching over, protection, communication	JPY 0.3 bn	JPY 1.1 bn	JPY 3.6 bn	JPY 34.1 bn

Source: Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-.”

<sup>329</sup> Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]

Robots will not be replacing human nurses or care-workers any time soon, and the government's plans are not to replace humans but rather lighten their workload. Grasso explains it;

When compared to humans, robot nurses are quicker to train, cheaper to maintain, easier to refuel and repair, and able to do very odd and repetitive tasks. Robotic nurses can do most of the boring and dangerous nursing jobs that may also result in the occupational exposure of human nurses to hazardous infections or chemicals ... Also, the use of robots may allow providers to offer their healthcare services at a lower cost.<sup>330</sup>

One example of nursing-care robots is a delivery robot made by Panasonic. The

Autonomous Delivery Robot - HOSPI(R) - has received ISO 13482;<sup>331</sup> standards for safety requirements for personal care robots, in accordance with the government's wishes to have globally accepted robots. Panasonic's "HOSPI(R)" is able to;

...autonomously deliver items such as pharmaceuticals and specimens in hospitals on behalf of hospital staff. Because the robot can maneuver around based on pre-programmed maps and by recognizing the surrounding environment with sensors, it is no longer necessary to embed wires, sensors etc. into the walls and ceilings or to place electromagnetic tapes on corridors. Even if there is a change in destination or layout, such information can be updated easily and at low cost. Also equipped with high performance sensors and collision-avoidance algorithm, the robot can move about safely and efficiently without colliding into passersby or various objects along its route.<sup>332</sup>

The aim of the Japanese government regarding this is stated in the New Robot Strategy report as "...work environments where nursing workers can provide services with satisfaction will be created by making the best use of robotic nursing equipment while maintaining the basic concept that care is given by human hands, and a paradigm shift to enhancing the work efficiency and reducing the number of workers will be aided by the use of robotic nursing equipment at care sites."<sup>333</sup> When the utilisation of robots in the

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<sup>330</sup> Grasso, "Challenges and advantages of robotic nursing care: a social and ethical analysis."

<sup>331</sup> ISO, *Robots and robotic devices — Safety requirements for personal care robots*.

<sup>332</sup> Panasonic, "Panasonic's Autonomous Delivery Robot - HOSPI(R) - Receives the International Safety Standard ISO 13482 as well as the First Certification under the New JIS Safety Standards."

<sup>333</sup> Ministry of Economy, Trade and Industry, *Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン—* [New Robot Strategy. Japan's Robot Strategy - Vision, Strategy, Action Plan]

nursing field is being discussed, it is imperative to understand the people's acceptance and willingness to use the robots.

A survey handled by the Cabinet Office, surveying whether or not people would be open to utilizing care robots for long-term care, that can be seen in Figure 19 shows that 59,8% of people answered either “I would like to use” or “I would rather use it” as a caregiver to a long-term care patient. The response was even higher at 65.1% for when receiving long-term care. These answers demonstrate that people are open to using care-robots in the nursing field and in the elderly care field.<sup>334</sup>

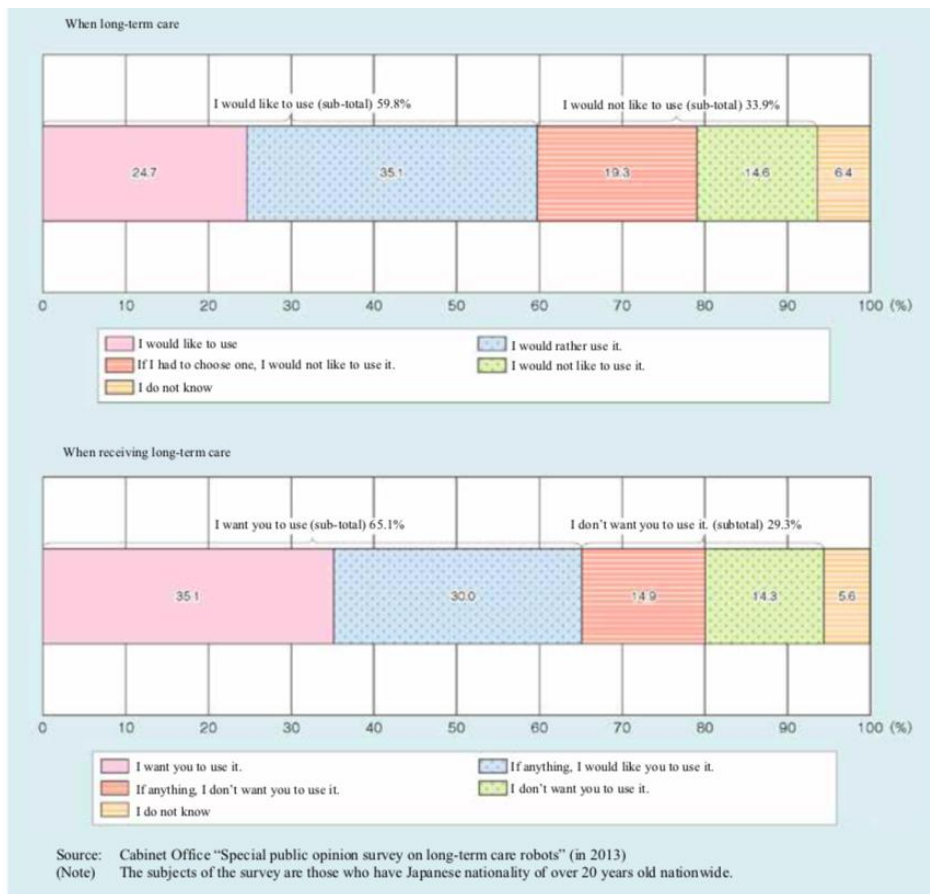


Figure 19. The intention to use long-term care robots  
 Source: Cabinet Office, *Annual report on the aging society:2018*

<sup>334</sup> Cabinet Office, *Annual report on the aging society:2018*.



There are different types of robots that can be categorized as care robots; “mobile servant robots that is capable of travelling to perform serving tasks in interaction with humans, such as handling objects or exchanging information”, “physical assistant robots that physically assists a user to perform required tasks by providing supplementation or augmentation of personal capabilities” including “restraint type physical assistant robot that is fastened to a human during use<sup>335</sup>” and “person carrier robots with the purpose of transporting humans to an intended destination” are listed as personal care robots on The ISO site.<sup>336</sup> Continuing this, in a report for EU-Japan Centre for Industrial Cooperation Dana Neumann adds, “monitoring robots for monitoring patients and/ or the elderly, supply of care at home utilising tele-care,” “companion robots for stimulating patients with cognitive disorders, encouraging social behaviour and eliciting emotional responses” and “care facility logistics robots for improving the working environment, optimising the workflow, being highly collaborative with staff” to the different categories of care robots.<sup>337</sup>

In its New Robot Strategy of 2015, the Japanese government asks the question “Is it possible to increase the frequency of conversation and outdoor activities through utilization of science and technology?” Robotic wheelchairs which use sensor and network technologies will help the elderly to move more freely indoors and even outdoors, giving them some independence while ensuring their safety. In addition to wheelchairs there are also;

...walking assistant robots, walking frames or exoskeletons and these kinds of walking aids ...can make patients feel much more comfortable and in control. Instead of being supported and led by several caregivers they can engage more

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<sup>335</sup> “Wearable suits or non-medical exoskeletons for physical assistance.” (Neumann)

<sup>336</sup> International Organization for Standardization, *Robots and robotic devices — Safety requirements for personal care robots*.

<sup>337</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-.”

actively in the process of recovery, which not only means more independence but also less stress both for patients and caregivers.<sup>338</sup>

Due to the growing number of people in need of care, demand for technologies such as exoskeletons, and other such walking-aids have a growing market. There are different approaches to exoskeletons; devices for rehabilitation is one of them. Other applications for exoskeletons as augmentation for able-bodied people and support for the disabled or physically challenged people.<sup>339</sup>

In their article “Development of power assisting suit for assisting nurse labor,” Keijiro Yamamoto explains one such device for exoskeletons as augmentation for able-bodied people;

The power assisting suit consists of shoulders, arms, waist and legs made of aluminum, and is fitted on the nurse body. The power assisting suit is originated with the concept of a master and slave system in one body. The arms, waist and legs have the pneumatic rotary actuators. The pneumatic rotary actuators are constructed with pressure cuffs sandwiched between thin plates. The action of the arms, waist and legs of the nurse are sensed with the muscle hardness sensor utilizing load cell with diaphragm mounted on a sensing tip. The dent of the sensing tip corresponds to the hardness of the muscle so that exerting muscle force produces electric signal.<sup>340</sup>

Following the trend of developing exoskeletons, or “power assist suits” as they are called in this study, Chiharu Ishii presents a new and easier to use exoskeleton that can be seen in Figure 20:

...a new power assist suit of a simple structure which attached an artificial muscle to the back of the overalls was developed for a transfer work in nursing care. The developed assist suit is lightweight and inexpensive as compared with the other assist suit. It is about 2kg. In addition, the caregiver can wear and remove the assist suit without taking a time.<sup>341</sup>

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<sup>338</sup> Ibid.

<sup>339</sup> Hamaya et al., “Learning assistive strategies for exoskeleton robots from user-robot physical interaction,” 67.

<sup>340</sup> Yamamoto et al., “Development of power assisting suit for assisting nurse labor,” 703.

<sup>341</sup> Ishii et al., “Development of a new type of lightweight power assist suit for transfer work,” 213.



Fig. 3. Power assist suit with one artificial muscle



Fig. 4. Power assist suit with two artificial muscles

Figure 20. Example image of power assist suit

Source: Ishii et al., “Development of a new type of lightweight power assist suit for transfer work”

Another such technology is from a joint project of Cyberdyne and University of Tsukuba, HAL (Hybrid Assistive Limb), can be seen in Figure 21. First developed in 2004, with earlier prototypes going back to 1997, but Dr. Sankai had in fact been working on this since 1991.<sup>342</sup>

<sup>342</sup> Lazarte, “Enter the first cyborg-type robot.”

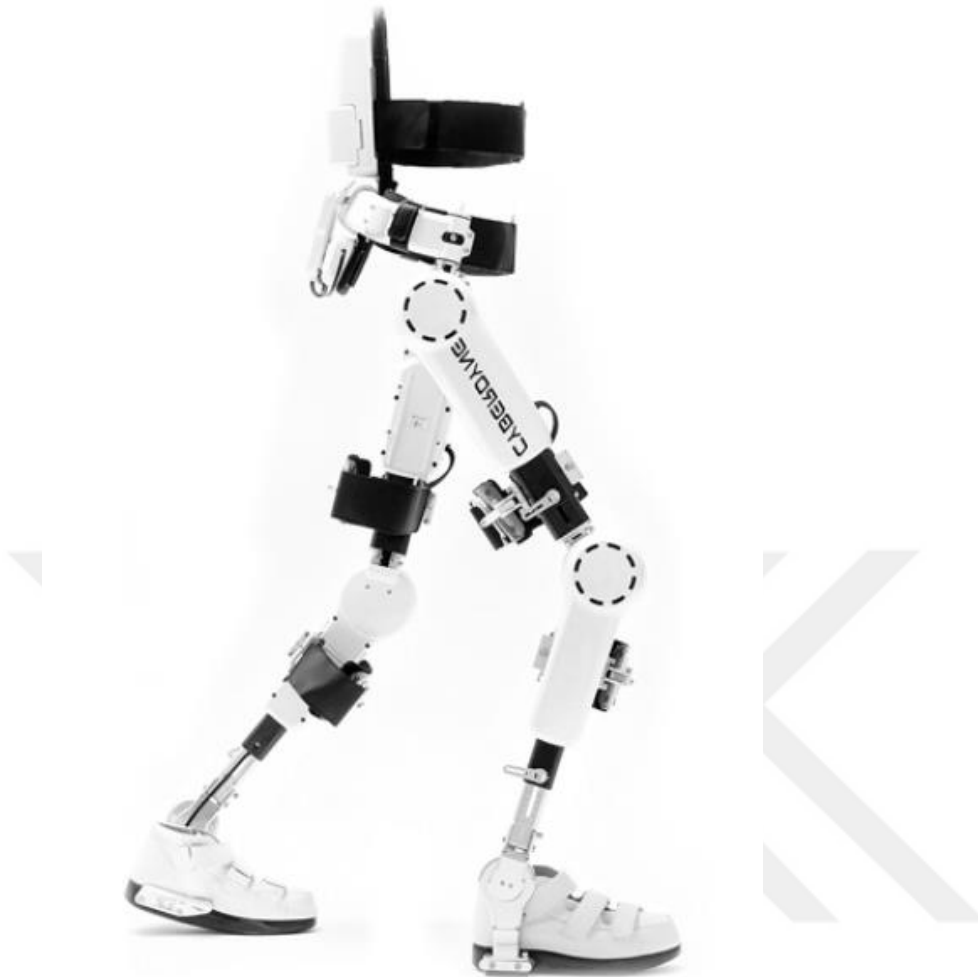


Figure 21. HAL

Source: Lazarte, “Enter the first cyborg-type robot.”

An “exoskeleton that can assist in daily activities in a rehabilitative capacity, or magnify the strength of the user by a factor of 10.”<sup>343</sup> By 2009, HAL was being used support nursing care-work. Since 2015 HAL is also able to “...provide exercise-assistive medical devices for patients who suffer from spinal cord injuries, traumatic brain injuries, cerebrovascular diseases, diseases of the brain, and neuromuscular system disorders.”<sup>344</sup> HAL is a cyborg medical exoskeleton, Cyberdyne describes HAL as;

...is the world’s first cyborg-type robot, by which a wearer’s bodily functions can be improved, supported and enhanced. Wearing of HAL<sup>®</sup> leads to a fusion of

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<sup>343</sup> Robots IEEE. “HAL”.

<sup>344</sup> Yamada, “An Acquaintance with An Aging Society.”

“man”, “machine” and “information”. HAL<sup>®</sup> assists a physically challenged person to move and enables him or her to exert bigger motor energy than usual. HAL<sup>®</sup> is also considered as the system that accelerates a motor learning of cerebral nerves.<sup>345</sup>

Other examples that can be seen in Figure 22 include Honda’s “Walking Assist” and Reif Corp’s “Assist Robot For Walking Rehabilitation Soutenir”<sup>346</sup>



Figure 22. Honda walking assist (left image) and Soutenir (right image)  
Source: Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-.”

There have been various developments and advancements in wheelchair technologies as well.<sup>347</sup> Starting in the 1990s, a powered wheelchair which enables the disabled to return to work had been developed. The wheelchair had voice-control and could also move along a previously programmed road automatically.<sup>348</sup> Wada et al., experimentally

<sup>345</sup> Cyberdyne. “What’s HAL?”

<sup>346</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-.”

<sup>347</sup> Yukawa et al., “Assistance System for Bedridden Patients to Reduce the Burden of Nursing Care (First report—Development of a multifunctional electric wheelchair, portable bath, lift, and mobile robot with portable toilet),” 132-133.

<sup>348</sup> Akishita, Jidō sōkō onsei seigyō kurumaisu 自動走行・音声制御車椅子 [Powered wheelchair equipped with voice control and automatic locomotion]

developed a “wheelchair with omni-directional wheels”<sup>349</sup> Hideo Kitagawa, continuing on the idea of an omni-directional wheelchair, proposed a new motion method for controlling the wheelchair at the same time suppressing vibrations and have smoother movement.<sup>350</sup> The developments are not only for the machinations of wheelchairs, Yoshio Matsumoto suggested a sensor for wheelchairs, which would use “laser viewfinder and map information” to move accordingly and without getting caught in obstacles.<sup>351</sup>

With the number of elderly rising, the chances of a person becoming bedridden also increase. The development of wheelchair-beds is a product of this line of thinking.<sup>352</sup> The patient can be moved outdoors without having to transfer to a wheelchair.<sup>353</sup> Robotic technologies such as Panasonic’s Resyone wheelchair-bed that can be observed in Figure 23 is a good example to transfer aids that lessens the burden on care-workers and assists in the prevention of injuries.<sup>354</sup>

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<sup>349</sup> Wada, “Omnidirectional control of a four-wheel drive mobile base for wheelchairs”

<sup>350</sup> Kitagawa et al., *Zenhōkōidō kurumaisu no nori-gokochi kōjō no tame no sōkō seigyō* 全方向移動車椅子の乗り心地向上のための走行制御 [Motion control of omni-directional mobile wheelchair considering user's comfort].

<sup>351</sup> Matsumoto, “Vision of Mobility Assistance”

<sup>352</sup> Ohishi, “The Development of Multi Functional Wheelchair for Bedridden Patients-The Cleaning System Using Robot Arm”

<sup>353</sup> Yukawa, “A study of multifunctional wheelchair for bedridden patients.”

<sup>354</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-”.



Figure 23. Resyone wheelchair-bed (© Panasonic)

Source: New Atlas. “Panasonic's robotic bed/wheelchair first to earn global safety certification.”

A more holistic approach to ALTs is the smart house, more definitively smart homes for the elderly and especially those with dementia. This concept is further studied in the paper “Psychogeritechnology”<sup>355</sup> in Japan: Exemplars from a super-aged society written by a joint group of scholars from Japan and the United Kingdom;

Supporting active and independent living for individuals with early stage cognitive decline is a rapidly developing field including the use of cognitive orthotics (ie, reminder apps on smart phones, medication prompters, geolocators, and electronic diaries) and telehealth, which relies on connected smart devices in the home (IoT) to monitor various physiological parameters of individuals (ie, heart rate, weight, ECG, temperature etc.), as well as environmental parameters, such as ambient temperature.<sup>356</sup>

<sup>355</sup> “psychogeritechnology,” a term we have coined to describe the range of technology approaches to the prevention, prediction, screening, assessment, diagnosis, management, and monitoring of people at risk of, or living with, dementia. ()

<sup>356</sup> Leroi et al. ““Psychogeritechnology” in Japan: Exemplars from a super-aged society”.

Furthermore, in Japan a laboratory is experimenting with what they call Living Labs, which are, for all intents and purposes, smart home laboratories.<sup>357</sup> “...laboratory is applying AI methods to create a behavioural profile of increasing frailty of gait using continuously collected data from supportive hand rails, thus enabling pre-emptive intervention.”<sup>358</sup> This technology is especially important as 70% of accidents the elderly have occurs at their houses, systems to prevent this and monitor the elderly becomes incredibly significant.<sup>359</sup>

Developing vehicles that can be safely used by the elderly with technological advancements, will create more opportunities for elderly to go out. The rate at which the elderly citizens go outside their house drop significantly as they return their drivers licence, usually voluntarily. An improvement in cars, could enable the elderly to continue going outdoors when necessary for shopping or socializing. The Japanese government with the aid of private companies such as Toyota,<sup>360</sup> Suzuki<sup>361</sup> and Mitsubishi<sup>362</sup> are moving forward with the creation of a car with advanced technology for older drivers with the name “Safety Support Car S” (Sapocar S). This car will be “...equipped with automatic brakes, acceleration suppression device for pedal misapplication, lane departure warning and advanced lights, the vehicle is expected to make certain contributions to the prevention of traffic accidents involving elderly drivers.”<sup>363</sup>

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<sup>357</sup> Nishida et al., “Living Function Resilient Service Using a Mock Living Lab and Real Living Labs: Development of Balcony-IoT and Handrail-IoT for Healthcare”

<sup>358</sup> Leroi et al., ““Psychogeritechnology” in Japan: Exemplars from a super-aged society”.

<sup>359</sup> Kimura, et al., “Implementation and evaluation of an algorithm determining robot movement for home robot in living space”

<sup>360</sup> Toyota, “Toyota Announces Toyota Safety Sense and ICS Safety Support Technologies that Together Reduce Rear-End Collisions by 90%.”

<sup>361</sup> Suzuki, “Safety Support.”

<sup>362</sup> Mitsubishi, “Mitsubishi Motors launches New eK Wagon & eK X keicars.”

<sup>363</sup> The Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]



There are also instances where the patient in need of long-term care also needs to visit the hospital frequently due to an accident or an illness and even need supervision from specialists residing in different regions. For this problem a solution using robotic technology is tele-care robots, to “...address the need for a less time-consuming treatment by providing remotely located physicians with a means of medical supervision. Assistant robotic platforms like that can be used both in healthcare facilities with the patient being hospitalised or at the patient’s home allowing them and their family to keep in touch with doctors and nurses.”<sup>364</sup>

An additional benefit to be gained from the use of robotic technologies lies with social robots. Social robots are a type of robotic technology fitted with an AI system, and primarily created to communicate with humans, and also other robots.<sup>365</sup> These type of robots are used to improve the mental health of older persons, as well as providing emotional support. Utilisation of these robots on a daily basis will not only lighten the burden of the caregivers, but also supply the elderly with companionship, albeit electronic but with high communication capabilities.<sup>366</sup> One well-used example is the Therapeutic robot Seal-Type Robot: PARO which can be seen in Figure 24 created in 2003 by the National Institute of Advanced Industrial Science and Technology (AIST) in Japan. Modelled after a real baby seal “...PARO is 57 cm long and weighs 2.5 kg. It is equipped with a sensor and a microphone which detect external stimuli and circadian rhythm to embody the real baby harp seal. With the learning function, PARO is designed

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<sup>364</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-”

<sup>365</sup> Duffy et al., “What is a Social Robot?”

<sup>366</sup> The University of Tokyo, “Japan: The Land of Rising Robotics. Japan: The World’s Leading “Robot Nation.”

to gradually establish a robotic personality by learning new names and preferred actions depending on the owner.’’<sup>367</sup>



Figure 24. An elderly with PARO, the therapeutic seal robot at a welfare facility  
Source: National Institute of Advanced Industrial Science and Technology

Studies in the field<sup>368</sup> show that uses of PARO or other this type of social robots have some social and mental effects<sup>369</sup> on the elderly in the long-term care institutions.<sup>370</sup>

However, in the beginning, the technology was not immediately embraced half because of mistrust and half as a result of the patients and care-workers not knowing how to use the technology.<sup>371</sup> A Project similar to PARO is Smiby,<sup>372</sup> a baby like robot developed by the Chukyo University. During the early stages, some companies discarded their similar

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<sup>367</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-.”

<sup>368</sup>The National Institute of Advanced Industrial Science and Technology (AIST), Kimura Clinic, and Brain Functions Laboratory participated in joint research involving PARO, a therapeutic seal robot, and patients with Alzheimer’s disease and other cognition disorders to discover the effect of the robot on improving brain function.

<sup>369</sup> Increase in conversation between older people and carers and depression improvement etc. were observed. (AIST)

<sup>370</sup> Hay, “Why Robots Are the Future of Elder Care.”

<sup>371</sup> Despite the difficult start, PARO has been successfully in use in Japan and throughout Europe since its introduction in 2003.

<sup>372</sup> Chukyo University, Sankangaku renkei purojekuto kokoro de taiwa suru robotto e 産官学連携プロジェクト 心で対話するロボットへ [Industry-government-academia collaboration project To a robot that communicates with the heart]. For related images see Appendix, Figure A6-A7.

projects as there was not enough interest in the field.<sup>373</sup> Nonetheless, these setbacks did not discourage everyone in the sector, as research and development in the field continued and judging by the sale of human assistant robot Pepper<sup>374</sup> in 2015 when the first batch of Pepper was sold for JPY 198,000 (US\$1850) each in less than one minute.<sup>375</sup> A Project similar to this was developed by RayTron, a communication robot called Chapit.<sup>376</sup>

Another care-robot in the field of nursing is PALRO created by Fujisoft that can be seen in Figure 25. A humanoid type robot that is able to interact with others using a human voice and is able to remember the faces<sup>377</sup> of humans.<sup>378</sup> Another example is Aibo,<sup>379</sup> a dog shaped robot developed by Sony. There are also health monitoring technologies in use as both an indication of current health and in the future the government plans to introduce “robots with sensor technologies and artificial intelligence will be pushed forward with an eye on looking after the aged and preventing them from falling prey to a serious disease such as dementia.”<sup>380</sup>

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<sup>373</sup> Neumann, “Human Assistant Robotics in Japan- Challenges and Opportunities for European Companies-”

<sup>374</sup> SoftBank, Peppā ペッパー[Pepper], For the related image see Appendix, Figure A2.

<sup>375</sup> Hay, “Why Robots Are the Future of Elder Care.”

<sup>376</sup> RayTron, Komyunikēshonrobotto Chapitto コミュニケーションロボットチャピット [Communication Robot Chapit]. For the related image see Appendix, Figure A8.

<sup>377</sup> PALRO can remember up to the faces of a 100 people.

<sup>378</sup> Inoue et al., “Effective Application of PALRO: A Humanoid Type Robot for People with Dementia.”

<sup>379</sup> Sony, Aibo. For the related image see Appendix, Figure A5.

<sup>380</sup> The Ministry of Economy, Trade and Industry, Robotto Shinsenryaku. Bijon, Senryaku, Akushonpuran. ロボット新戦略—ビジョン・戦略・アクションプラン— [New Robot Strategy. Japan’s Robot Strategy - Vision, Strategy, Action Plan]



Figure 25. Humanoid type robot PALRO.

Source: Inoue et al., “Effective Application of PALRO: A Humanoid Type Robot for People with Dementia.”

#### 4.3 Robots in future challenges and prospects

Robotic technologies have been advancing rapidly, with real-life applications. Most prominently in sectors such as manufacturing, agriculture, automobile industry, logistics and in the military. Presently, robots are becoming a part of our world and affecting our daily lives with observable societal impact, especially its effects on businesses and employment.<sup>381</sup> “The recent explosion of interest in robotics has taken a number of forms. There has been much public and media interest in research and development initiatives undertaken by *Google* and other private and public entities on ‘driverless’ cars.”<sup>382</sup> Companies such as *Toyota*,<sup>383</sup> *Bosch* and *Midea*<sup>384</sup> have been making considerable investments in social robotics field. All these new investments made and developments indicate that in the near future the production of economic robots for daily

<sup>381</sup> Willcocks et al., *Service automation: Robots and the future of work*.

<sup>382</sup> Share et al., “Preparing for a robot future? Social professions, social robotics and the challenges ahead,” 46.

<sup>383</sup> Christopherson, “Toyota creates robots to assist and support ageing populations.”

<sup>384</sup> Vincent, “Germany’s biggest industrial robotics company is working on consumer robots.”

use will be possible and their presence in both private and public spheres will most probably increase.<sup>385</sup> With this, advancements made in the field are reported frequently in both fiction and non-fiction. “Print and social media articles reflect the diverse (potential or real) impacts of robots: in novel applications of the technology...”<sup>386</sup>

“Robots are coming for our jobs”, “Robots will take our jobs”, headlines like this any many more are crowding the news sites but empirical evidence suggests this is not necessarily the case, at least for Japan. Using an approach found by Daron Acemoglu and Pascual Restrepo,<sup>387</sup> “IMF staff calculations... found increased robot density in manufacturing to be associated not only with greater productivity, but also with local gains in employment and wages. Notably, these findings—which exclude crisis periods—are the opposite of results of a similar exercise based on US data. It appears that Japan’s experience may differ significantly from that of other advanced economies.”<sup>388</sup> However, while these positive results are encouraging there is the problem of “polarization between workers, implying that a relatively small proportion of white-collar workers account for a large share of earnings.” as Nobuaki Hamaguchi and Keisuke Kondo explain it.<sup>389</sup> Research on the subject also suggests that “...the female labor force, which has swelled in the past five years, is particularly vulnerable to displacement, given the heavy concentration of women in nonregular jobs (that is, temporary, part-time, or other positions outside the mainstream of Japan’s lifetime employment system), whose tasks are more susceptible to automation...”<sup>390</sup>

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<sup>385</sup> Fortunati, “Robotisation and the domestic sphere.”

<sup>386</sup>Share et al., “Preparing for a robot future? Social professions, social robotics and the challenges ahead,” 46-47.

<sup>387</sup> Acemoglu et al., “Robots and Jobs: Evidence from US Labor Markets”.

<sup>388</sup> Schneider et al., “Land of the Rising Robots.”

<sup>389</sup> Hamaguchi et al., “Regional Employment and Artificial Intelligence.”

<sup>390</sup> Schneider et al., “Land of the Rising Robots.”

The main challenges, which are listed when discussing the impact of robots in nursing-care and healthcare industry are; privacy issues, dignity issues, liability issues, safety and security issues. Privacy issues are the downside of better monitoring technologies, which are helpful especially with the elderly patients. Unless the information is regulated, or corporate policies or protocols exist regarding this technology, these robots could become a threat to the private life of the elderly and other persons in contact with the technology.<sup>391</sup> Furthermore, as Ryan Calo writes in his article *Robots and Privacy*, people might be more willing to share private information with their robotic companion, which, in any other situation they would withhold.<sup>392</sup> Another issue that needs to be settled is the question of whether the data collected from the cameras and microphones attached to the robots are being uploaded to the cloud.<sup>393</sup>

The complete removal of human caregivers is not something policy-makers or care-workers desire, nor is it feasible. Humans are by nature social animals; they need human interaction in order to stay sane. Psychologist Adam Waytz writes; "...the concept of humans as "social by nature" has lent credibility to numerous significant ideas: that humans need other humans to survive, that humans tend to be perpetually ready for social interaction, and that studying specifically the social features of human functioning is profoundly important."<sup>394</sup> This lines up with the dignity issues, as replacing a human caregiver with a robotic one might affect the mental health and happiness of the patient. In their article *Human interaction: the critical source of intangible value*, David O'Donnell goes into detail about the critical value of human interaction and the need for a "more enlightened economic and social equation" which

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<sup>391</sup> Grasso, "Challenges and advantages of robotic nursing care: a social and ethical analysis."

<sup>392</sup> Calo, R., (2014). "Robots and Privacy."

<sup>393</sup> Proia et al., "Consumer cloud robotics and the fair information practice principles: Recognizing the challenges and opportunities ahead"

<sup>394</sup> Waytz, " Humans are by nature social animals."

puts ideas of community and lifeworld that place human interaction at the centre.<sup>395</sup>

Decisions need to be made on the subject of robotic technologies in healthcare and nursing sectors, but when making these decisions, the line between “dignity and independence on one hand and possible loneliness on the other” need to be taken into account. We are still in the infancy stage of widespread use of robotics in these fields, but especially because we are at the beginning there is a great need for regulations and responsible development. Jim Torresen’s thoughts on the subject are;

The exploitation of robots within elderly care is unlikely to have a quick transition. Thus, today’s elderly do not have to worry about being placed under machine care. Rather, those of us who are younger, including current developers of elderly care robots, are more likely to be confronted with these robots when we get old in the future. Thus, it is in our own interest to make them user friendly.<sup>396</sup>

In the field of care-work, Grasso puts this as; “The very presence of a human entails the patient value recognizing him or her as a unique individual rather than an impersonal entity. This cannot be replaced by a robot because of its “mechanical,” “pre-programmed” and thus “neutral” way to interact with patients.” A solution to this issue would be avoiding extreme replacement in care-services and make sure that the patient has periodical interactions with the problems that might arise in terms of liability is not limited to the healthcare sector, every field which is using or will use robotic technologies in the future suffer from this issue.<sup>397</sup> Regarding liability and accountability issues in the healthcare sector Grasso writes;

The mechanical nature of nursing-care robots makes impossible to attribute them liability in case of malfunctioning or any other adverse consequence related to their usage. As a result, it could result extremely complicated to attribute civil and criminal liability to natural and legal persons in relation to a harmful event caused by a robot. Such a liability could theoretically fall on several different persons like the manufacturer, the programmers, the providers, and the

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<sup>395</sup> O'Donnell et al., “Human interaction: the critical source of intangible value.”

<sup>396</sup> Torresen, “A review of future and ethical perspectives of robotics and AI.”

<sup>397</sup> Rommetveit et al., “Make way for the robots! Human- and machine-centricity in constituting a European Public-Private Partnership.”

technicians. Such confusion could lead to a lack of accountability and represent a burning issue for the affected patient, who may face the burdensome task of identifying the responsible subject. Such a task could become even impossible taking into consideration the age and the vulnerability of the individuals who are commonly supposed to make use of nursing-care robots.<sup>398</sup>

The concept of responsibility is a human one, and to expect the same concern for morality from an artificial agent is not realistic. Luciano Floridi and Jeff W. Sanders write about the question of morality and responsibility regarding robots and AI technologies in their paper “On the morality of artificial agents;”

The whole conceptual vocabulary of ‘responsibility’ and its cognate terms is completely soaked with anthropocentrism. This is quite natural and understandable, but the fact can provide at most a heuristic hint, certainly not an argument. The anthropocentrism is justified by the fact that the vocabulary is geared to psychological and educational needs, when not to religious purposes.<sup>399</sup>

The whole issue of responsibility becomes even more complex with the use of AI. To give care-robots autonomy in decision making, AI technologies are being used and as a consequence; “...attributing the liability of a harmful event caused by a wrong decision taken by the robot itself could become a real legal conundrum.” In order to solve this issue clear definitions need to be made on the subject of civil and criminal liability in terms of artificial agents.<sup>400</sup>

The utilisation of robots in healthcare and nursing sectors will bring robots closer to humans than ever, and as the interactions between robots and humans increase so will the concerns about safety and security. Safety must be the most significant factor in terms of development of robotic technologies for healthcare and nursing sectors,<sup>401</sup> even if the global economy with its competitive nature urges the companies in the opposite direction.<sup>402</sup> “There is the need for an improved technique that will eliminate or reduce

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<sup>398</sup> Grasso, “Challenges and advantages of robotic nursing care: a social and ethical analysis.”

<sup>399</sup> Floridi et al., “On the morality of artificial agents,” 362.

<sup>400</sup> Grasso, “Challenges and advantages of robotic nursing care: a social and ethical analysis.”

<sup>401</sup> Fischinger et al., “Hobbit, a care robot supporting independent living at home: First prototype and lessons learned.”

<sup>402</sup> Stevenson et al., *Do lunch or be lunch: The power of predictability in creating your future.*



safety-related failures as well as eliminating unpredictable behaviors. Another specific concern about security is on how to keep robots safe from being hacked.”<sup>403</sup>

The impact robots have on society is still not fully understood, but as more robots especially social robots invade our homes and society, their influence will grow.<sup>404</sup> The increasing public awareness also brings with it fears and concerns.<sup>405</sup> In recent years, the field of social robotics has been developing at a fast pace, especially in the care sector; elderly care, healthcare and, care and education of children.<sup>406</sup> In 2016, SPARC<sup>407</sup> has pinpointed elderly care as a possible sector for growth as a consequence of changing demographics around the world.<sup>408</sup> Likewise, in 2017 a paper in the *Journal of autism and developmental disorders* identifies social robotics as a possible means in helping the children with autism, ...interacting with robots can be particularly empowering for children with ASD,<sup>409</sup> because it may overcome various barriers experienced in face-to-face interaction with humans. Moreover, robot-assisted interventions can be tailored to the needs of the specific child and can be used in an identical manner as often as needed.”<sup>410</sup>

A different issue that might arise from the use of social robots is covered by Kate Darling in her article *Extending legal protection to social robots: The effects of anthropomorphism, empathy, and violent behavior towards robotic objects*;

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<sup>403</sup> Grasso, “Challenges and advantages of robotic nursing care: a social and ethical analysis.”

<sup>404</sup> Kiggins et al., *The political economy of robots: Prospects for prosperity and peace in the automated 21st century*, 1-5.

<sup>405</sup> Share et al., “Preparing for a robot future? Social professions, social robotics and the challenges ahead,” 47.

<sup>406</sup> Conti et al., “Robots in education and care of children with developmental disabilities: a study on acceptance by experienced and future professionals.”

<sup>407</sup> SPARC is a Public-Private Partnership between the European Commission, and European industry and academia to facilitate the growth and empowerment of the robotics industry and value chain, from research through to production.

<sup>408</sup> SPARC, “Robots that may help you in your silver age.”

<sup>409</sup> Autism spectrum disorder.

<sup>410</sup> Huijnen et al., “How to implement robots in interventions for children with autism? A co-creation study involving people with autism, parents and professionals,” 3080.

Another concern is the danger of manipulation through social robots. If people develop attachments to their robotic companions, can the companies who control the hardware and software exploit this attachment? Should companies be allowed to make use of the fact that individuals might have a massively increased willingness to pay for technology upgrades or repairs? What about sneaking advertisements for products into children's dialogs with their robotic toys?<sup>411</sup>

Developing emotional attachments to robotic technologies is not necessarily negative, nor is it unwanted by itself. The use of seal robot PARO is a good example of this, as it is being used successfully in treating patients with dementia.<sup>412</sup> While there are some issues which need to be solved to move forward, there are endless possibilities for the use of robots in almost every sector.<sup>413</sup> There are incredible opportunities in robotic technologies for healthcare and nursing sectors. But as Brenda K. Wiederhold's discussion on the subject explains it, we are not yet at a stage where we could leave the whole of the care-work to robots; "While there is significant potential for robots to solve large-scale problems in healthcare, one problem remains: we remain decades away from robots that can replace more sophisticated human labor functions."<sup>414</sup>

One example given by Wiederhold is Robear<sup>415</sup>; "a large, plastic caregiving bear that is intended to assist with patients who have mobility needs."<sup>416</sup> Toshiharu Mukai, the robot's primary creator says, "the robot isn't ready for prime time and may not be for decades ... It's more of an academic robot". Mukai also notes that "Robear also struggles to maneuver in small Japanese apartments."<sup>417</sup> Once such technologies are developed to a degree where they could be safely used in daily life, the caregivers burdens will

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<sup>411</sup> Darling, "Extending legal protection to social robots: The effects of anthropomorphism, empathy, and violent behavior towards robotic objects," 221.

<sup>412</sup> Inoue et al., "Effective Application of PALRO: A Humanoid Type Robot for People with Dementia."

<sup>413</sup> Darling, "Extending legal protection to social robots: The effects of anthropomorphism, empathy, and violent behavior towards robotic objects," 221.

<sup>414</sup> Wiederhold, "Robotic Technology Remains a Necessary Part of Healthcare's Future Editorial," 511.

<sup>415</sup> Nagoya Riken, ROBEAR. For the related images, see Appendix, Figure A3-A4.

<sup>416</sup> Wiederhold, "Robotic Technology Remains a Necessary Part of Healthcare's Future Editorial," 511.

<sup>417</sup> Emont, "Japan Prefers Robot Bears to Foreign Nurses."

decrease tremendously. A project similar to Robear is Ri-Man, a robot developed by Riken.<sup>418</sup>

Interactions between robots and humans are also a subject still open for discussion, in 2010, a paper titled "How safe are service robots in urban environments? Bullying a robot." was co-authored by Pericle Salvini, a researcher at the 'Scuola Superiore Sant'Anna' in Italy, who first expressed "robot bullysm" as a new concept. The word bullying in this instance describes all sorts of "...improper and violent behaviour, intended to cause damages or impede the robot operation."<sup>419</sup> Human beings are at times, known to be violent against unmoving objects, and if static objects can become targets for vandalism, so can moving objects. Salvini argues that, "bullying" or vandalising robots could become troublesome for humans.

A phone box is often an object of vandalism—a robot is something that moves and can bring stuff. If vandalised, a moving object is much more dangerous than a fixed object like a phone box...Consider how anybody with a stick or spray would be able to sabotage a robot's functioning ... If it's not programmed to manage this problem it may hurt something or somebody.<sup>420</sup>

Robot bullying is especially prominent in children. A behavioral study by the research team of Salvini in South Korea shows that young people "...tended to react to the robot's presence with extreme curiosity and, quite often, to treat them aggressively."<sup>421</sup>

Following this a similar study was conducted in Japan titled "Why do children abuse robots?" Interviewing children who have been observed to abuse robots, and the team found "...serious abusive behaviors with physical contact such as kicking, punching, beating, folding arms, and moving (bending) the joints of robot's arm and head. ... In these scenes, some children frequently obstructed the robot's path regardless of the robot's utterance requesting for the children to stop the obstruction, covered up the

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<sup>418</sup> Riken, RI-MAN リーマン. For the related image see Appendix, Figure A9.

<sup>419</sup> Salvini et al., "How safe are service robots in urban environments? Bullying a robot," 1-2.

<sup>420</sup> Salvini et al., "How safe are service robots in urban environments? Bullying a robot," 1-2.

<sup>421</sup> Jozuka, "When humans bully robots there will be consequences."

robot's eyes with their hands, and beat the robot's head.”<sup>422</sup> Abusive behaviour towards robots by children or adults may become an issue in the future unless a solution to at least lessen the abuse is found. Obstructive behaviour against the robots may cause delays, interfere with the robots objective and vandalised robots may inadvertently cause injuries as a result of system malfunctions.<sup>423</sup>

Challenges in terms of “ethics, human-robot relationships, user experience, social impacts and issues of autonomy and control”<sup>424</sup> are not yet solved, nor do we yet clearly understand the psychological impacts of utilising robots as caregivers. When a new technology becomes widespread, we have limited control over the impact it will have on society, and to our behaviour. The impact of the internet and smartphones have in some ways altered the way we all live in previously unseen ways, and the same can be said for any new technology at varying degrees.<sup>425</sup>

The effects of using robotic technologies in care services are not yet fully understood, nor are we yet clear on the societal impacts of widespread use of robotics. We need to be careful in the implementation of new technologies as Amber Case cyborg anthropologist and the curator of the exhibition Humans need not apply writes;

We shouldn't just let these technologies fold into our lives unexamined, we ought to care about how we think about these things and develop an understanding of the meaning and consequences of the objects we build. Every time we say there's something we should or should not do, it comes with a sense of morality. We see evidence. We might not take a position on it, but we are invited to question it. This is a future in which ethics are at stake, and as authors of our own destiny, we are advised to take a more active role in the creation of our everyday lived realities.<sup>426</sup>

Robotic technologies are being used more frequently in medical and nursing fields as the elderly populations increase globally and decrease in working-age population create

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<sup>422</sup> Nomura et al., “Why do children abuse robots?” 350-365.

<sup>423</sup> Jozuka, “When humans bully robots there will be consequences.”

<sup>424</sup> Share et al., “Preparing for a robot future? Social professions, social robotics and the challenges ahead,” 57.

<sup>425</sup> Torresen, “A review of future and ethical perspectives of robotics and AI.”

<sup>426</sup> Case, “Take a step back and consider an automated society.”

labour shortages. Especially in Japan, with estimated shortages of 377,000 by 2025 in the nursing field, the use of robotic technologies is unavoidable. To achieve an affordable market for nursing and care robots the Japanese government is supporting projects and newly starting companies that will do work in these fields.



## CONCLUSION

The ageing of the world population; both demographic and individual, has created a conundrum, especially for the industrialised nations. However, this demographic trend is spreading through the world and will soon not be contained in just the developed world. Thus, it has become incredibly important to find viable solutions to this global problem. If this ageing trend continues, and there are no signs of it slowing down, by 2050 there will be more than two billion elderly globally. The main issue is that the phenomenon of ageing does not exist by itself, the demographic ageing generally comes with a shrinking in the working-age population as it is the result of low fertility rates coupled with increased life expectancy. This inverted population pyramid effects societal structures, economy, and even culture as a top-heavy population pyramid means that a large number of older persons will continue to affect all layers of human life.

Even in elderly populations, not all age-brackets are increasing at an equal pace. The fastest growing age group is now the centenarians, people over the age of 100. As the upper-brackets of the elderly population, namely the over 80 years old population increases, the time period between retirement and end of life is getting longer. The traditional retirement age, which is generally around 60 to 65 years of age, is becoming harder to manage, as social security costs are starting to cripple government budgets. The early retirement age is also leading to a decrease in their involvement in communities, causing a decrease in their self-worth as well as pushing them towards loneliness.

Japan is leading this ageing trend with the highest rate of ageing, higher than other developed nations. It is estimated that by 2050, more than one-third of its

population will be in the elderly category. As Japan is experiencing the ageing phenomenon earlier than most countries, a tried and tested solution does not exist, and what Japan does now to solve these issues will later become a roadmap to most countries with similar issues. The government of Japan, since realising this irreversible demographic ageing process, and the following shortage of labour force markets will experience, turned towards technological development, especially robotic technologies to search for a viable solution. Japan, because of its position as a world leader in robotics, is an especially good choice for realising a Robotic Revolution, as the government has named it.

There are two sides to demographic ageing, one is the shrinking of the working-age population; the labour force and the other is the increasing number of older persons; the retirees or the section of the population relying on social security benefits. The fields where these two sides come together, like the healthcare sector and the nursing sector are particularly affected by this trend. Shortages in both sectors exist even now, and will continue to worsen in the near future. The government aim is to utilise robots and robotic technologies in these fields as a way to, not counter, but mitigate the problem. There are some obstacles to clear before enabling a widespread utilisation of robotic technologies in these fields: economic obstacles; the necessary robotic technologies must be meaningful costwise, social obstacles; the acceptance of robots as part of the societal structure, legal obstacles; the slow changing policies and legislature could impede the application of the technologies, ethical issues; how right is it to leave the elderly, especially if they are not of sound mind, at the hands of robots? There may be more obstacles to clear as these technologies become widespread and are being utilised more and more.

The demographic issues and labour shortage problems of Japan will not be solved only by incorporating robotic technologies in the near future, especially not at the rate the government wishes it to be. But it is also true that technological advancements and widespread use of robots in a social context will at the very least help mitigate Japan's burdens. As it does not seem likely that the Japanese will allow for an easier immigration process in the near future and there is no easy way to increase fertility to a degree where the population ageing issue could be countered, at this time, Japan actually has no other solution but to rely on technological developments.

However, the use of robotic technologies in nursing homes, even if only in an assistive capacity, will help the caregivers substantially. Firstly, assisting them in a physical capacity will lessen the strain on their bodies. Secondly, they will save time by using assistive technologies for transfer and moving the patients. The ability of care-workers to abstain from strenuous physical activity with the help of assistive technologies is tremendous as a high percentage of them suffer from back pain. As it is an underappreciated and underpaid line of work, care-workers will immensely benefit from these technologies. Surgical robots in the medical field have seen substantial success around the globe, and other areas in healthcare, from diagnostics to rehabilitation are becoming increasingly reliant on robotic technologies. Robotic technologies where the machine meets with actual human beings advance more slowly, compared with robotic technologies in the industrial sphere as the ethical, legal and societal hurdles are much higher and repercussions much more severe where humans interact directly with robots.

I have a more optimistic view of the future where robotic technologies will in all likelihood dominate many of the sectors, as well as becoming a part of our daily lives. I do not doubt that there will be resistance for all kinds of reasons, but a new technology



that enough people believe is crucial for the betterment of humankind, will break through the scepticism. “Necessity is the mother of invention”, innovation usually happens when there is a necessity and human beings are pragmatic in nature, if an invention makes their life easier in the long run, that technology will infiltrate societies.



## APPENDIX

### FURTHER IMAGES OF MEDICAL AND CARE ROBOTS



Figure A1. Mai Supūn Shokuji Shien Robotto マイスプーン食事支援ロボット[My Spoon meal assistance robot]

Source: Secom. Mai Supūn Shokuji Shien Robotto

マイ Spoon 食事支援ロボット[My Spoon Meal Assistance Robot])



Figure A2. Peppā ペッパー[Pepper]  
Source: SoftBank. Peppā ペッパー[Pepper]



Figure A3. Robea ロベア [ROBEAR]  
Source: Nagoya Riken. ROBEAR



Figure A4. Robea ロベア [ROBEAR]  
Source: Nagoya Riken. ROBEAR



Figure A5. Aibo  
Source: Sony. Aibo



Figure A6. Sumaibi スマイビ [Smiby]

Source: Chukyo University. Sankangaku renkei purojekuto kokoro de taiwa suru robotto e 産官学連携プロジェクト 心で対話するロボットへ [Industry-government-academia collaboration project To a robot that communicates with the heart]



Figure A7. Interaction with Sumaibi スマイビ [Smiby]

Source: Chukyo University. Sankangaku renkei purojekuto kokoro de taiwa suru robotto e 産官学連携プロジェクト 心で対話するロボットへ [Industry-government-academia collaboration project To a robot that communicates with the heart]



コミュニケーションロボット Chapit (チャピット)

Figure A8. Communication Robot Chapit

Source: RayTron.Komyunikēshonrobotto Chapitto

コミュニケーションロボットチャピット [Communication Robot Chapit]

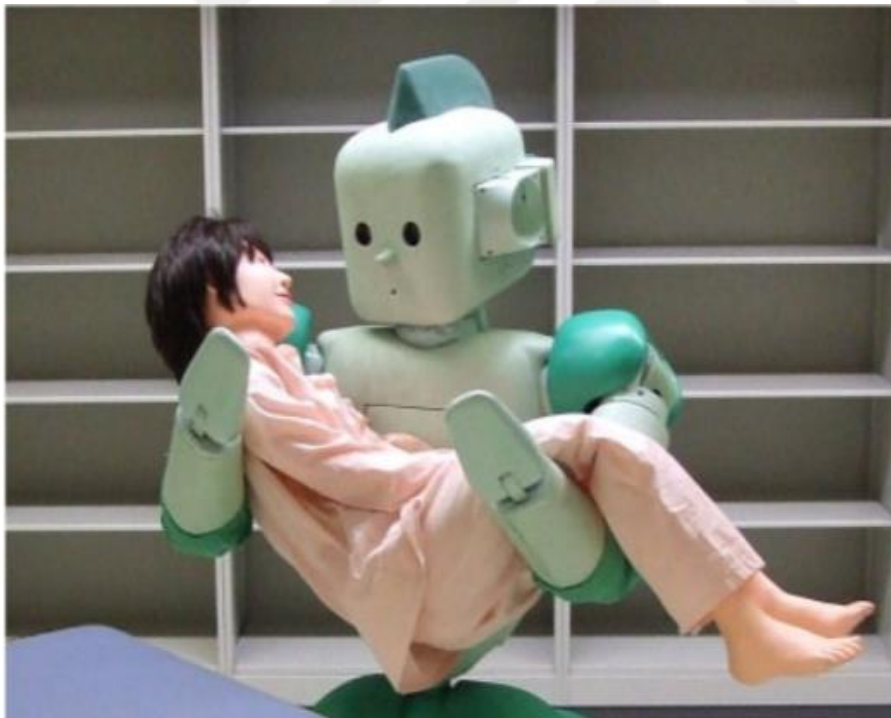


Figure A9. RI-MAN

Source: Riken. RI-MAN リーマン

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