Provisional translation

[Moonshot Goal #7]

R&D Concept of ”Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one’s life with relief and release from health concerns until 100 years old”

July, 2020
February, 2022
February, 2024
Cabinet Office, Government of Japan
Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Ministry of Health, Labour and Welfare (MHLW)
Ministry of Economy, Trade and Industry (METI)

1. Moonshot Goal

With the Japan Agency for Medical Research and Development (AMED) as a research promotor, the Cabinet Office, MEXT, MHLW and METI will promote R&D for attaining the following Moonshot Goal (Decision by Headquarters for Healthcare Policy July 14, 2020).

<Moonshot Goal>

”Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one’s life with relief and release from health concerns until 100 years old”

[Realization of a society where everyone can prevent diseases spontaneously in daily life]

- Establish infrastructure to maintain good mental and physical health by developing technologies, in order to stay healthy and prevent the onset and aggravation of diseases by regulation of immune systems or sleep, etc., and to visualize individual physical and mental state in daily life and urge people to voluntarily take healthy maintenance actions most suitable for them by 2040.
- Develop technologies to monitor all living body trends with lower physical and mental load by 2030.

[Realization of medical networks accessible for anyone from anywhere in the world]

- Establish a medical network to provide the same level of medical care as a normal time regardless of region and even upon disasters and emergencies by developing diagnostic and treatment devices for simple tests and treatments at home, etc. and diagnosis- and treatment-free technologies for part of chronic diseases by 2040. In addition, develop methods for radical treatment and precision medicine for diseases such as cancer and dementia by substantially reducing the development period of drugs and medical devices, etc. through establishment of data science and evaluation systems by 2040.
- Establish a technology platform to provide quality medical and nursing care suitable for each individual appropriately even with less providers by developing compact, speedy and high-sensitivity diagnostic and treatment devices as well as technologies to further enhance doctors’ medical opinion and diagnostic capability by 2030.

[Realization of drastic improvement of QoL without feeling load (realization of an inclusive society without health disparity)]

- Establish a social infrastructure to enable self-reliant life at home without depending on nursing care by developing such technologies as the recovery of body function with rehabilitation without feeling load, normalization of ailing biocontrol systems, regeneration or substitution of weakened organs and so forth by 2040.
- Develop technologies to improve body function through load-reducing rehabilitation and support self-reliant life at home and to improve ailing living biocontrol systems by 2030.

2. Direction of research and development

Based on expert hearings and study at expert panel of healthcare policy, the direction of research and development at this point in time is as follows.

(1) Social and healthcare issues in the background

In Japan, the population of 100 years and older is expected to be 300,000 or more in 2040. The research by U.S. and other countries also said, “In Japan, a half of the population born in 2007 will live longer than 107 years.” The arrival of 100 years of life is thus around the corner ahead of other countries of the world.

Not only the average life expectancy but healthy life expectancy has also extended steadily to 72.68 years for men and75.38 years for women in 2019. While the difference between healthy life expectancy and average life expectancy, that is, unhealthy period with limitations to daily life due to health reasons like diseases has been reducing for both men and women during the period from 2010 to 2019, it is still close to 10 years and efforts for further reduction are desired.

In view of Japan’s structure of diseases, not only single-target type diseases such as infectious diseases and genetic diseases but multiple-factor diseases like so-called life-style related diseases and age-related diseases are giving significant impact on the people and this tendency is expected to continue in the future. In these diseases, the mortality rate caused by "cancer" is significantly higher than that of others.

In order to further extend healthy life expectancy amid ongoing growth of average life expectancy, in the face of responding to those diseases, the importance of prevention increases in addition to diagnosis and treatment and it is desired to live with the least restrictions to a daily life even if affected with a disease, that is to take measures for living positively with diseases to go hand in hand. Regarding dementia, in particular, it is said that there will be approximately seven million people with dementia by 2025 as society ages. There is a need to further advance the development of an inclusive society, as being represented by the enforcement of “The Basic Act on Dementia to Promote an Inclusive Society” (Act No.55 of 2023).

Fig.1. DALYs FY2040 estimate survey by disease and annual changes in mortality rate (per 100,000 population) by major cause of death

DALYs FY2040 estimate survey by disease

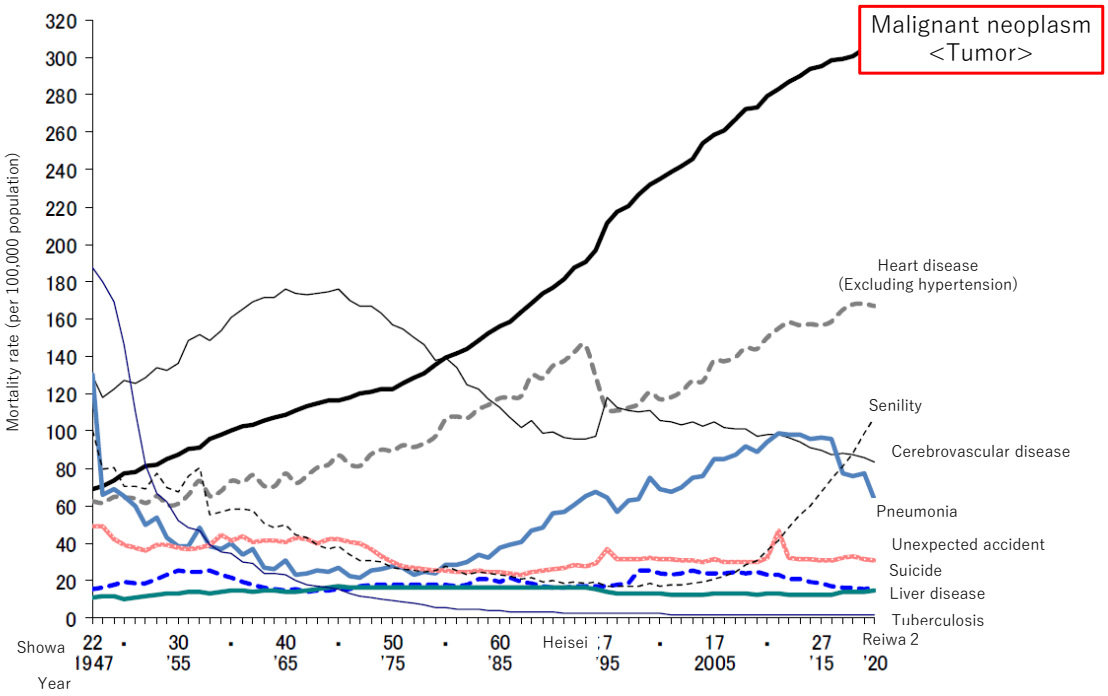
DALYs top 20 of 169 diseases for 2040 estimate

(DALY shows comprehensive indicators taking both death and impediment into account)

	2040	DALYs per 100,000 persons	DALYs rate of change since 2015* (Domain of uncertainty)	Classification of disease
Chronic disease	1 Alzheimer's disease	3048.9	52.2 (47.4 to 56.7)	Gerontology & dementia
	2 Backache	2141.3	10.8 (-20.7 to 35.9)	Gerontology & dementia
	3 Ischemic heart disease	1951.8	29.4 (25.3 to 33.3)	Lifestyle diseases
	4 Stroke	1543.0	-7.7 (-20.3 to 4.8)	Lifestyle diseases
	5 Presbycusis	1323.5	39.9 (17.6 to 57.7)	Gerontology & dementia
	6 Fall	1179.7	26.7 (3.9 to 45.0)	Injury
Infectious disease	7 Lower respiratory infection	1093.0	27.6 (23.3 to 31.3)	Infectious disease
	8 Diabetes	919.2	35.7 (13.0 to 54.8)	Lifestyle diseases
	9 Depression	723.6	20.4 (-7.5 to 44.2)	Psycho-neurologic disease
	10 Bronchial and lung cancer	675.0	-36.6 (-42.9 to -30.5)	Cancer
	11 Liver cirrhosis	580.6	29.3 (22.6 to 35.7)	Digestive organ
	12 Mouth disease	578.2	39.9 (8.0 to 63.0)	Other non-infectious disease
Injury	13 Neck pain	575.1	9.7 (-26.1 to 37.1)	Gerontology & dementia
	14 Colorectal cancer	552.8	-25.7 (-33.3 to -18.6)	Cancer
	15 Visual disturbance	512.7	33.8 (6.1 to 55.3)	Gerontology & dementia
	16 Pancreatic cancer	500.6	18.7 (15.7 to 21.3)	Cancer
	17 Headache	489.5	-17.1 (-74.1 to 24.2)	Psycho-neurologic disease
	18 Chronic kidney disease	475.2	-8.4 (-23.2 to 5.6)	Lifestyle diseases
	19 Disorder of the newborn	433.9	14.2 (-10.8 to 35.0)	Growth
	20 Chronic obstructive pulmonary disease (COPD)	425.4	-47.4 (-68.2 to -28.4)	Respiratory organ

* GBD 2017. *Lancet* 2017; 392(10159): 1859-922.

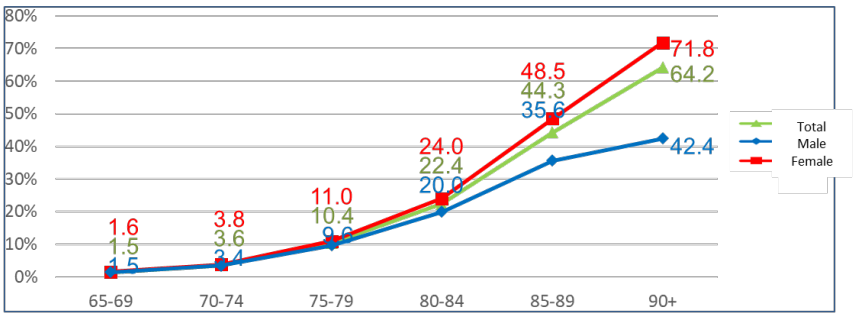
Dept. of Community & Global Health, Graduate School of Medicine, the University of Tokyo (including data not released in paper)



(Source) Ministry of Health, Labor and Welfare "Overview of Reiwa 2nd Year (2020) Vital Statistics Monthly Report (Approximate Number)"

Fig.2. Prevalence rate of dementia by age group and the estimated number of people with dementia

Prevalence rate of Dementia by Age Group (Based on the Ten Thousands Cohort Research)



Results of the cohort study for dementia prevalence rate at Hisayama-cho (Fukuoka pref.), Nakajima-cho (Ishikawa pref.) and Nakayama-cho (Ehime pref.) by "Japan Prospective Studies Collaboration for Aging and Dementia (JPSD-AD)", Research and Development Grants for Dementia, Japan Agency for Medical Research and Development (AMED) (Number of cases: 5,073 persons)
Made based on the data provided from principal investigator, Dr. Ninomimya, Kyushu University

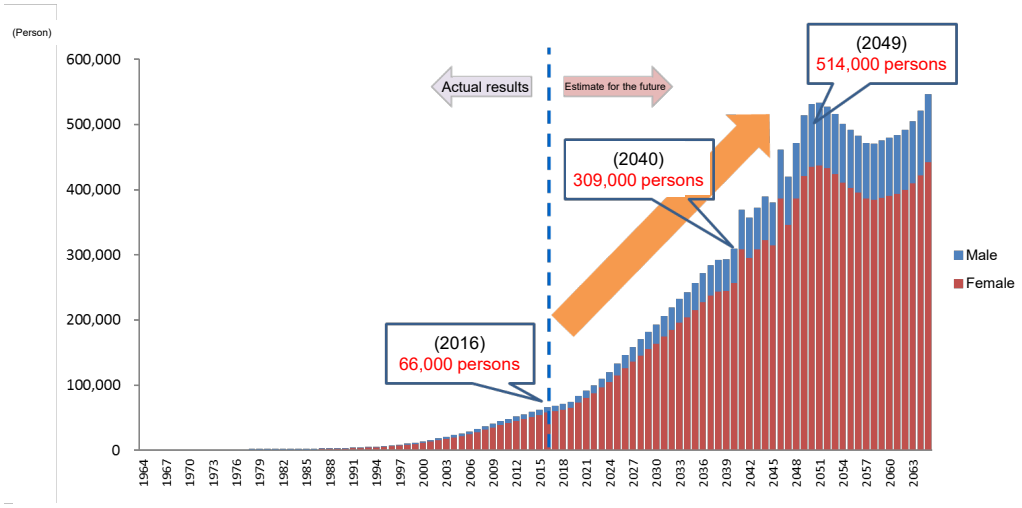
Estimated Number of People with Dementia

Year	2012	2015	2020	**2025**	2030	2040	2050	2060
Future projections when the prevalence of dementia at each age is constant # in million / Rate	4.62 15.0%	5.17 15.2%	6.02 16.7%	**6.75** **18.5%**	7.44 20.2%	8.02 20.7%	7.97 21.1%	8.50 24.5%
Future projections when the prevalence of dementia at each age increases (※) # in million / Rate		5.25 15.5%	6.31 17.5%	**7.30** **20.0%**	8.30 22.5%	9.53 24.6%	10.16 27.0%	11.54 33.3%

"The Research on the Estimated Number of People with Dementia in Japan" (Health and Labour Sciences Research Grants, Special Research Project in FY2014. Prof. Ninomiya, Kyushu U.)
(※) The research found out that age, sex, and the prevalence of the lifestyle disease (diabetes) affect the prevalence of dementia based on the model based on Hisayama town research. In this estimation, the prevalence of diabetes is assumed to increase by 20% by 2060.

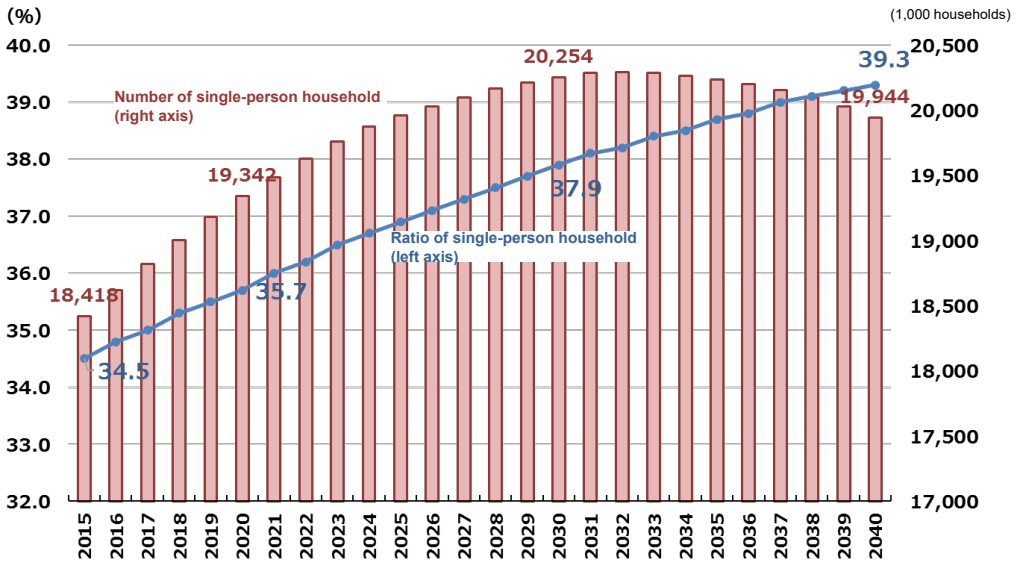
As a result of declining birthrate and aging population, three major metropolitan areas which enjoyed the population bonus now enter a rapid aging situation. Particularly in Tokyo, the ratio of increase in hospital and nursing care needs is the highest nationwide, threatening the outflow of medical and nursing care providers from a locality. In provincial areas, on the other hand, the declining population advances "a sponge effect of provincial cities" and lower density of DID (densely inhabited district), making it difficult particularly for hilly and mountainous areas to maintain a village function. Fund outflow as a result of service transfusion from Tokyo will also become the norm.

Fig.3. Annual changes of people aged 100 years and older



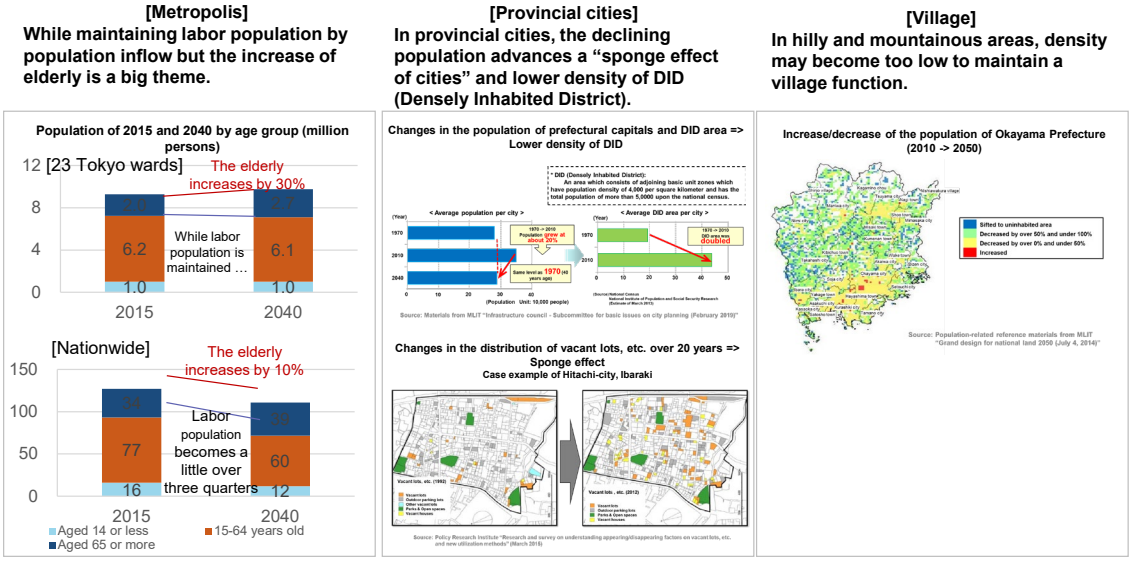
(Source) Ministry of Health, Labour and Welfare “Annual changes of people aged 100 years and older by gender” National Institute of Population and Social Security Research “Estimated future population of Japan” (Estimate of April 2017)

Fig.4. Changes in the ratio and number of single-person household



(Source) National Institute of Population and Social Security Research “Future estimated number of households of Japan (National total): Prepared by estimate of 2018

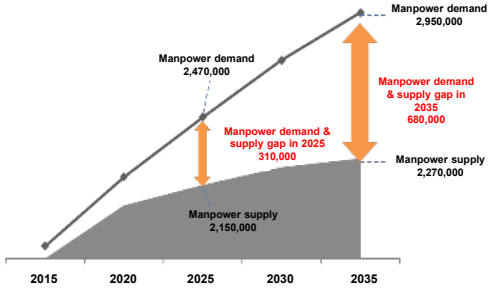
Fig.5. Medical issues of urban and provincial areas



(Source) National Institute of Population and Social Security Research "Estimated future population of Japan" (Estimate of 2017), Prepared based on the summary of primary and secondary reports of Ministry of Internal Affairs and Communications, Regional Governments Strategy 2040 Initiative Study Group

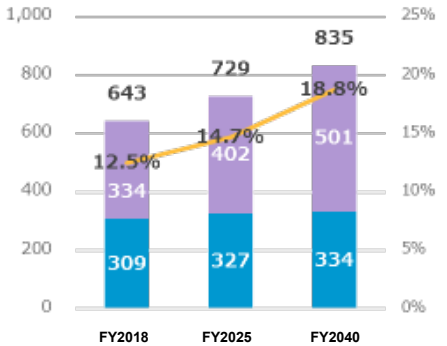
Under such circumstances, while medical and nursing care demand increases explosively in urban areas, the withdrawal of hospitals and nursing homes is highly likely in provincial areas. Particularly for nursing care, the demand will increase year after year as the number of the elderly increases and the total population of those dependent on care will hit 10 million in 2035. Consequently, the labor shortage in the nursing care industry will amount to 680,000 people and to fill the gap, one out of five workers needs to engage in medical and nursing care industry in 2040.

Fig.6. Changes in manpower demand & supply gap of nursing care industry



(Source) Made from the data 4-1 of the 6th Council on Fiscal and Economic Policy of 2018

Fig.7. Changes in the number of medical and nursing care staff

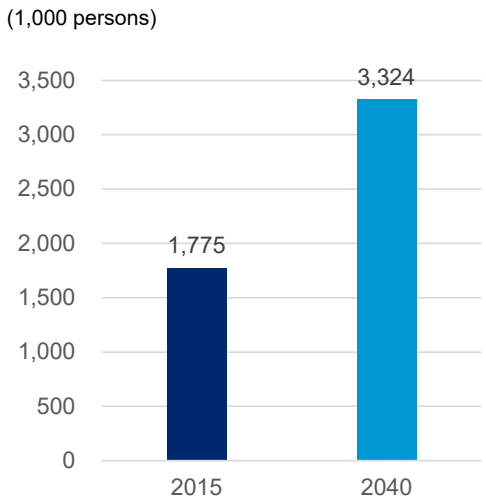


(Source) Made from the data 4-1 of the 6th Council on Fiscal and Economic Policy of 2018

In addition, responding to the labor shortage in Japan, the number of foreign residents is expected to increase and 17.75 million foreign residents as of 2015 are estimated to increase to 33.24 million in 2040. In provincial areas, the growth rate of the number of foreign residents

already exceeds 10%. With the increase of population movement from overseas, the provision of medical systems to meet diverse environments is required in order to cope with the difficulties such as conversing in Japanese.

Fig.8. Estimated population of foreign residents in Japan



(Source) Made from National Institute of Population and Social Security Research "Estimated future population of Japan" (Estimate of 2017)

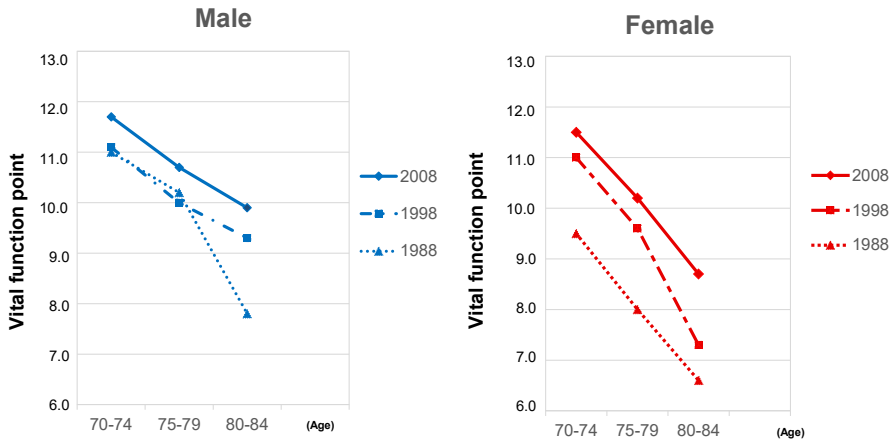
Fig.9. Changes in the number of foreign residents by prefecture

Prefecture	Growth rate by the end of 2018
Kagoshima	15.9%
Shimane	15.3%
Kumamoto	14.7%
Miyazaki	14.5%
Hokkaido	13.9%
Okinawa	13.7%
Aomori	13.0%
Saga	12.1%
Ishikawa	11.4%
Shiga	10.2%

(Source) Immigration Control Bureau of the Ministry of Justice "Number of foreign residents in Japan as of the end of June 2019 (Quick estimation)"

Furthermore, in recent years, there are many senior citizens who still want to work, resulting in the increase of their labor-force participation ratio and subsequent needs for establishing social systems enabling them to participate. For example, according to the survey by the Japan Gerontological Society and the Japan Geriatrics Society, for the current senior citizens, the appearance of the change in physical and psychological functions due to the aging process is delayed by 5 to 10 years compared to 10 to 20 years ago, showing a rejuvenation phenomenon. Under such circumstances, senior citizens who want to work even after 70 years of age account for 80% of them.

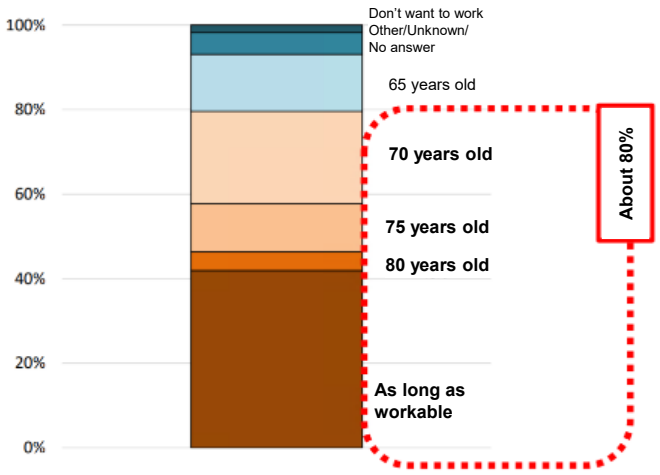
Fig.10. Vital function difference in periods



(Source) Quoted/revised from "Working group report on the study of definition of senior citizens" of the Japan Gerontological Society and the Japan Geriatrics Society

Fig.11. Age group of senior citizens who want to work

- Senior citizens who want to work even after 70 years of age account for 80% of them



(Source) Future Innovation Working Group Interim Summary data (prepared based on the data of Ministry of Education, Culture, Sports, Science and Technology and the Cabinet Office

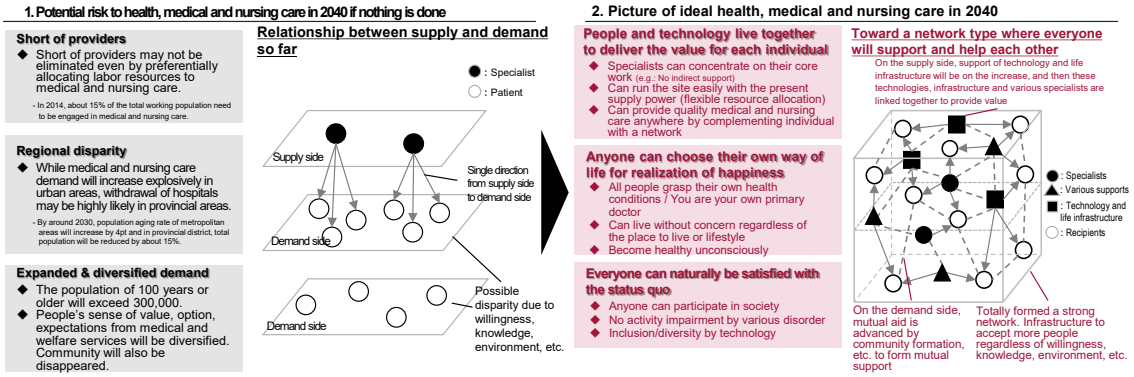
(2) Field/area to be promoted with challenging research and development

Under such circumstances, the environment is sought where people can enjoy life and play an active part in society without health concerns at any age with reducing unhealthy period, the difference between average life expectancy and healthy life expectancy, to zero as much as possible. In particular, we should aim to realize a society where we overcome cancer --the biggest cause of death-- by 2040, for enjoying one's life with relief and release from health concerns until 100 years old (=The society with zero-cancer). Furthermore, we should also aim to realize an inclusive society where people with dementia can live with dignity and hope and everyone including with dementia can support each other and live

together. On the other hand, there is concern about the lack of provider for medical and nursing care systems to support such environment. To maintain such systems, it is important to have medical network systems under which anyone can be a provider and help each other rather than dividing duties between supply side (doctors, nurses, etc.) and demand side (patients and persons requiring nursing care).

It is therefore important to [1] prevent diseases spontaneously in the course of a daily life; [2] establish medical networks accessible to necessary medical care from any place; and [3] realize a society in which QoL can be drastically improved without feeling the load even under a decline of physical and mental function. The field and area to cover these, such as technologies to prevent the onset and aggravation of disease, technologies to measure and predict biological information and promote behavior change, technologies to simplify and automate diagnosis and treatment, establishment of an infrastructure for research and development using data science, technologies to complement and enhance body function and remedy disorder and so on shall be challenged for research and development.

Fig.12. Picture of ideal health, medical care and nursing care

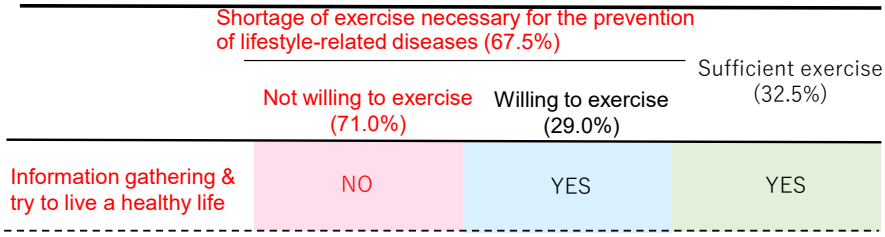


(Source) Future Innovation WG "Message from Future Innovation WG: Realizing the next generation care where people and advanced technology live together to support individual way of life" March 2019

[Realization of a society where everyone can prevent diseases spontaneously in daily life]

There was an opinion that the past preventive measures have so far reached only those who have relatively high health literacy and interest in health and the approaches to those who have low health literacy and low interest in being healthy has been insufficient. In fact, this no-interest population may account for as much as 70% and, with new information gathering on health being almost none, it is considered that their behavior change can hardly be expected.

Fig.13. Interest in health



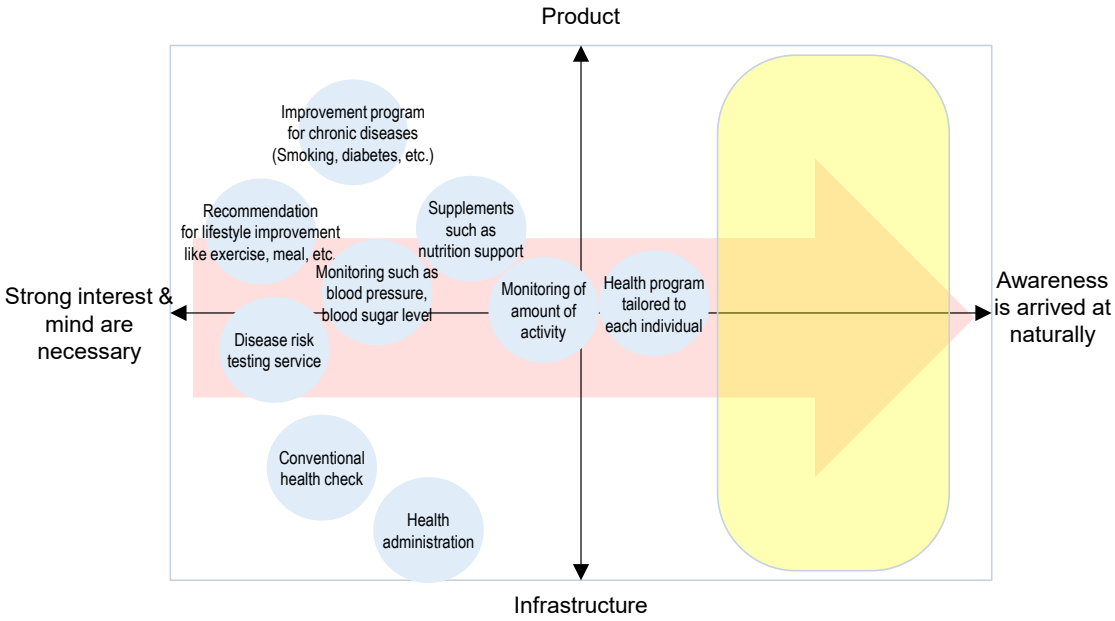
FY2010 University of Tsukuba, Kuno Laboratory (1,914 effective answers)

(Source) Shinya Kuno, University of Tsukuba, Graduate School of Comprehensive Human Sciences "Health points for behavior change project including unconcerned group for healthcare" October 28, 2015 (partly modified)

Therefore, efforts will be made for the development of technology to voluntarily make decisions or change behavior while forecasting future health conditions of each and every one and to have mechanisms embedded to lead to health in every line of daily life.

The importance of exercise, nutrition, sleep, etc. is also pointed out for health maintenance. Focus will also be on the research and development of health maintenance and prevention of onset and aggravation of diseases based on the understanding of the mechanism affecting the homeostasis of biological functions such as immunity and sleep.

Fig.14. Direction to be focused on for realizing a society where prevention is a matter of course in daily life

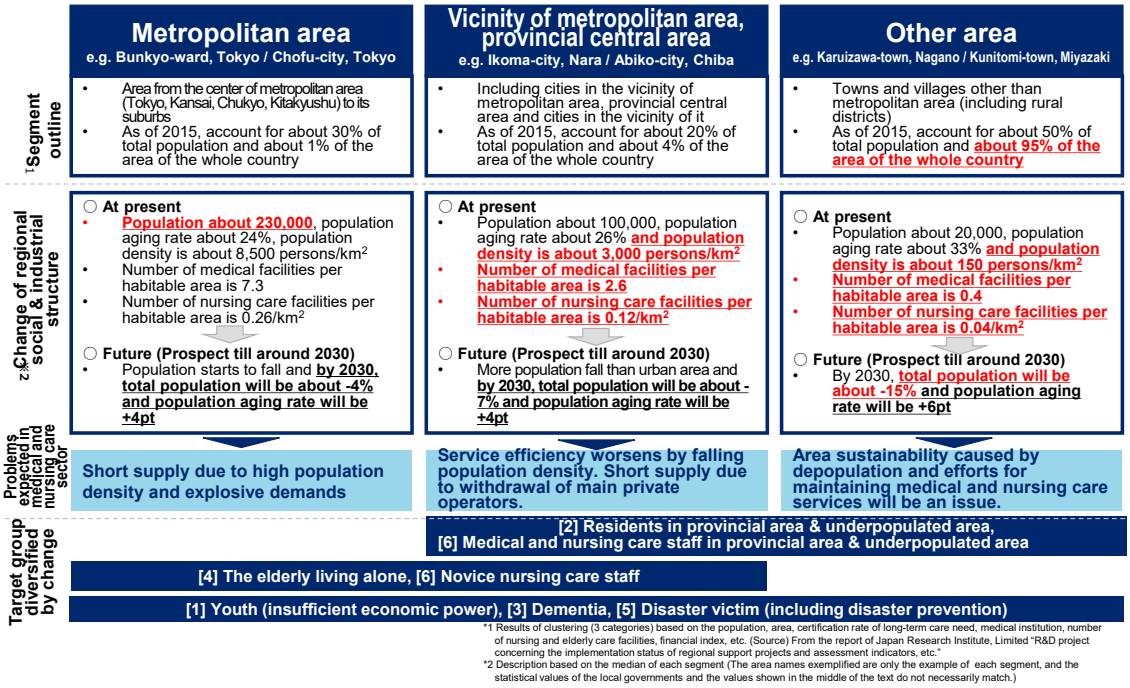


(Source) METI commissioned project "Investigation project on the future priorities in health, medical and welfare sectors in 2040" expert panel data

[Realization of medical networks accessible for anyone from anywhere in the world]

In around 2040, population density will increase in metropolitan areas where medical and nursing care demand will be explosively increase. In provincial areas, on the other hand, deteriorating efficiency of medical and nursing care service and insufficiency of supply by the withdrawal of private operators due to declining population density are envisaged.

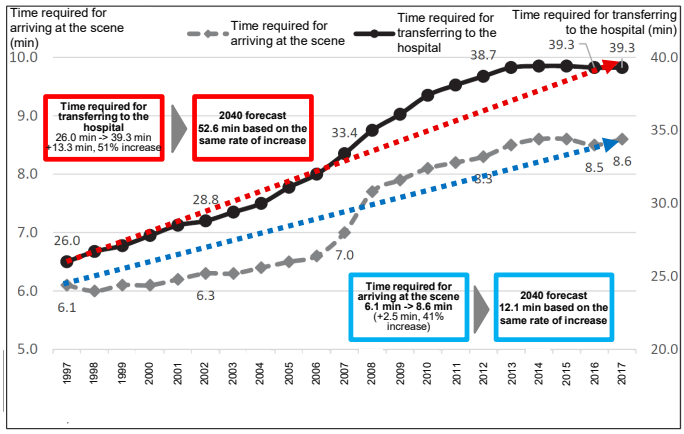
Fig.15. Changes in social structure by regional segment and suggestions



(Source) METI commissioned project "Investigation project on the future priorities in health, medical and welfare sectors in 2040" expert panel data

Under the circumstances, it has become more important than ever to secure access to medical care centering on provincial areas in light of already increased time required for transferring to the hospital for critical care. It is also pointed out that, due to the shortage of specialist medical teams and insufficient emergency response, there is significant regional disparity in the death rate of acute diseases, leading to higher death rate in provincial areas.

Fig.16. Relation between time required for transferring to the hospital and aggravation of disease



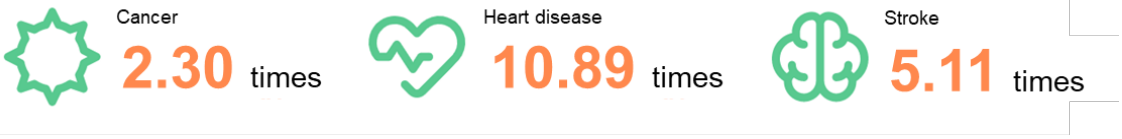
(Note) Due to the effects of the Great East Japan Earthquake, compiled by excluding the data of Kamaishi Otsuchi District Administrative Affairs Union Fire Department and Rikuzentakada-city Fire Department Headquarters for 2010 and 2011.

Elapsed time for over 50% death rate (guideline)

Symptom	Time
Cardiac arrest	3 to 5 min
* Time required for arriving at the scene as of 2017	8.6 min
Respiratory arrest	About 10 min
Copious bleeding	About 30 min
* Time required for transferring to the hospital as of 2017	39.3 min

(Source) Fire and Disaster Management Agency “Present situation of lifesaving and rescue, 2018 version”, Hokkaido Kushiro General Subprefectural Bureau website “Your first aid - Six minutes to save a life”

Fig.17. Regional disparity of death rate



(Source) Fire and Disaster Management Agency “Present situation of lifesaving and rescue, 2018 version”, Hokkaido Kushiro General Subprefectural Bureau website “Your first aid - Six minutes to save a life”

It has also become more important to secure medical care access particularly at the time of disasters as shown by the higher death rate in patients undergoing dialysis for diabetic retinopathy in the Great East Japan Earthquake due to damages caused to medical institutions. Amid the probability as high as 70% for Nankai Trough Earthquake or Tokyo metropolitan earthquake to occur within 30 years to come, reinforcement of medical care access upon such disasters is also imperative. It is also assumed that a new infectious disease may spread, and securing medical access upon the occurrence of a pandemic will be required.

Table 1. Ratio of patients who need to visit hospitals regularly

	Disease name	Ratio in outpatients
1	Hypertension	15.2%
2	Diabetes	7.3%
3	Dental disease	6.5%
4	Unknown	6.4%
5	Low back pain	6.3%
6	Other	4.7%
7	Eye trouble	4.1%
8	Hyperlipidemia	3.8%
9	Depression, other mental diseases	3.1%
10	Joint disease	2.7%

Problematic diseases

(Source) MHLW “2016 National Livelihood Survey”

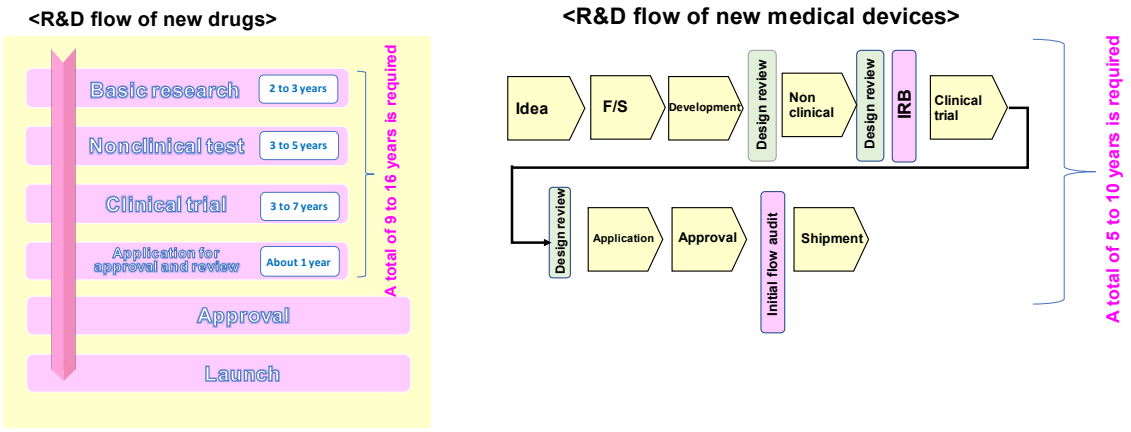
Table 2. Comparison of death rate of dialysis patients in the three Tohoku prefectures

	Total number of deaths			Rough death rate		
	2010	2011	Up year-on-year	2010	2011	Up year-on-year
Iwate	317	334	3.5%	11.0%	11.5%	0.5%
Miyagi	459	524	16.2%	9.6%	10.8%	1.2%
Fukushima	441	494	15.3%	9.6%	10.9%	1.3%
Average of three Tohoku prefectures	1,217	1,352	12.4%	9.9%	11.0%	1.1%
Average of four Shikoku prefectures	1,120	1,166	4.1%	10.3%	10.5%	0.2%
National average	28,882	30,743	6.4%	9.8%	10.2%	0.4%

(Source) The Japanese Society for Dialysis Therapy “Academic study report on the Great East Japan Earthquake – Proposal for dialysis medical development upon disasters”

In terms of an access to drugs and medical devices, the state of being already approved for use in overseas while use is not approved yet in Japan, or so-called “drug lag” and “device lag”, is being improved by the initiatives taken so far. In the meantime, there has been little change in the fact that drugs and medical devices still take a long time from the research stage to their market launch and their success rate is not so high, either. Drugs take 9 to 16 years and medical devices (particularly those of which safety and effectiveness need to be evaluated carefully) take 5 to 10 years of R&D period. It is anticipated to accelerate each stage of R&D and achieve higher accuracy to streamline each process for the reduction of the R&D period and promote regulatory science at the same time, thereby improving access to innovative drugs and medical devices.

Fig.18. R&D period for drugs and medical devices

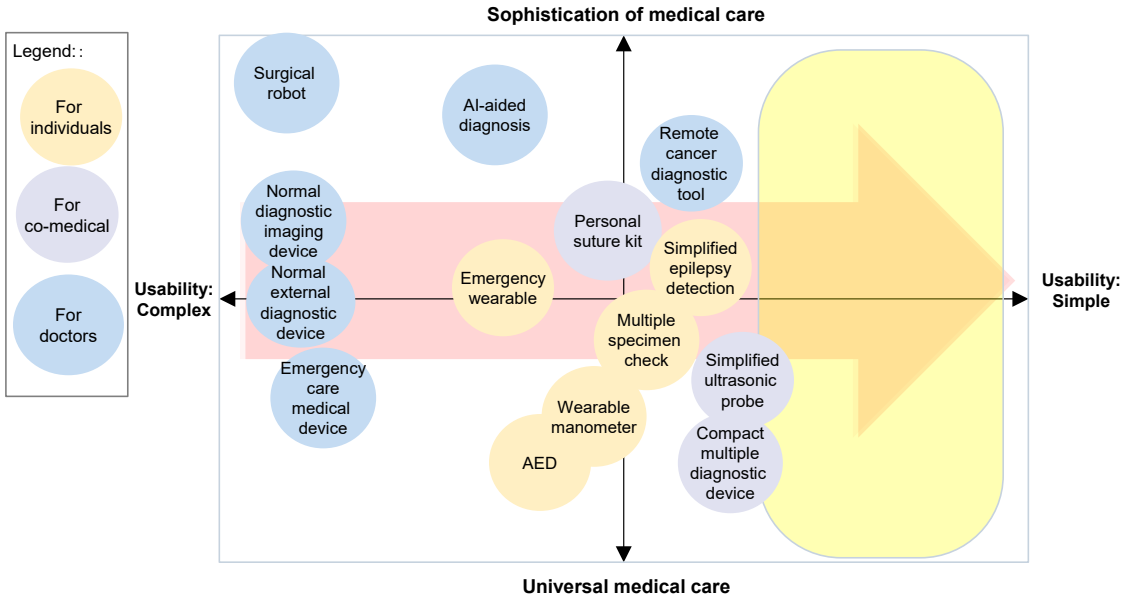


Source: Website of the Japan Pharmaceutical Manufacturers Association

Source: Medical Engineering Technology Industrial Strategy Consortium & The Japan Federation of Medical Devices Association "Medical Devices Regulatory Science Handbook"

In light of those social issues, efforts will be made to significantly reduce development period for drugs and medical devices and develop methods for radical treatment and precision medicine for major diseases. At the same time, exert efforts to realize technologies to provide high-quality medical and nursing care for anyone regardless of the skills of medical and nursing care staff and to establish infrastructure accessible to necessary medical and nursing care regardless of where one lives and even at the time of disaster or emergency.

Fig. 19. Direction of emphasis for realizing medical networks accessible to necessary medical care from anywhere in the world

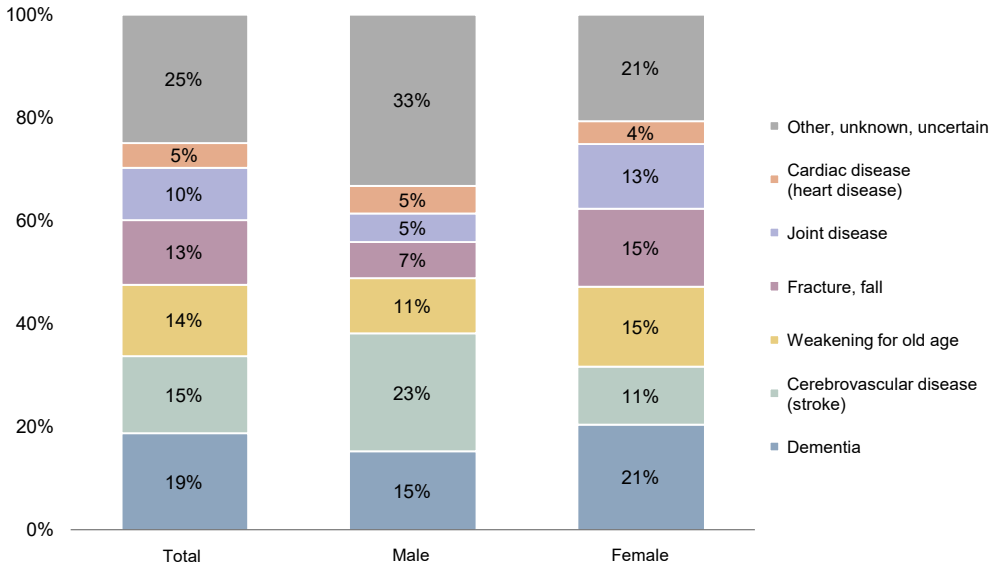


(Source) METI commissioned project “Investigation project on the future priorities in health, medical and welfare sectors in 2040” expert panel data

[Realization of drastic improvement of QoL without feeling load (realization of an inclusive society without health disparity)]

The three of dementia, cerebrovascular disease and weakening due to old age account about half of the reason for becoming care-requiring conditions and it is imperative that the measures have to be taken for these diseases.

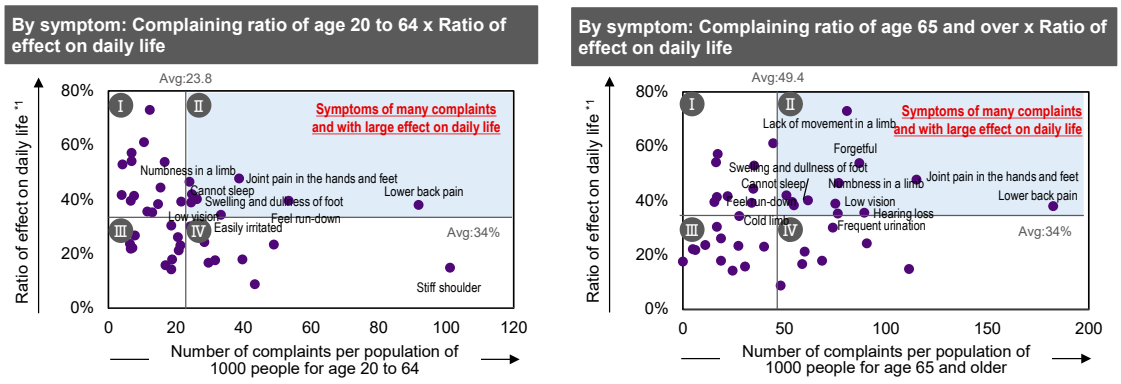
Fig.20. Care-requiring factors for 65 years or older by sex



(Source) Made from MHLW “FY2016 National Livelihood Survey”

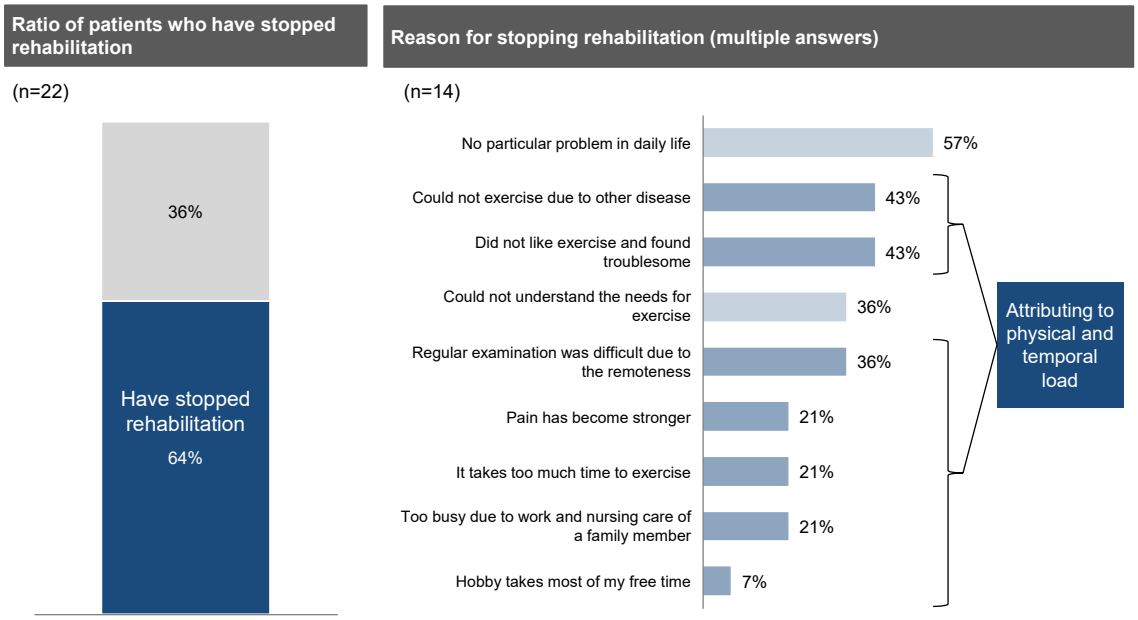
On the other hand, there are many who appeal a pain or visual and auditory sense disorder in the working generation between 20 and 64 years of age and, as a symptom to affect a daily life, backache and joint pain in the hands and feet are listed. In addition, upon becoming 65 years or older, symptoms like feeling listless and sleeplessness are added. Therefore, reducing factors of QoL are considered not only by a simple disease but by symptoms of physical disorder. Besides, there are many who give up rehabilitation for remedying such disorder for reasons of its difficulty, pain and lack of effects.

Fig.21. Relationship between complaining ratio by symptom and effect on daily life by generation



(Source) Made from MHLW “FY2016 National Livelihood Survey”

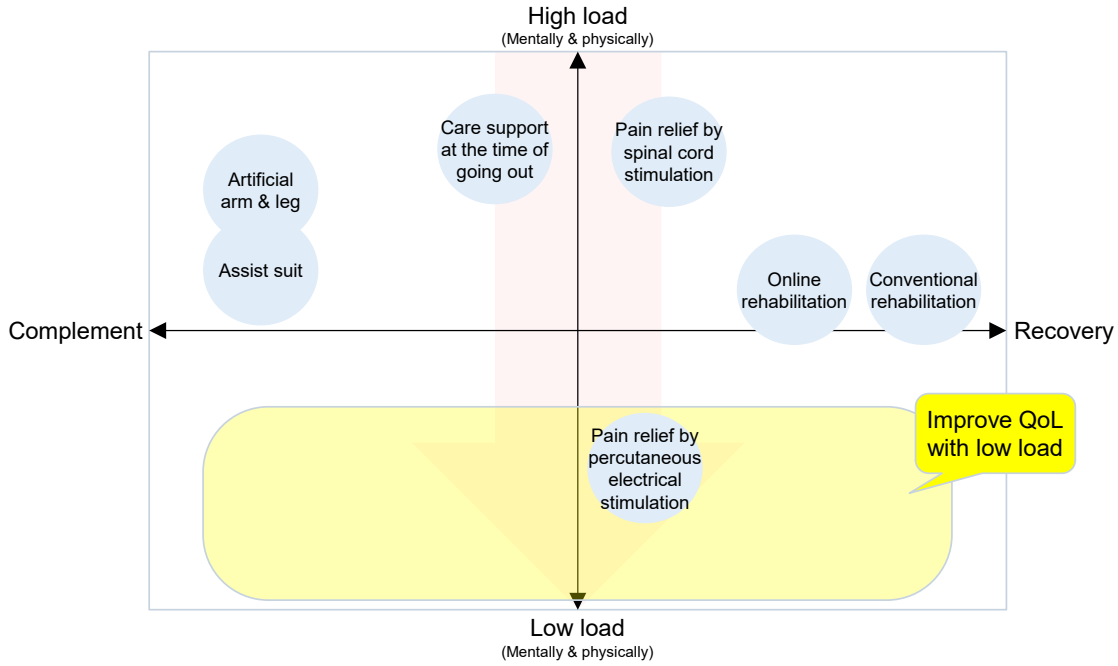
Fig.22. With/without suspending rehabilitation and its reason



(Source) Made from Ken-ikukai Group research case example “Present situation and issues of outpatient rehabilitation”

Therefore, technologies will be developed to expand and complement physical functions, leading to the drastic improvement of QoL with reduced load, independent life at home without relying on nursing care and for everyone to enjoy life until 100 years old.

Fig. 23. Direction of emphasis for realizing drastic improvement of QoL without feeling load



(Source) Data of expert panel, “Investigation project on the future priorities in health, medical and welfare sectors in 2040”

(3) Research subject for attaining the goal

In the Moonshot Research and Development Program, establish the field and area of challenging research and development, and promote challenging research and development to contribute to “Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one’s life with relief and release from health concerns until 100 years old.” At the R&D, it is important to control the "chronic inflammation", which has been known as the basis of the onset of age-related diseases that are having a great impact on the people. In addition, in order to adopt the most efficient and effective means, research the latest scientific trends and put them to good use in promoting the research and development.

Specifically, the following R&D will be promoted.

[Realization of a society where everyone can prevent diseases spontaneously in daily life]

Research and development to collect and analyze mental and physical data accurately to promote behavior change based on individual characteristics and research and development for the prevention of the onset and aggravation of diseases based on the understanding of biological function such as immunity, sleep, etc. are envisaged.

[Realization of medical networks accessible for anyone from anywhere in the world]

Research and development for elimination of medical blank even at the time of emergency and disaster to drastically reduce the death rate and aftereffect and, at the same time, R&D

to eliminate problem of medical and nursing care provider shortage and R&D leading to substantial reduction of development period for drugs, medical devices, etc. are envisaged.

[Realization of drastic improvement of QoL without feeling load (realization of an inclusive society without health disparity)]

In addition to enabling independent life by maintaining and improving health conditions, R&D is envisaged to maintain QoL by complementing the physical and mental functions even upon the occurrence of disorder.

Regarding moonshot type R&D for the realization of the society with zero-cancer (=Japan Cancer Moonshot) and for overcoming dementia, the R&D should be promoted comprehensively with ensuring synergistic effects between projects towards achieving the goal.

In order to attain the goal, various research approaches will become important such as the fusion between basic research and practical research, fusion between medical research and research of other field as well as adoption of the latest knowledge, data sharing and utilization. The R&D will be promoted toward the attainment of goal by adopting various knowledge and ideas and evaluating them at each stage gate.

In addition, with a view to smooth social implementation of research results, study a structure in which researchers of various fields can participate on the changes in social systems at home and abroad, and ethical, legislative and social issues.

(4) Direction of research and development toward attainment of Goal

○ 2030

[Realization of a society where everyone can prevent diseases spontaneously in daily life]

Develop technologies to monitor all living body trends with lower physical and mental load.

[Realization of medical networks accessible for anyone from anywhere in the world]

Establish a technology platform to provide quality medical and nursing care suitable for each individual appropriately even with less providers by developing compact, speedy and high-sensitivity diagnostic and treatment devices as well as technologies to further enhance doctors' medical opinion and diagnostic capability.

[Realization of drastic improvement of QoL without feeling load (realization of an inclusive society without health disparity)]

Develop technologies to improve body function through load-reducing rehabilitation and support self-reliant life at home and to improve ailing living biocontrol systems.

○ 2040

[Realization of a society where everyone can prevent diseases spontaneously in daily life]

Establish infrastructure to maintain good mental and physical health by developing technologies, in order to stay healthy and prevent the onset and aggravation of diseases by

regulation of immune systems or sleep, etc., to visualize individual physical and mental state in daily life and urge people to voluntarily take healthy maintenance actions most suitable for them.

[Realization of medical networks accessible for anyone from anywhere in the world]

Establish a medical network to provide the same level of medical care as a normal time regardless of region and even upon disasters and emergencies by developing diagnostic and treatment devices for simple tests and treatments at home, etc. and diagnosis- and treatment-free technologies for part of chronic diseases by 2040. In addition, develop methods for radical treatment and precision medicine for diseases such as cancer and dementia by substantially reducing the development period of drugs and medical devices, etc. through establishment of data science and evaluation systems.

[Realization of drastic improvement of QoL without feeling load (realization of an inclusive society without health disparity)]

Establish a social infrastructure to enable self-reliant life at home without depending on nursing care by developing such technologies as the recovery of body function with rehabilitation without feeling load, normalization of ailing biocontrol systems, regeneration or substitution of weakened organs and so forth.

In order to realize sustainable care systems to overcome major diseases by 2040, for enjoying one’s life with relief and release from health concerns until 100 years old, after establishing technologies to prevent the onset and aggravation of diseases, technologies to measure and predict biological information and promote behavior change, technologies to simplify and automate diagnosis and treatment, establishment of an infrastructure for research and development using data science, technologies to complement and enhance body function and remedy disorder and so on, it is necessary to sophisticate technologies so that the implementation scene can be expanded from specific environments to a daily life and general medical and nursing care fields. To this end, the target at the time of 2030 will be the goal to the practical stage under basic technologies and specific environments.

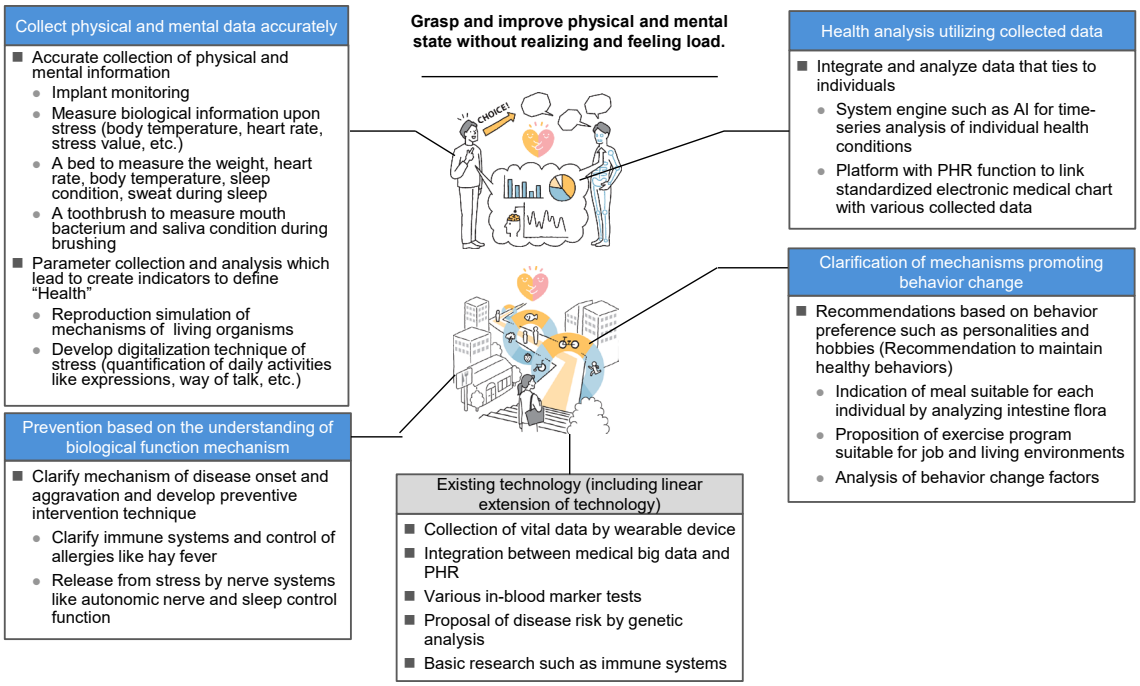
<Reference: Analysis for the attainment of goal>

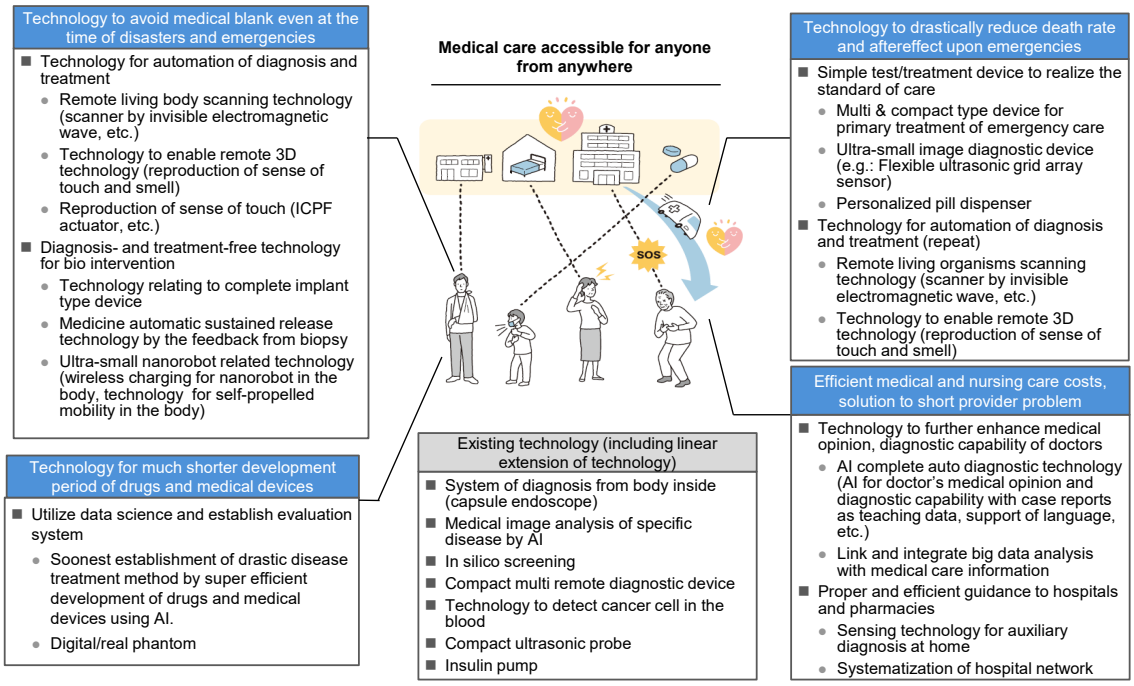
The analysis based on the hearings of experts is summarized as follows.

(1) Structure of field and technology groups concerning the Goal

Technology groups for each target are shown in the following figure. Under this Goal, research and develop necessary technology component and it is also necessary to integrate and use/utilize them, for which challenging research and development are required.

Fig. 24. Research and development example of each target





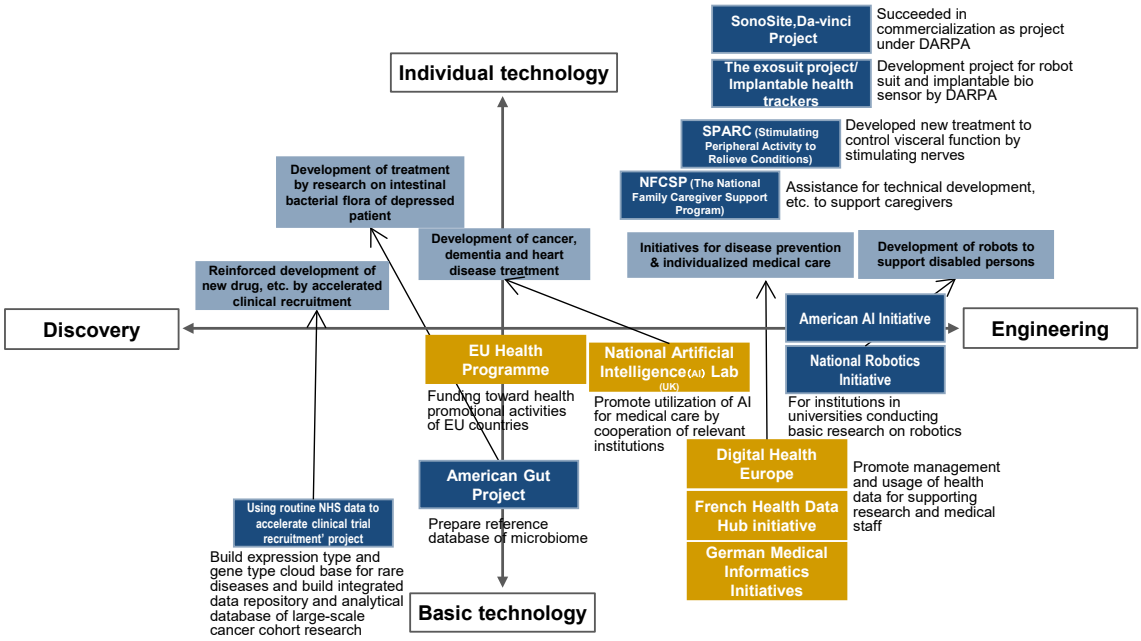
(Source) METI commissioned project "Investigation project on the future priorities in health, medical and welfare sectors in 2040" expert panel data, partially revised

(2) Trends of related research and development

[1] Moonshot-type research and development in the world health and medical fields

The following exists as research and development similar to the Moonshot R&D Program in the world health and medical fields.

Fig. 25. Moonshot-type R&D in the world health and medical fields



(Source) METI commissioned project “Investigation project on the future priorities in health, medical and welfare sectors in 2040” expert panel data

[2] U.S. major project “Precision Medicine Initiative”

This is the new and bold research initiatives to revolutionize the advancement of health and treatment of disorder announced by President Obama in his State of the Union address of 2015 and long-term research activities involving the National Institute of Health (NIH) and other multiple research centers.

Aiming to develop a new patient-led research model for possible promotion of biomedical discoveries and provide clinicians with new tools, knowledge and therapies for the selection of the best therapy for each patient, the U.S. research cohort comprising one million volunteers or more was created. All of Us Research Hub was launched as a research base where data management is underway. The U.S. Congress has approved US$1.455 billion for 10 years from 2016.

Table 3. Data available for researchers of All of Us

Data available for researchers of All of Us	
Data source	**Details**
Present information	
Health survey	The first survey includes sociodemographic characteristics, overall health, lifestyle and information on the use of substances, and subsequent module covers individual and family medical history and access to medical care.
Body measurement	Prior protocol measurement includes blood pressure, heat rate, weight, BMI, hip and waist size.
Living body sample	Blood and urine samples are tested on DNA, RNA, cfDNA, serum and blood plasma. If blood sample cannot be obtained, saliva sample is used.
Electronic health record	The first capture of structured data includes invoice code, medical history, test results, vital sign, and records from medical provider organization. In the pilot research, Sync for Science and other data collection by health data aggregator are tested.
Digital health information	Data can be captured from compatible devices owned by participant like Fitbit. Interaction is being studied between pilot research of other device and health app.
Future information	
Health survey	Additional module including the survey on the factor determining the social action of health is under development.
Bioassay	Pilot research of genotyping and total genomic sequence will be started by the beginning of 2020. Additional pilot test of bioassay is planned.
Medical bill invoicing data	A system to use invoicing data such as invoice code and medication data is under development.
Geographical space and environmental data	These types of data include geographical space linkage to measurement values such as meteorology, air quality, pollutant data level, and census data. Assay of exposure and measurement of sensor base are being studied.
Other information	Voluntary donation of data from social network (Twitter feed, etc.) and additional living body sample collection are being studied.

(Source) The NEW ENGLAND JOURNAL of MEDICINE 'The "All of Us" Research Program'

[3] U.S. major project "Cancer Moonshot"

Cancer Moonshot is a large national project announced in January 2016 for the purpose of the prevention, early detection and improvement of treatment of cancer. This is an initiative with the National Cancer Institute (NCI) playing a major role under direct control of the National Institute of Health (NIH) and the U.S. government approved fund provision to the Cancer Moonshot for US$1.8 billion in seven years from 2016, which is to be appropriated to NCI in each financial year over seven years.

Specifically, the Blue Ribbon Panel (BRP) established as a working group of the National Cancer Advisory Board (NCAB), a specialist group appointed by the President, reported ten innovative recommendations in order to achieve ambitious target of the Cancer Moonshot whereby the progress equivalent to ten years in the prevention, diagnosis and treatment of cancer would be made in five years and research implementation team was launched in acknowledgement of it. In addition, jointly with 11 major bio pharmaceutical companies, Partnership for Accelerating Cancer Therapies (PACT), a cooperative research by the public and private sectors, was established under the budget of US$215 million for five years, and then initiatives with unified effort of public and private sector took place.

Table 4. Budget by category for fiscal 2018 in Cancer Moonshot

<Budget by category for fiscal 2018>

Research category	Budget (USD)
Network for direct engagement with patients	864,531
Translational science network of immunotherapy for cancer	67,643,470
Identification of therapeutic target to overcome refractoriness to cancer therapy	4,005,166
Building national cancer data eco system	9,557,020
Fusion cancer protein in childhood cancer	37,358,770
Research for minimizing debilitating side effects of cancer therapy	32,162,876
Prevention and early detection: Implementation of approach based on evidence	32,547,322
Retrospective analysis of living body sample from patients who received standard therapy	8,370,414
Preparation of human tumor atlas	74,246,242
Development of new cancer technologies	38,356,361
Total	**305,112,172**

(Source) NIH National Cancer Institute

[4] U.S. major project “Development of Da-Vinci, a surgery supporting robot”

In the latter half of the 1980s, for the realization of a remote surgery of soldiers in a battle field, the U.S. Army requested SRI International to develop it, which was an organization developing various element technologies used for remote robots at that time as a project under DARPA (Defense Advanced Research Projects Agency).

Under the supervision of DARPA, with the investment for about JPY300 million per month since 1995, Intuitive Surgical Inc. has developed a world most practical surgery supporting robot whereby a doctor operates by remote-controlling a robot arm looking at the 3D image obtained by an endoscope. It was commercialized in 1999 by Intuitive Surgical Inc., a venture capital company established in Silicon Valley, and received FDA certification in 2000.

(3) Strength of Japan and overseas trends

Table 5 shows comparison of the present situation and trends between Japan and other major countries. According to the reports, etc. from the Center for Research and Development Strategy, Japan Science and Technology Agency (JST-CRDS), the main trends of relevant research and technology fields are as follows.

In the field of immunological science, Japan shows strength in biochemically and molecular

biological mechanism research but falls behind others in the next generation immunological basic research such as immune informatics and immunity engineering. According to the 2016 survey by Thomson Reuters, Japan's immunology is ranked 5th in the world in the citation rates for theses, which is the highest in all Japanese biological sciences area and at the same rate as materials science and chemistry. Contribution of immunology in Japanese science is still high but trends are on the decrease when considering the departure of the youth from immunology and the lack of fund. In the field of development, there is no Japanese seeds-derived biopharmaceuticals that follows Actemra and Nivolumab. The Japan's original seeds of new type treatment technologies such as CAR-T and TCR-T are extremely limited and the fact is that overseas technologies are gradually making inroads into Japan and clinical trials are being started. To break through this situation, it is imperative that the basic research in Japan is revitalized.

In the field of time science (biological clock), Japan is a front runner in the world in basic study such as the discovery and molecular mechanism of suprachiasmatic nucleus (SCN), discovery of mammal clock gene "Per" and 24-hour formation mechanism at the level of clock proteins and leading the world of basic study of RNA-autonomous circadian clock protein. Furthermore, search and identification of sleep and arousal substances are at the world top level and leading the world in the achievement of the discovery of Orexin and elucidation of neural mechanism. As for development, Takeda Pharmaceutical launched melatonin receptor agonist which acts on intracerebral clock centrum as a sleep inducer.

In the field of gerontology, as institutions professing in aging research in Japan, there are National Center for Geriatrics and Gerontology, Tokyo Metropolitan Institute of Gerontology, and Institute of Development, Aging and Cancer, Tohoku University but are mostly for disease research and their scales are not sufficient. For high social needs and necessity for government support, dementia-related R&D are underway by multiple companies in collaboration with national institutes, universities, etc. but the research system is still far from being sufficient when compared to the U.S. and Europe including uncertainty of the research support. In anti-aging medical care as a whole, activities of domestic companies are predominantly low as compared to Europe and America.

With regards to the field of healthcare IoT, Japan is promoting R&D of devices, materials and measurement technologies in the world-leading medical measurement field mainly by universities and public research institutions. The R&D are underway at universities and companies on minimally invasive diagnostic devices using interstitial fluid for biological sample, bio-device using noninvasive biological gas, and power supply, sensor and material for wearable devices. In addition, it draws high attention as exemplified by the presentation of medical diagnostic devices by large and midsize companies of Japan and there are many who are studying new entry.

In the field of measurement data analysis, while basic study is active in Japan on medical image processing, etc., there is restrictions on the data to be handled and shortage of absolute number of participating researchers. Various measures have been taken in Japan for the strengthening and acceleration, but we are far from being advantageous in light of many countries of the world investing a huge sum of fund and vigorously promoting their research. However, it has become an essential domain in promoting every field of science

and we need to take initiatives strategically.

In the field of regenerative medicine, Japan has so far reported many world-leading important study reports including establishment of human iPS cell, large scale culture of ES cell, and establishment of organoid. Furthermore, in recent years, the development is accelerating for clinical researches and clinical trials and Japan is trailing only U.S. in the number of clinical trials using pluripotent stem cell. Japan implemented the first clinical research by transplanting autologous iPS cell, thus leading the world in the application of iPS cell. On the other hand, Japan trails in regenerative medicine using other cell strain and not depending on cell therapy and so forth.

In the field of diagnostic drug and biomarker, expectations are high on liquid biopsy in the diagnosis area but Japan, with insufficient study results on human, got a late start compared to other countries. Japan has successful cases of new drug to be among the top five in the world but the examination guidelines for new diagnostic drug is much different from those of Europe and America, resulting in insignificant number of successful cases. The small domestic market is also a problem.

In the field of life-style related disease, Japan has strength in kidney disease research with remarkable achievements leading the world in hypoxia, fibrosis and regeneration research, and basic research leading to the clarification of a patient condition of COPD and NASH with achievements equal to those of Europe and the U.S. However, leading those excellent basic research results to clinical trial and actual application requires a huge amount of fund and it is therefore difficult to develop independently in Japan.

In the field of psychiatric and neurological disorders, milestone researches have been made in the basic neuroscience ahead of the world such as development of fMRI and PET ligand for intracerebral molecule and basic researches for neural circuit visualization of marmoset and protein visualization in the neurodegenerative process, influencing the trends of psychiatric disorder research. Also, Japan exerts efforts in their application to neuro rehabilitation in therapies for neurodegeneration disease and development of near-infrared spectroscopy expected for use as a wearable device, showing a progress close to the U.S. in the decoding technologies in motion and perception systems and application to BMI.

In the field of generic robotics, extensive researches including the development of soft actuator, research on flexible electronics, development of flexible high polymer material along with a treatment system combining high-intensity focused ultrasound with a robot are underway and development of a healthcare device such as a rehabilitation robot, wearable device, etc., applying them is very popular. Amid various surgical robots already commercialized or nearing their commercialization in many countries, the movement of Japan is a bit slow. The world trends of research and technology in medical and healthcare sector is in a process of its center of gravity being shifted from “Medical treatment” to “Prevention” and its subject from “Across-the-board” to “Individualization” and the future direction of study will be toward “personalized medicine” and “predictive medicine” of a whole nation participation type.

When the trends of papers are further reviewed by modalities (technology and technique), among modalities of increasing the number of papers and popularity of researches, Japan is increasing the number of papers particularly in the field of “Wearable device,” “Microbiome,”

"Rehabilitation," and so on. (Source: Web of Science and PubMed of Clarivate Analytics)

Table 5. International comparison of relevant research and technology area

Country, Region	Phase	Immune science		Time science (biological clock)		gerontology		Healthcare IoT (Bio measurement, sensor, wearable)		Measurement data analysis (AI)		Diagnostic agent & Biomarker (liquid biopsy)		Regeneration medicine		Lifestyle related disease		Psychiatric and neurological disorder		Robot basic technology	
		Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend	Present	Trend
Japan	Basic research	○	↘	◎	↗	○	→	○	→	○	→	○	↗	◎	→	◎	→	◎	↗	○	→
	Practical research	○	→	○	→	○	→	○	↗	△	↘	○	↗	◎	↗	○	↘	◎	→	○	→
U.S.	Basic research	◎	↗	◎	↗	◎	↗	◎	↗	◎	↗	◎	→	◎	↗	◎	→	◎	↗	◎	↗
	Practical research	◎	↗	◎	↗	◎	↗	◎	↗	◎	↗	◎	↗	◎	↗	◎	→	◎	↗	◎	→
Europe	Basic research	◎	→	◎	↗	◎	→	◎	→	○	↗	○	→	○	↗	◎	→	◎	→	○	→
	Practical research	◎	↗	○	↗	◎	→	◎	→	○	↗	◎	↗	◎	↗	◎	→	◎	→	○	→
China	Basic research	◎	↗	○	↗	△	↗	○	↗	◎	↗	○	↗	○	↗	○	↗	○	↗	△	→
	Practical research	○	↗	×	↗	△	↗	○	↗	◎	↗	○	↗	○	↗	○	↗	△	→	△	→

(Source) Overview report of JST CRDS research & development Life science & clinical medicine field (2019)
Nanotechnology & material field (2019)

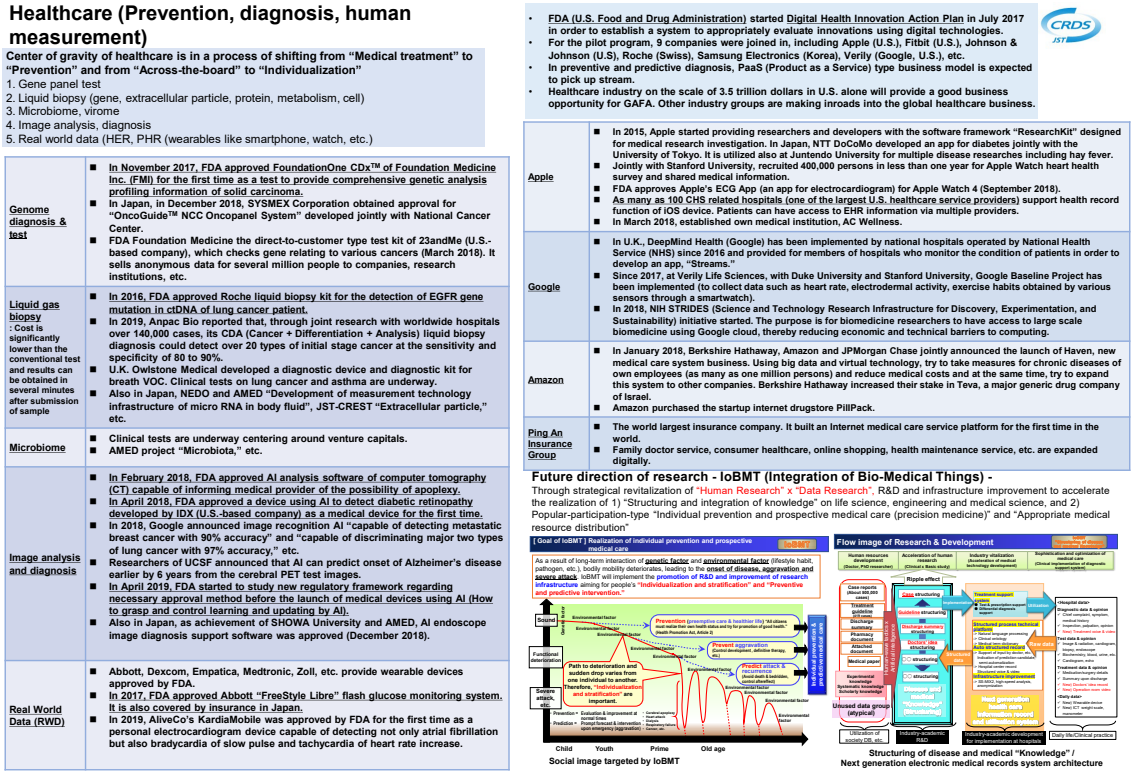
(Note 1) Phase Basic research phase: Base study level at universities, national laboratories, etc.
Practical research & development phase: Technical development level(including prototype development), Mass production technology level

(Note 2) Present * This is not relative assessment based on the present situation of Japan but absolute assessment.
◎: Notable activities and results are seen compared to other countries ○: Activities and results to some extent are seen
△: Notable activities and results are not seen compared to other countries X: Activities and results worthy of special mention are not seen

(Note 3) Trend ↗: Upward trend →: Keeping the status quo ↘: Downward trend

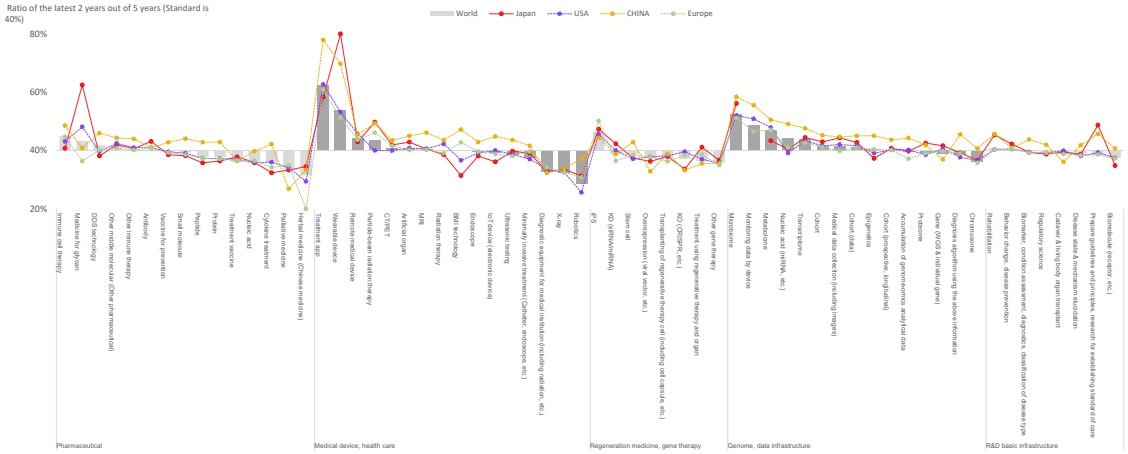
(Source) Center for Research and Development Strategy, Japan Science and Technology Agency (Overview report of research and development) Life science & clinical medicine field (2019)

Fig. 26. Direction of future healthcare research



(Source) Center for Research and Development Strategy, Japan Science and Technology Agency (Overview report of research and development) Life science & clinical medicine field (2019)

Fig. 27. Survey of distribution of papers (Ratio of 2016-2017 to 2013-2017)



(Source) Cabinet Secretariat, Office of Healthcare Policy, The 19th Healthcare Promotion Expert Panel, Reference Data 5 "The Next Generation Medical R&D Promotion Program"