The Economist Intelligence Unit
Healthcare

Medtech and a Vibrant Japan

The role of medical technology in healthcare spending, workforce productivity and economic growth

A report by The Economist Intelligence Unit

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About this research

Japan is facing a demographic transition that would see its workforce shrink in both absolute and relative terms. Low birth rates, limited immigration and world-leading longevity have created a silver-haired population: over a quarter are older than 65 years of age[1], with this rising to a third within 10 years[2]. These numbers have led some to describe Japan as a "hyper-aging" society. The potential implications of this demographic shift include a shrinking labour market and spiralling healthcare costs.

In this environment, it is necessary for Japan to make important decisions around how and where to invest an increasingly limited budget in order to maximise outcomes, especially in Japan's already-stretched healthcare system. Part of this discussion will naturally centre on investment in medical technologies, in the form of devices and diagnostics. Policy makers face a difficult challenge when weighing the cost-benefit of various medical technologies, as direct healthcare costs are easily obtainable, but the gains in both direct avoided downstream healthcare spend and indirect economic contributions are much harder to tease out.

It is with this challenge in mind that the EIU were commissioned by AdvaMed to investigate the total economic impact that medical technology has on Japan. The research was to examine the economic burden of diseases in Japan and, for a range of screening and treatment technologies, quantify their direct and indirect costs compared to non-technology using control groups —in short, do the savings offered by medical technologies outweigh the costs?

The research was conducted in four phases. The first phase was a literature review to quantify the diseases that have the greatest burden on Japanese society, and to identify approaches to model the direct and indirect costs of technologies on the healthcare system and wider society. The second phase consisted of prioritising the specific diseases and medical technologies locally relevant to the Japanese setting. The third phase developed a framework to measure the economic costs and savings of the selected devices versus not using devices, while the final, fourth phase quantified the economic effects to assess the impact of medical technology in Japan.

Our approach used the example of four diseases and eight medical devices to derive findings regarding the impact of medical technologies. While different technologies will offer their own specific costs and benefits, we believe that this broad-based approach of looking at a range of technologies across the most burdensome diseases in Japan will offer fresh insights. The report offers a timely opportunity to illuminate the role medical technology has played in supporting Japan's healthcare service and in harnessing its constrained labour force.

[1] "Japan Statistical Yearbook 2017, Chapter 2: Population and Households", *Ministry of Internal Affairs and Communication, Statistics Bureau*, 2016.

[2] "Population Projections for Japan: 2011 to 2060, table 1-1", *National Institute of Population and Social Security Research*, 2012.

Executive summary

Across many mature economies in Europe and Asia, socioeconomic trends have resulted in aging populations, with profound impact on healthcare systems, workforce, and budget. Japan presents one of the most interesting markets in this regard, as its 'hyper-aging' population – more than 30% of its population is over 60 – is accompanied by population decreases of a million over the previous 5 years[3]. This has resulted in a net workforce decline in both absolute and relative terms, acting as a constraint to its productive capacity, to potential GDP growth, and ultimately to continued economic prosperity. At the same time, an increasing burden of care falls on a disproportionally smaller population.

To mitigate the impact of this second demographic transition, Japan is increasingly looking for ways to better harness the potential of its existing workforce via initiatives that promote healthy aging, increase workforce participation, and retain skilled labour. Healthcare innovations that allow for preventive interventions, early diagnosis, and improved patient mobility and independence are in line with these goals. While there are many pre-emptive levers that can be pulled to enable this – such as diet, exercise and management of mental health – this whitepaper seeks to investigate the impact of medical technology in achieving these goals.

Attention is naturally concentrated around the question of how to invest in health in a way that improves outcomes in a cost-effective manner and increases labour productivity. As such, it is important to consider the impact that medical technology will have on direct and indirect costs to the healthcare system, and to the economy at large. For example, advances in treatment or early diagnosis may impact direct healthcare costs via a reduction in length of hospitalisation, while the indirect impact to the wider economy may arise from patients being able to return to the workforce and a reduction in the burden on informal caregivers.

To study the impact of medical technologies on the Japanese economy, this study focused on four disease areas that have a large burden on Japan: cerebrovascular disease, lung cancer, diabetes mellitus and musculoskeletal disorders. For each disease area, two technologies were assessed—one for screening or early diagnosis, and one for management of the disease. The devices were selected based on the Japanese standard of care and depth of data available around economic contribution per medical device.

[3] "Japan Statistical Yearbook 2017, Chapter 2: Population and Households", *Ministry of Internal Affairs and Communication, Statistics Bureau*, 2016.

Table 1: Medical Devices Investigated

Disease	Medical Technology (Screening)	Medical Technology (Treatment)
Cerebrovascular disease	Carotid Angiography with catheter	Metal mesh cages: Stent retrievers
Musculoskeletal disorders	Dual-energy X-ray absorptiometry	Hip replacement surgery-hip implants
Diabetes mellitus	HbA1c test kit	Insulin pump
Lung cancer	Low-dose Spiral CT scan (CT scanners)	Linear accelerators for external beam therapy

Models were developed for each technology to assess its economic impact, in terms of a) direct healthcare costs and b) indirect wider societal costs. The quantification of relevant costs and the impact of the technology were based on published literature on medical, occupational health and health economics. Where possible, costs were taken from Japanese sources or case studies. Where these were not available, data from non-Japanese sources were used. In-depth interviews with Japanese experts in the relevant disease field were used to validate the cost and impact assumptions. The principal findings, specific to the context of Japan, are as follows:

Medtech interventions for screening and treatment provide overall net savings to the system despite their high up-front costs, with significant savings arising from:

- Greater labour force participation and workforce productivity: Many advances in treatment or early diagnosis allows for a reduction in hospital stays, reduction in disability and/or faster recovery. This allows patients to return to workforce, or it prevents labour force drop-out due to disability.
- Decreased mortality and morbidity rates: The primary goal of any medical intervention is to improve the quality of life and/or to prolong life. This would also result in more productive years, and more intangible benefits such as better mental health.
- Reduced downstream healthcare costs – Technology can facilitate earlier disease detection and provide effective treatments with the potential to reduce the economic burden of disease and the cost of care.
- Greater independent living – Many medical advances allow patients to gain mobility and motility, reducing the need for long-term care. This reduces the need for formal and informal care and releases caregivers into the workforce.

Early diagnosis of stroke, the most common form of cerebrovascular disease, provides net savings of ~¥83k, mostly from avoided healthcare costs and reduced absenteeism.

- Quick diagnosis of stroke reduced the need for acute care totalling ¥85,607 ($820), as speed and accuracy in identifying the location of a bleed or clot increased the favourable outcomes and prognosis of a patient, reducing further healthcare expenditure.
- Better prognosis also allowed patients to return to normal life, reducing absenteeism in the working population and overall average savings of ¥20,159 ($193) across the patient population.

Table 2: Average impact per patient per year, 2016

Disease	Medical Technology	Average savings per patient (JPY | *USD*)
Cerebrovascular disease	Carotid Angiography with catheter	**¥83,935 | *$804***
	Metal mesh cages: Stent retrievers	**¥649,378 | *$6,217***
Musculoskeletal disorders	Dual-energy X-ray absorptiometry	**¥24,347 | *$233***
	Hip replacement surgery-hip implants	**¥2,932,054 | *$28,071***
Diabetes mellitus	HbA1c test kit	**¥113,123 | *$1,083***
	Insulin pump	**¥65,115 | *$623***
Lung cancer	Low-dose Spiral CT scan (CT scanners)	**¥40,299 | *$385***
	Linear accelerators (LINAC) for stereotactic body radiation therapy (SBRT)	**¥448,967 | *$4,298***

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- This more than offsets the direct costs to the healthcare system of ¥21,830 ($209) per patient, as the long lifetime and quick throughput allows the investment in the capital equipment to be spread across a wide patient pool.

Using mechanical thrombectomy (with stent retrievers) in the treatment of strokes sees annual savings of ~¥650k due to increased independence and reduced absenteeism.

- Patients who receive surgical intervention post-stroke are more likely to be independent, reducing their need for caregivers. GDP gains from returning these caregivers to the wider workforce is estimated to be ~¥688,117 ($6,588) annually, a net gain compared to treatment with tissue plasminogen activators (tPA), the universal standard for ischemic stroke.
- Additionally, for working-age patients, they are more likely to return to work, resulting in an increased GDP contribution of ~¥33,381 ($320) annually across the patient pool.
- These gains are only slightly moderated by the additional cost of ¥72,201($691) to the health system for a mechanical thrombectomy annually, spread across the average remaining life span of the patient.

Screening using Dual Energy X-Ray Absorptiometry (DXA) allows early diagnosis of osteoporosis and reduces the incidence of hip fracture, saving an average of ~¥24k.

- DXA scanner allows for early diagnosis of osteoporosis, allowing patients to better manage their disease, reduce the risk of hip fracture and avoid the associated costs of surgery, hospitalisation, and follow-up consultations, resulting in an overall net savings of ¥66,666 ($638) across the patient population.
- This more than mitigates the direct healthcare costs of DXA screening of ¥42,001 ($402).

- GDP contributions in this case is negligible, as most of the patient population are above retirement age.

Hip replacements for patients with chronic musculoskeletal issues allows for increased mobility and reduced reliance on caregivers, which offset direct healthcare costs, resulting in cost savings of ~¥2,900k.

- Hip replacement surgery, as an alternative to pain killers, allow patients to retain mobility and independence, reducing their need for caregivers and allowing them to retain work. This has an estimated net impact of caregivers to GDP of ¥5,572,616 ($53,352) annually per patient.
- Working-age patients are also able to continue to lead more productive lives, resulting in a net GDP contribution of ¥1,350,343 ($12,928).
- However, as in all surgeries, there are GDP losses from hospitalisation and from the inherent mortality risk. This has been estimated to result in a net loss of ¥2,850,401 ($27,290).
- Hip replacements also has a higher treatment expenditure per person of ¥1,140,505 ($10,919), with the cost of the implant spread across the remaining years of the patient.

Early confirmation of diabetes saved ~¥113k, due to reduced absenteeism from better disease management.

- The HbA1c blood test is used to confirm diagnosis of diabetes, allowing patients to be educated about diabetes, reducing sick-days due to disease mismanagement. This will result in an estimated ¥123,568 ($1,183) GDP gain, as patients do not miss work due to bladder infections, joint pains, and dizziness, all symptoms of mismanaged disease.
- The savings of additional follow-up consultations to diagnose the disease total ¥20,890 ($200) and more than offset the direct cost to the healthcare system of ¥10,445 ($100) from the cost of conducting the test.

For the patient population that require insulin, using an insulin pump results in a net average saving of ~¥65k per patient due to reduced absenteeism and reduced caregiver requirement.

- For diabetics, insulin pumps allow better and more accurate insulin administration through both pre-programmed continuous doses and calculated injections based on immediate requirements. Working-age patients are able to manage their disease better and reduce their number of sick days, benefiting the economy by an estimated ¥91,957 ($880) per patient across the patient population annually.
- Risk of early mortality will also decrease in diabetics using pumps as compared to patients managing their disease using syringes, resulting in a net GDP gain of ¥15,332 ($147) across the patient population.

- Additionally, because an insulin pump is meant to be user-friendly, it reduces the need for care. This is an estimated net gain to GDP of ¥78,823 ($755).
- These figures offset higher cost of intervention and long-term care related to insulin pumps compared to traditional vial and syringe method of administration, estimated at ¥120,997 ($1,158).

Early detection of lung cancer saves ~¥40k, mostly from avoided costs of more-advanced cancers.

- The use of low dose CT scans can be used to identify non-symptomatic early-stage lung cancers in high-risk populations (e.g. smokers), allowing for early treatment in roughly 20% of patients who test positive for lung cancer. This avoids the higher costs of later-stage treatment, averaging ¥83,602 ($800) across the screened population.
- Early detection avoids absenteeism that would otherwise result from the developing cancer. As lung cancer progresses, patients are more likely to miss work as a result of debilitating non-specific symptoms, such as worsening coughs and chest discomfort which results in average overall net cost to the economy of only ¥1,523 ($15).
- The cost of the procedure itself is ¥41,780 ($400) per patient, with the long working life and relatively quick throughput moderating the high fixed-capital requirements of the device.

Rescue therapy using linear accelerators (LINAC) in stereotactic body radiation therapy (SBRT) results in a net saving of ~¥450k, mostly from reduced need for palliative care.

- SBRT is used as a salvage therapy for inoperable non-small cell lung cancers, where the alternative is palliative care. This reduces the need for palliative care, saving ¥924,225 ($8,848) annually.
- The reduced mortality also results in continued estimated contribution to GDP of ¥113,004 ($1,082) annually across the patient pool.
- These gains offset the direct costs of LINAC for SBRT to the healthcare system, estimated at ¥588,262 ($5,632) per patient due to high capital costs, multiple consultations and long inpatient recovery.

The results show that for the devices studied, the wider societal and economic benefits in the medium to long term outweigh the direct cost impact on healthcare systems.

1. Introduction: Aging population, stretched healthcare spending

Governments and healthcare providers across the globe are engaged in a persistent contest between competing priorities: to meet the increasing demand for healthcare services, while managing the rising cost of those services, without compromising on quality. This has become an increasingly difficult balance for OECD countries, as healthcare expenditure continues to increase relative to GDP growth, driven by the combination of an aging population, increased prevalence of complex chronic diseases, and expensive technological advances. This places a significant pressure on payers, and in the case of single-payer markets like Japan, the public treasury.

In many ways, Japan is at the forefront of this issue. In addition to the factors above, it has also had to contend with sluggish economic growth and a rapidly shrinking society. After the 'lost decade' in the 1990s, the promise of economic growth in the 2000s has been waylaid by the global financial crisis and by the 2011 earthquake and tsunami. This economic malaise has also been blamed for the historically low birth rate. Coupled with Japan's famed longevity and its strict immigration policies, this has resulted in the shrinking, 'hyper-aging' population of today: 26% of its population is over 65[4], with this increasing to 30% by 2024[5]. Meanwhile, its population is forecasted to decline from 127m in 2015 to 121m over the same time period4, 5. This has amplified the difficulties its healthcare system faces, as it needs to meet the challenge of not only continuing to finance the healthcare system to meet growing demand, but also a potentially dwindling tax base as its workforce shrinks. As a result, initiatives to promote healthy aging, increase female participation in the workforce, and retain skilled labour have gained traction in an effort to harness the thin labour markets in Japan.

Novel medical treatments and innovative technologies offer a way to mitigate the effects of this second demographic transition. Many of these new advancements are aimed at enabling preventative early diagnosis, better disease management, and improving post-procedure independence. While the up-front costs are substantial in many cases, the adoption of these technologies allows the avoidance of even larger costs further down the line. In the interest of the wider economy and society, uptake of cost-effective medical technologies can provide long-term savings and benefits through improved health outcomes, quality of life, and participation in society such that individuals are also able to contribute to their society longer, and do not require caregivers to drop out of formal employment.

[4] "Japan Statistical Yearbook 2017, Chapter 2: Population and Households", *Ministry of Internal Affairs and Communication Statistics Bureau*, 2016.

[5] "Population Projections for Japan: 2011 to 2060, table 1-1", *National Institute of Population and Social Security Research*, 2012.

What is medtech?

Medical technology, frequently referred to as 'medtech', in an umbrella term that describes a wide spectrum of healthcare devices. While the definition of this term can be fluid, for the purpose of this paper, the scope of this term encompasses devices used to diagnose, monitor and treat medical conditions, and includes big-ticket capital investments (e.g. MRI machines), single-use diagnostic tools (e.g. blood sugar monitors), interventional devices (e.g. radiotherapy devices) and implants, amongst others.

Modelling the impact of medtech

Japan has one of the most developed and advanced healthcare systems in the world. Consistently ranking highly in multi-country surveys to determine the 'best' healthcare system, including topping EIU's own report on Health Outcomes and Costs[6], Japan has many reasons to be proud of the excellent outcomes and high efficiency.

Reflecting its status as a mature economy, the disease burden in Japan is primarily due to non-communicable diseases, colloquially known as lifestyle diseases. This is a result of several feedback loops: significant healthcare investments in the 20th century to combat infectious diseases, increased longevity and aging populations, and changes in Japanese lifestyle habits. To build a representative model of Japan's healthcare burden the following criteria were used to select four diseases that have a large impact on the Japanese population:

- **Large social burden:** Diseases with a large prevalence and/or incidence rate, that contribute high population Disability Adjusted Life Years (DALYs) and are significant contributors to the total disease burden in Japan
- **Large economic burden:** Along with large prevalence and incidence, diseases should be a large cause of spending for the healthcare system, and require significant resources and investment
- **Public interest:** All diseases should have significant government attention, and are important pillars in future healthcare plans.

Using these criteria, the following diseases were selected: cerebrovascular disease, lung cancer, diabetes mellitus and musculoskeletal disorders. More details about the selection of the four disease areas, and a brief introduction to their epidemiological profile in Japan, can be found in the Appendix.

Because 'medical technologies' encompasses a wide variety of devices, from large-scale scanners, to one-off diagnostic tools, to surgical implants, each disease area has been investigated via two devices, one for 'screening', and one for 'treatment'. The models estimate the direct and indirect costs of each device compared to either no care or care delivered without a medical technology. Taken together, the eight models offer an illustrative estimate of the net impact medtech has on Japan. Table 3 shows the medical technologies that were chosen to be covered in the cost models.

[6] "Health outcomes and cost: a 166-country comparison", *Economist Intelligence Unit*, 2014.

Table 3: Medical technologies used in model

Disease	Medical Technology	Use
Cerebrovascular disease	Carotid Angiography with catheter	To diagnose stroke and identify source of the stroke
	Metal mesh cages: Stent retrievers	To treat ischemic strokes by retrieving and removing clots
Musculoskeletal disorders	Dual-energy X-ray absorptiometry	To diagnose early-stage osteoporosis
	Hip replacement surgery-hip implants	To treat chronic hip pain
Lung cancer	Low-dose Spiral CT scan (CT scanners)	To diagnose early-stage lung cancer, before significant symptoms are present
	Linear accelerators (LINAC) for stereotactic body radiation therapy (SBRT)	To treat non-operable non-small cell lung cancers, where the alternative is palliative care
Diabetes mellitus	HbA1c test kit	To diagnose early-onset diabetes
	Insulin pump	To manage diabetes by administering timed, small doses of insulin

For additional details on the methodology, refer to the Appendix.

To maximize this model's ability to offer representative findings from which wider illustrative conclusions can be drawn, devices were selected to mirror the diversity of possible contributions medtech can offer to the healthcare system. Thus, the selection included existing standards of care, newly introduced technologies, diagnostic and treatment tools, fixed capital equipment, single-use devices, and implants. The devices were also screened to ensure applicability to the Japanese context. More details of device selection can be found in the Appendix.

These devices were then assessed based on their potential beneficial impact on the following domains:

Direct impact on the healthcare system

1. Decreased mortality and morbidity rates: The primary goal of any medical intervention is to improve quality of life and/or to prolong life. This would also result in more productive years, and more intangible benefits such as better mental health.
2. Reduced downstream healthcare costs – Technology can facilitate earlier disease detection and provide effective treatments with the potential to reduce the economic burden of disease and the cost of care.

Indirect impact to the economy

3. Greater labour force participation and workforce productivity. Many advances in treatment of early diagnosis allows for a reduction in hospital stays, reduction in disability and/or faster recovery. This allows patients to return to the workforce, or it prevents labour force drop out due to disability
4. Greater independent living – Many medical advances allow patients to gain mobility and motility, reducing the need for long-term care. This reduces the need for formal and informal care and releases caregivers into the workforce.

These were then contrasted against the direct and indirect costs of using the medical technology to arrive at the total impact.

While the direct costs of medical technology to the healthcare system are easily measured, indirect costs such as workforce participation, avoided emergency admissions and reduced length of stay in hospital can be difficult to identify and measure. To assess the impact of each of the devices, a research program was executed that used both primary and secondary sources to develop a model specific to Japan. More details about the research program can be found in the Appendix.

2. Economic impact of screening

Many medical devices can be considered 'screening' tools, used for both identifying propensity for developing a certain disease in high-risk populations (low dose CT scanners for lung cancer), or for confirming diagnosis in suspected patients (CT angiography for stroke). The types of medical devices used to screen encompass large capital equipment (e.g. DXA scanners for osteoporosis) and single-use test-kits (HbA1c tests for diabetes). By modelling the net impact of these four devices, this representative sample aims to provide inferable findings across the wider domain of screening devices.

These four devices have resulted in an estimated net positive of between ¥24k for DXA screening for osteoporosis to ¥113k for HbA1c testing for diabetes per person annually. Most of these gains are seen in two areas:

- Avoided downstream healthcare costs: Many devices result in earlier disease detection and diagnosis. This allows preventative measures and earlier treatments, which typically have a lower-cost to the healthcare system than treatments for more advanced disease. This is a direct gain, as it results in savings to the healthcare system.
- Reduced patient absenteeism: Early diagnosis allows for a reduction in hospital stays, reduction in disability and/or faster recovery. This allows patients to return to the workforce, or it prevents labour force drop-out due to disability. This is an indirect gain, as it projects GDP gains based on workforce contribution.

Table 4: Average impact per patient per year, 2016

Disease	Medical Technology	Average savings per patient
Cerebrovascular disease	Carotid Angiography with catheter	**¥83,935 | *$804***
Musculoskeletal disorders	Dual-energy X-ray absorptiometry	**¥24,347 | *$233***
Diabetes mellitus	HbA1c test kit	**¥113,123 | *$1,083***
Lung cancer	Low-dose Spiral CT scan (CT scanners)	**¥40,299 | *$385***

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As Japan formulates its strategy on how to effectively deploy its healthcare dollars, it is important to keep in mind the direction of these findings. Most of the conversation thus far has focused on the direct costs, but attention must also be paid to the avoided costs and net contributions these interventions have to the healthcare system and the economy as a whole.

We describe below the details of the models used for each of the four disease areas.

Modelling methodology

For a measure of direct impact of using the screening technology, the study considered the total cost (and savings) to the healthcare system on an annual basis. This included the cost of device spread over its number of uses, costs of GP and specialist consultations and on-going medication costs. In addition, this also included avoided medical costs associated with earlier diagnosis and treatment. In Japan, such a database of cost items is available and to validate the data, interviews were conducted with specialists.

For the indirect impact, which considers the costs or savings incurred by the overall economy, the study split the typical patient pool into working and non-working based on an age cut-off of 65 years. The benefits (and costs) accrued to the working population due to reduced absenteeism and productivity foregone were modelled based on the GDP per working population, and averaged across the total patient population to arrive at the average impact.

Figure 1: Elements of screening model

Direct impact	Definition	Indirect Impact	Definition
- Screening costs	• Cost of purchasing the device, spread over its number of uses Cost of other costs: reagents, physician consultations associated with the screening	- Time cost to screen	GDP loss due to the initial consultation [not applicable for non-working population]
+ Avoided treatment	• Early diagnosis resulting in avoided downstream treatments	+ Avoided absenteeism	Additional workdays gained from diagnosed diesase (either via better disease management, or reduced hospitalization) x GDP [not applicable for non-working population]
+ Earlier diagnosis	• Avoided cost of longer diagnosis period, preventing disease progression • Any additional consultations for diagnosis		

Modelling the four devices

Computed Tomography Angiography (CTA) for cerebrovascular disease (ischemic stroke)

Cerebrovascular disease is an umbrella term used to describe conditions related to issues with the blood supply to the brain. While there are a few different types of cerebrovascular disease, the most common are transient ischemic attacks (TIA), haemorrhagic stroke, and ischemic stroke. To accurately model the impact of a specific medical device, this study narrowed the field of focus to ischemic stroke.

A stroke – both haemorrhagic and ischemic– occurs when the blood supply to part of the brain is either restricted or completely blocked. This lack of blood to the brain results in the death of brain cells which can lead to brain damage and in some cases can be fatal. Ischemic stroke – strokes caused by blood clots – are the most common type of stroke, accounting for 87% of all cases. Most stroke cases are in individuals over the age of 60, but 20-25% are observed in the working age population between the ages of 40 and 60.

Computed Tomography Angiography (CTA) is considered the gold standard technique for the diagnosis of stroke in Japan. Patients tend to undergo this procedure in the emergency setting, having presented with symptoms such as numbness or weakness, especially on one side of the body. The CTA allows neurologists to quickly identify the location of the blood clot or aneurysm in order to then identify the most effective treatment. Timing is crucial in the diagnosis of a stroke as the window between diagnosis and timely management could be the difference between a patient recovering their ability to live independently or facing a lifetime of paralysis and disability. The procedure takes about 30-40 minutes with patients being directed straight to treatment after diagnosis.

The average annual net benefits associated with the CT angiogram (CTA) are ¥399,521 ($3,825) in the working-age population versus ¥63,818 ($611) for the non-working population, resulting in a total savings per person of ¥83,935 ($804) when using CTA.

Table 5: Benefits (costs) of CTA (2016)

<table>
<tr><th colspan="2">Per Patient / Per year</th><th>Description</th><th>Working age</th><th>Non-working age</th></tr>
<tr><td rowspan="3">Direct</td><td>**- Screening costs**</td><td>Cost of device, staff time to perform the screening, consultation</td><td colspan="2">**(¥21,830)**
($209)</td></tr>
<tr><td>**+ Avoided treatment**</td><td>Avoided additional acute care costs due to timely and accurate treatment</td><td colspan="2">**¥85,607**
$820</td></tr>
<tr><td>**+ Avoided consultation**</td><td>None – emergency procedure</td><td colspan="2">**¥0**</td></tr>
<tr><td rowspan="2">Indirect</td><td>**- Time cost to screen**</td><td>None – emergency procedure</td><td>**¥0**</td><td>**¥0**</td></tr>
<tr><td>**+ Avoided absenteeism**</td><td>Additional workdays gained from better prognosis due to better treatment x GDP/day</td><td>**¥335,702**
$3,214</td><td>**¥0**</td></tr>
<tr><td colspan="2"></td><td>TOTAL per patient</td><td>**¥399,521**
$3,825</td><td>**¥63,819**
$611</td></tr>
<tr><td colspan="2"></td><td>TOTAL Average benefit per patient</td><td colspan="2">**¥83,935 \|** *$804*</td></tr>
</table>

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As stroke patients would be treated immediately in the emergency department rather than in primary care, there were no costs associated with consultations or outpatient services. For the same reason, there is no GDP impact related to screening time.

Early diagnosis achieved through using CTA is estimated to result in 80-90% of patients going on to be independent. Thus, further treatment costs are avoided due to early diagnosis, and GDP gained from additional workdays due to a better prognosis. Additionally, the different outcomes achieved through early diagnosis versus late diagnosis were incorporated in the model – data from scientific literature was used to show that a greater proportion of individuals returned to independence following early diagnosis than those who experienced a delay in diagnosis.

Dual-energy X-ray absorptiometry (DXA) for musculoskeletal disorder (osteoporosis)

Musculoskeletal disorder (MSD) is an umbrella term used to describe chronic conditions that affects muscles, bones and joints and include conditions such as rheumatoid arthritis, osteoarthritis, osteoporosis, major limb trauma, and spinal disorders. In this study, to isolate the benefits of a specific medical technology – the dual-energy X-ray absorptiometry (DXA) – this report will be investigating osteoporosis, which poses a significant burden on the Japanese economy.

Typically, patients with osteoporosis are asymptomatic unless a fracture has occurred. Hip fracture is the most serious complication of osteoporosis and has been recognized as a major cause of becoming bedridden in Japan. The DXA is regarded as the gold standard technique for osteoporosis diagnosis according to multiple guidelines, including the Japanese Guidelines for Osteoporosis. It allows for pre-diagnosis, early diagnosis and fracture risk prediction. Patients identified as high-risk – typically women above 50 – receive screening during their routine medical check-ups or when they suffer pain in their joints. They are alerted when their results indicate they are at risk of developing, or have developed osteoporosis. Those who have been identified as at risk will be prescribed non-medical preventative interventions such as weight-bearing exercise and to increase calcium and vitamin D intake. In some cases, pharmaceutical interventions may be prescribed, but this has not been accounted for in our model.

The net annual benefit from DXA scanner technology was ¥19,637 ($188) per working age patient and ¥24,650 ($236) per non-working age patient, averaging to ¥24,347 ($233) across both populations. As is evident, the screening technology studied generated economic returns that were substantially greater than their costs.

Prior to screening using DXA scanner, an appointment needs to be booked with an osteoporosis specialist in Japan. The average cost to the healthcare system per consultation is ¥20,890 ($200) which includes physical examination and blood tests for bone biomarkers. Along with the cost of the device over its lifetime use, the direct impact of screening technology as compared to the control group is ¥42,001 ($402) per patient per year as compared to the control group who do not incur any costs. The average length of procedure from patient presentation until discharge i.e. collection of results is approximately 3 hours. Therefore, the costs associated with screening time is ¥8,460 ($81) per patient per year as compared to patients who do not undergo screening.

Table 6: Benefits (costs) of DXA Screening (2016)

	Per Patient / Per year	Description	Working age	Non-working age
Direct	- Screening costs	Cost of device per use (total cost divided by total uses), physical examination, blood test for biomarkers	**(¥42,001)** *($402)*	
	+ Avoided treatment	Avoided probability of hip fracture and associated cost	**¥4,000** *$38*	
	+ Avoided consultation	Avoided follow-up consultations before diagnosis	**¥62,670** *$600*	
Indirect	- Time cost to screen	3 hours lost due to screening x GDP/hours	**(¥8,461)** *($81)*	**¥0**
	+ Avoided absenteeism	Additional workdays gained from prevented hip fractures x GDP/day	**¥3,447** *$33*	**¥0**
		TOTAL per patient	**¥19,637** *$188*	**¥24,650** *$236*
		TOTAL Average benefit per patient	**¥24,347** | *$233*	

1USD = 104.45 JPY
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Early diagnosis of osteoporosis and appropriate intervention, as well as timely and appropriate rehabilitation allow people to keep their jobs, improves management of the disorder and reduces the burden of chronic disease on the wider economy and society. This is highlighted in the reduced absenteeism impact which resulted in a net positive value of ¥3,447 ($33) per patient per year. Through early intervention with DXA, patients who have a high incidence of hip fracture, can benefit from the avoided cost of hip replacement surgery, thus resulting in savings of ¥4,000 ($38).

HbA1c tests for diabetes

In recent years there has been rapid growth in diabetes mellitus, especially Type 2 diabetes in Japan, owing largely to increased longevity and lifestyle changes. Many patients with Type 2 diabetes are asymptomatic, and their disease remains undiagnosed for many years. Prevention, timely diagnosis, and treatment are important in diabetic patients. Many of the complications associated with diabetes, such as nephropathy, retinopathy, neuropathy, cardiovascular disease, stroke, and death, can be delayed with early intervention.

The HbA1c blood test is regarded as the gold standard technique for diagnosing diabetes according to guidelines from the Japan Diabetes Society (JDS). Patients who report symptoms that are consistent with the onset of diabetes, including fatigue, blurry vision or weight loss, are tested for their plasma glucose level and given the HbA1c test. Results from these are sufficient to diagnose borderline or onset of diabetes during the examination. Those who have a borderline diagnosis are given lifestyle advice to reduce their chance of developing diabetes. The HbA1c is also used to monitor existing diabetic patients, to ensure good disease management, but this is not within the scope of our study.

From our model, the net annual benefit from confirmatory diagnosis using the HbA1c test was ¥232,088 ($2,222) per working age patient and net annual cost of HbA1c test was ¥10,445 ($100) per non-working age patient, averaging to ¥113,123 ($1,083) across the patient population.

Table 7: Benefits (costs) of HbA1c blood test (2016)

<table>
<tr><th colspan="2">Per Patient / Per year</th><th>Description</th><th>Working age</th><th>Non-working age</th></tr>
<tr><td rowspan="3">Direct</td><td>- Screening costs</td><td>Cost of single-use device, physical examination</td><td colspan="2">(¥31,335)
($300)</td></tr>
<tr><td>+ Avoided treatment</td><td>N/A: Prudent model, as downstream costs is dependent on multiple factors</td><td colspan="2">¥0</td></tr>
<tr><td>+ Avoided consultation</td><td>Avoided follow-up consultations before diagnosis</td><td colspan="2">¥20,890
$200</td></tr>
<tr><td rowspan="2">Indirect</td><td>- Time cost to screen</td><td>2 hours lost due to screening x GDP/hour</td><td>(¥5,640)
($54)</td><td>¥0</td></tr>
<tr><td>+ Avoided absenteeism</td><td>Additional workdays gained better managed disease x GDP/day</td><td>¥248,173
$2,376</td><td>¥0</td></tr>
<tr><td colspan="2"></td><td>TOTAL per patient</td><td>¥232,088
$2,222</td><td>(¥10,445)
($100)</td></tr>
<tr><td colspan="2"></td><td>TOTAL Average benefit per patient</td><td colspan="2">¥113,123 | $1,083</td></tr>
</table>

1USD = 104.45 JPY
EIU Analysis and Primary Research

Along with the cost of the device over its lifetime use, the direct impact of screening technology as compared to the control group is ¥31,335 ($300) per patient per year. The average length of procedure from patient presentation until discharge is approximately 2 hours. Therefore, the costs associated with screening time is ¥5,640 ($54) per patient per year versus the control group.

Early diagnosis of diabetes and appropriate intervention reduces complications, allows people to retain their jobs, help better management of disease, and reduces the burden of disease on the wider economy and society. This is highlighted in the reduced absenteeism impact which resulted in a net positive value of ¥248,173 ($2,376) per patient per year. Through early intervention, patients who have a high risk of diabetes, can benefit from the avoided cost of treatment. Overall the indirect impact per working-age patient was ¥263,423 ($2,522) and the indirect impact of earlier diagnosis per non-working age patient was ¥20,890 ($200).

Computed tomography (CT) scanners for lung cancer

Low dose computed tomography (CT) scanners, also known as a helical CT scan, are non-invasive medical imaging tests that have been used for early detection of lung cancer in high-risk populations in Japan since 1993[7]. The use of low dose CT scanners has steadily increased in Japan since its introduction, even though it is not officially recommended. The number of certified physicians and

[7] Nawa T., Nakagawa T., Mizoue T., Endo K., "Low-dose computed tomography screening in Japan", *J Thorac Imaging*, 2015; 30(2): 108-14.

radiologic technologists specifically for CT screening has also increased over the years. Low dose CT scans can be used to identify non-symptomatic early lung cancers in high-risk patients (particularly smokers), thus allowing early treatment and so reducing lung cancer mortality. Currently, several hundred thousand low-dose CT screenings are performed annually in Japan.

The model estimates the net one year annual benefit from low dose CT screening for people with suspected lung cancer to be ¥31,648 ($303) per working age patient and ¥41,780 ($400) per non-working age patient, averaging out to ¥40,299 ($385) per patient.

Table 8: Benefits (costs) of Low-dose spiral CT scanner (2016)

Per Patient / Per year		Description	Working age	Non-working age
Direct	**- Screening costs**	Cost of device, staff time to perform the screening, consultation	**(¥41,780)** *($400)*	
Direct	**+ Avoided treatment**	Avoided additional cost of late-stage (stage 3) cancer, compared to stage 1 cancer	**¥83,602** *$800*	
Direct	**+ Avoided consultation**	None	**¥0**	
Indirect	**- Time cost to screen**	12 hours lost due to screening x GDP/hour	**(¥33,842)** *($324)*	**¥0**
Indirect	**+ Avoided absenteeism**	Additional workdays gained better managed disease x GDP/day	**¥23,690** *$227*	**¥0**
		TOTAL per patient	**¥31,648** *$303*	**¥41,780** *$400*
		TOTAL Average benefit per patient	**¥40,299** | *$385*	

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Experts consulted for the report stated that low dose scanning is offered to high-risk individuals – most patients are between 60 to 80 years of age, about 15-20% of patients are of working age, and 1-2% are seen in their thirties. The actual scan takes less than a minute. This high throughput, along with the 5 year lifespan of the device, allows the cost of the device to be spread across 5,000 uses, resulting in a fairly low cost/use. In addition, while, the scan can be performed, analysed and the results known within a day for urgent cases, for most patients the process tends to involve three or four trips to the clinic: once to agree on the need for a scan and arrange a time, once for the scan itself, and once to discuss the results. This results in a total average of 12 hours of work across all appointments.

As the test is only performed for high-risk individuals, roughly 20% of the screened population test positive for asymptomatic lung cancer. Early diagnosed cancer (asymptomatic stage one) may be treated by surgery alone, while lung cancer diagnosed at a later stage will typically require courses of both chemotherapy and radiotherapy. The model assumes that patients undergoing screening will have their cancers diagnosed at stage one; while if they are not screened, diagnosis tends to occur at stage three, with associated costs of ¥548,885 ($5,255) for stage one therapy, and ¥966,894 ($9,257) for stage three therapy[8].

Early diagnosis of lung cancer not only improves outcomes but also benefits the healthcare system and wider society in two other ways. Firstly, people with undiagnosed lung cancer are often burdened with symptoms as their cancer develops, meaning that they suffer and miss time at work until they are finally diagnosed with lung cancer. Also, when they are finally treated at a later stage they have to take more time off work. Based on expert interviews and secondary sources, it is estimated that people with undiagnosed lung cancer will miss on average 35 days of work due to poorly managed or mismanaged symptoms – including time taken off work to visit healthcare services, time spent on sick leave and time for treatment and recovery when they are finally treated.

[8] Cipriano L.E., Romanus D., Earle C.C. et al., "Lung cancer treatment costs, including patient responsibility, by stage of disease and treatment modality, 1992–2003", *Value Health*, 2011; 14(1): 41-52.

3. Economic impact of treatment

In addition to screening, discussed in the previous chapter, many medical devices can be considered interventional tools for treatment. Similarly, the types of medical devices used include capital-intensive fixed assets (e.g. linear accelerators for lung cancer) and single-use devices (stent retrievers for stroke). Medical devices can also be implants (hip replacements for musculoskeletal disorders) or externally worn devices (insulin pumps for diabetes). By modelling the net impact of these four devices, this representative sample aims to provide inferable findings across the wider domain of interventional devices.

These four devices have resulted in an estimated net positive of between ¥65k for insulin pumps for diabetes, to ¥2,932k for hip implants per person annually. Most of these gains are seen in two areas:

- Reduced need for caregivers: Medical device interventions typically allow patients a higher chance of returning to independence. This requires them to rely less on caregivers, and allow caregivers to be released back into the wider economy.
- Reduced absenteeism: Similarly to above, medical device intervention allows patients to return to independence, allowing them to return to work. The net impact of absenteeism for the patient is smaller than that for the caregiver because many patients are elderly and above the age of retirement – they do not have formal employment to return to.

Table 9: Average impact per patient per year, 2016

Disease	Medical Technology	Average savings across patient population
Cerebrovascular disease	Metal mesh cages: Stent retrievers	**¥649,378 | *$6,217***
Musculoskeletal disorder	Hip replacement surgery-hip implants	**¥2,932,054 | *$28,071***
Diabetes mellitus	Insulin pump	**¥65,115 | *$623***
Lung cancer	Linear accelerators (LINAC) for stereotactic body radiation therapy (SBRT)	**¥448,967 | *$4,298***

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In contrast to screening, the bulk of the positive impact is due to indirect gains. However, the net impact of these gains are substantial, especially as Japan deals with the thin labour markets that are the result of the demographic transition. The idea that investing in medical devices as a method to continue to harness its existing labour pool has some merit, and should be considered as Japan formulates its strategy on how to effectively deploy its healthcare budget.

Details of each model are described below.

Modelling methodology

To model the economic impact of treatment, in contrast to the screening model, the impact of the medical device was modelled against a control group, i.e. pharmacological treatment for cerebrovascular disease and musculoskeletal disorders, no intervention for lung cancer and alternative form of intervention for diabetes. This is because while there are scenarios where screening does not occur, it is highly unlikely that a patient, once diagnosed, would not seek some form of treatment. To ensure the impact of medtech was captured, instances where the treatment choices are between medtech versus alternative interventions, such as pharmaceuticals were chosen. The devices selected and their controls are listed below:

Table 10: Modelling technologies vs. control

Disease	Treatment technology	Baseline/Control Group
Cerebrovascular disease	Stent retrievers for mechanical thrombectomy	Clot-dissolving medicine (tissue plasminogen activators, tPA)
Musculoskeletal disorder	Hip replacement implants	Pain-relieving medications such as NSAIDs
Diabetes mellitus	Insulin pump	Vial and syringe
Lung cancer	Linear accelerators for external beam therapy	No intervention

The direct and indirect impact for treatment intervention were modelled against the control group to calculate the annual net benefit per patient for a period of one year.

For a model of the direct healthcare costs (and benefits) of medtech intervention, the study considered the cost of the intervention over the patient's remaining life, costs of GP and specialist consultations, medical cost of the procedure and the associated hospitalization costs. The longer term costs of recovery was also included in the model, as were the costs of any complications.

Similar to the screening model, the indirect costs were also broken up into working and non-working populations, with lost productivity due to hospitalisation, early mortality and continued absenteeism as a result of the disease included in the model. This model also includes caregiver absenteeism across both working and non-working populations, to capture the impact an intervention has on limiting independence, impacting the overall economy.

Figure 2: Elements of treatment model

Direct Impact	Definition	Indirect Impact	Definition
• Cost of intervention	• Cost of device/uses over lifetime • Cost of physician consultations associated with the device	• Lost productivity due to hospitalization	Time needed for surgery and recovery x GDP per working day [not applicable for non-working population]
• Cost of recovery and complications	• No. of rehab sessions per month x months rehab needed x cost per session • Costs associated with complication from more invasive treatments	• Absenteeism	% who take sick leave due to disease x no. of days of sick leave x GDP per working day [not applicable for non-working population]
		• Caregiver absenteeism	% of family member that needs to give up work x average number of working days per annum x GDP per working day
		• Early mortality	Years GDP lost due to disease vs healthy population [not applicable for non-working population]

Modelling the four devices

Mechanical thrombectomy using stent retrievers, for cerebrovascular disease (ischemic stroke)

There are generally two treatments for ischemic stroke where a blood clot has been identified as the root cause of the problem: medical management using thrombolysis and mechanical thrombectomy, using stent retrievers. Thrombolysis with tissue plasminogen activators (tPA) has long been used as a treatment for ischemic stroke, acting by dissolving the blood clot. However, mechanical thrombectomy has been shown to have better outcomes than medical management as a greater proportion of patients return to independence.

Stent retrievers used in mechanical thrombectomy are used to treat patients after the location of the blood clot has been identified during diagnosis. The device is inserted via a catheter into the blood vessels to retrieve the clot and therefore allow blood to start flowing to the brain once again. Evidence shows that the first few hours between presenting at the emergency department and receiving treatment are vital in the outcome and prognosis for an individual. Mechanical thrombectomy needs to be performed within 6 hours, whereas medical management allows a window of 4 hours for the hope of a successful outcome.

The net annual benefit associated with the mechanical thrombectomy using stent retrievers is ¥1,173,628 ($11,236) in the working-age population versus ¥615,915 ($5,897) for the non-working population, with a net overall gain of ¥649,378 ($6,217). Most of these gains are from the reduced need for caregivers, and reduced absenteeism. The findings show that although up-front treatment expenditure may be greater when using mechanical technology, the benefits gained from indirect costs far outweigh those seen following medical management. In addition, this model does not include other intangible benefits such as quality of life and better mental health – this would likely increase the benefits associated with greater independence seen with mechanical thrombectomy.

Table 11: Net benefits (costs) of mechanical thrombectomy vs tissue plasminogen activators (tPA) (2016)

Per Patient / Per year		Description	Working age	Non-working age
Direct	**Cost of intervention**	Higher cost of stent retriever surgery vs. clot dissolvers	**(¥105,582)** *($1,011)*	
Direct	**Cost of recovery and complications**	Includes acute care costs, and outpatient drugs	**¥33,381** *$320*	
Indirect	**Loss productivity due to hospitalisation**	No difference in hospitalisation period, with longer outpatient recovery modelled under absenteeism	**¥0**	**¥0**
Indirect	**Absenteeism**	Workdays missed due to outpatient care, additional sick days	**¥557,713** *$5,340*	**¥0**
Indirect	**Caregiver absenteeism**	Greater independence from stent retrievers, reducing need for caregivers	**¥688,117** *$6,588*	
Indirect	**Early Mortality**	Inconclusive evidence on differences in all-cause mortality between the two interventions	**¥0**	**¥0**
		TOTAL per patient	**¥1,173,628** *$11,236*	**¥615,915** *$5,897*
		TOTAL Average benefit per patient	**¥649,378** | *$6,217*	

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In terms of direct healthcare costs, mechanical thrombectomy was ¥72,201 ($691) higher compared to medical intervention. This is because the cost of intervention – i.e. the surgery – is significantly higher than using clot dissolvers. This is slightly offset by the lower cost of complications. Mechanical thrombectomy results in better outcomes, with a higher ratio of patients able to return to independence, and fewer suffer a fatal stroke. Thus, there is some difference in healthcare expenditure for acute care. There was no significant difference in healthcare use for recovery, as patients take approximately 9 days of hospitalisation and 7 weeks of immediate rehabilitation for both interventions.

For indirect costs to the economy, most of the difference is due to absenteeism and caregiver absenteeism, as there are no significant difference in the hospitalisation requirement between the two interventions. To model absenteeism, the costs for the 6% of patients who are of working age were modelled. Working-age patients who make a full recovery after a mechanical thrombectomy typically take an additional 2 weeks to recover to independence, whereas those who have medical management take 4 weeks. In contrast, patients who make a partial recovery – i.e. who recover, but remain dependent – recover on average after 3.5 months and 5 months respectively. This results in a net cost of ¥557,713 ($5,340) in the working-age population, and a net cost of ¥33,381 ($320) when averaged across the patient population.

The greatest burden felt as a result of stroke is not mortality, but rather the level of disability. A significant portion of patient make a partial recovery, where they are in a dependent state following a stroke. This results in a higher requirement for caregivers – both formal and informal – where the patient has to be looked after by a full-time caregiver, in many cases a family member. This has a negative impact on GDP, as these individuals could have participated in the wider economy.

Hip replacement implants for musculoskeletal disorder

Around 15% of the Japanese population suffers from moderate to severe chronic musculoskeletal pain persisting for at least 6 months[9]. Treatment for musculoskeletal pain is generally based on a biomedical model that has been used for many years i.e. treatment with non-steroidal anti-inflammatory drugs (NSAIDs), channel blockers and opioid analgesics to alleviate chronic pain. These medications are widely used for their anti-inflammatory and analgesic effects.

Medical devices, on the other hand, allow for better disease management and cure. In particular, hip replacement surgery for chronic pain can dramatically reduce sick days and raise productivity. This technology often improves the chances of curing a patient’s condition, can extend his or her survival and can boost the economy through expanded workforce participation and stronger performance on the job.

The estimated annual net health system costs and additional impact on GDP from hip replacement implants was ¥2,338,883 ($22,392) per working-age patient and ¥4,432,112 ($42,433) per non-working age patient, with an average benefit of ¥2,932,054 ($28,071).

A patient presenting with hip pain will undergo physician consultations before undergoing hip replacement surgery. Due to surgery, the patient would spend on an average 23 days in hospital and cost the healthcare system ¥13,474 ($129) per hospitalization day, followed by approximately 12 sessions of rehabilitation over a period of 3 months. The cost of hip replacement procedure is around ¥731,150 ($7000) per patient with additional medical cost of hip implant device (¥292,982 / $2,805) and cost of physician consultations (¥62,670 / $600) both pre- and post-surgery. On the other hand, a patient underdoing pharmacological treatment for chronic hip pain only incurs the cost of pain- and inflammation-relieving medications such as NSAIDs and COX-2 inhibitors (¥376,020 / $3,600) with the additional medical cost of consulting a physician every quarter. Upon summation of the costs, the annual

[9] Matsuda S., Muramatsu K., Kubo T., Fujino Y., “Disease Burden of MSD for the Japanese Society Fit for Work Scheme as a Solution for This Problem”, *Asian Pacific Journal of Disease Management*, 2012; 6(2): 37-44.

Table 12: Net benefits (costs) of hip replacement vs. pain relievers (2016)

Per Patient / Per year		Description	Working age	Non-working age
Direct	**Cost of intervention**	Cost of implant and surgery, including hospitalisation vs. pain relievers	**(¥715,602)** *($6,851)*	
Direct	**Cost of recovery and complications**	Rehab required for hip replacements	**(¥424,903)** *($4,068)*	
Indirect	**Loss productivity due to hospitalisation**	Time taken for radiotherapy and recovery	**(¥1,015,254)** *($9,720)*	**¥0**
Indirect	**Absenteeism**	Workdays missed due to outpatient care, additional sick days	**¥1,884,311** *$18,040*	**¥0**
Indirect	**Caregiver absenteeism**	Cost of end-of-life care, included caregiver absenteeism	**¥5,572,616** *$53,352*	
Indirect	**Early Mortality**	One year survival	**(¥2,962,286)** *($28,361)*	**¥0**
		TOTAL per patient	**¥2,338,883** *$22,392*	**¥4,432,112** *$42,433*
		TOTAL Average benefit per patient	**¥2,932,054** | *$28,071*	

1USD = 104.45 JPY
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direct impact for hip replacement surgery for working and non-working age population was ¥1,600,090 ($15,319) per patient to the healthcare system. The annual direct impact for pharmacological treatment for working and non-working age population was ¥459,580 ($4,400) per patient.

For indirect costs, lost productivity due to hospitalization of ¥1,015,254 ($9,720) was modelled only for the treatment scenario since undergoing pharmacological treatment does not require hospitalization. The number of days needed for surgery and recovery were assumed to be 45 days on average. The indirect impact of absenteeism resulted in a net negative value of ¥1,353,672 ($12,960) per patient per year. On the other hand, the impact of absenteeism for control group resulted in a higher negative value of ¥3,237,981 ($31,000). Early diagnosis and intervention, as well as timely and appropriate rehabilitation allow people to keep their jobs, help better management of disease and reduce the burden of chronic disease on the wider economy and society.

The indirect costs of ill-health extend beyond lost productivity and foregone income of the individual, often impacting the labour participation of family members. Employees who had a family member undergoing hip replacement surgery, experienced reduced productivity of ¥11,145,233 ($106,704), as many have had to give up work to take care of the patients. On the other hand, employees with a family members on pharmacological treatment for hip joint disorder experienced a higher lost productivity of ¥16,717,849 ($160,056) due to extra reliance needed by patients with chronic pain.

Insulin pumps for diabetes

Approximately 13.5% of the Japanese population has either Type 2 diabetes or impaired glucose tolerance[10] with highest prevalence within the working age population (54-65 years). Variations in blood glucose have been implicated in causing complications which can lead to a number of comorbidities and mortality in diabetics. Insulin is generally administered using multiple daily injections with the dose adjusted according to eating, physical activity and blood glucose levels. Medical devices such as insulin pump, on the other hand, allow for better disease management as the device allows the ability to easily administer multiple insulin boluses without the need for injections, thus allowing for more accurate insulin dosing. Moreover, the insulin pump predicts the amount of active insulin thereby avoiding 'insulin stacking'.

[10] Neville S.E., Boye K.S., Montgomery W.S. et al., "Diabetes in Japan: a review of disease burden and approaches to treatment." *Diabetes Metab Res Rev.*, 2009 Nov;25(8):705-16.

The overall economic impact from insulin pumps is presented as an average net gain of ¥65,115 ($623) per person in one year – this was achieved by combining the gains of ¥168,407 ($1,612) for the 51% of patients who are working-age, with the net annual costs of ¥42,198 ($404) for the 49% of patient who are not of working age.

Table 13: Net benefits (costs) of insulin pumps vs syringe and vial (2016)

<table>
<tr><th colspan="2">Per Patient / Per year</th><th>Description</th><th>Working age</th><th>Non-working age</th></tr>
<tr><td rowspan="2">Direct</td><td>Cost of intervention</td><td>Higher cost of insulin pumps, spread over lifetime of use, vs. syringe and vial. Includes care and examination fees</td><td colspan="2">(¥123,260)
($1,180)</td></tr>
<tr><td>Cost of recovery and complications</td><td>Chance of complications, and associated cost of complications</td><td colspan="2">¥2,263
$22</td></tr>
<tr><td rowspan="4">Indirect</td><td>Loss productivity due to hospitalisation</td><td>No hospitalisation required for either interventions</td><td>¥0</td><td>¥0</td></tr>
<tr><td>Absenteeism</td><td>Workdays missed due to outpatient care, additional sick days</td><td>¥180,490
$1,728</td><td>¥0</td></tr>
<tr><td>Caregiver absenteeism</td><td>Greater independence from insulin pumps, reducing need for caregivers</td><td colspan="2">¥78,823
$755</td></tr>
<tr><td>Early Mortality</td><td>Lower all-cause mortality for patients on insulin pumps</td><td>¥30,092
$288</td><td>¥0</td></tr>
<tr><td colspan="2"></td><td>TOTAL per patient</td><td>¥168,407
$1,612</td><td>(¥42,198)
($404)</td></tr>
<tr><td colspan="2"></td><td>TOTAL Average benefit per patient</td><td colspan="2">¥65,115 | $623</td></tr>
</table>

1USD = 104.45 JPY
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This higher up-front costs and associated care fees are the key barriers to wider insulin pump adoption when compared to syringe and vial administration. However, the cost of complications arising from use of insulin pump are significantly lower as compared to insulin injection due to better management of disease. Upon summation of the costs, the per patient annual direct cost to

the healthcare system for insulin pumps totalled ¥249,976 ($2,393), in contrast to vial and syringe treatment, which amounted to ¥128,979 ($1,235). This net cost to the healthcare system of ¥120,997 ($1,158) is more than offset by the indirect benefits of the medical device. In both cases, in-patient care or hospitalisation was not required, but patients may need to spend up to a day in a healthcare facility to understand how to best use their insulin pump and how to administer insulin via a syringe.

Due to the degree of control and feedback from the insulin pump, patients typically reduce the number of work days missed. Working-age patients on insulin pumps typically miss only 3 days of work per year, versus 11 days for those on syringe and vial. This results in a gain from absenteeism from insulin pumps of ¥180,490 ($1,728) per year. Moreover, the productivity lost due to early mortality was higher for patients using self-injection approach as compared to insulin pumps. Insulin pump can dramatically reduce the cost of complications and risk of early mortality, thus boosting the economy through expanded workforce participation and stronger performance on the job.

The indirect costs of the additional effort to administer insulin via a syringe extend beyond lost productivity and foregone income of the individual, often impacting on the labour participation of family members. Employees with a family member undergoing treatment using insulin pump experienced reduced productivity of ¥185,148 ($1,773). In contrast, employees with a family member on vial and syringe treatment for diabetes experienced a higher lost productivity of ¥263,966 ($2,527), due to extra care needed by patients.

Overall the indirect impact of using technology per working-age patient was ¥282,362 ($2,703) and the indirect impact of caregiver absenteeism per non-working age patient was ¥185,143 ($1,772). On the other hand, the indirect impact of vial and syringe treatment per working-age patient was ¥571,767 ($5,474) and the indirect impact of caregiver absenteeism per non-working age patient was ¥263,966 ($2,527). To conclude, technology did not reduce the cost of medical care. However, improved quality of life and reduced early mortality rate contributed to significant economic gains generated by higher workplace productivity.

Linear accelerators (LINAC) for stereotactic body radiation therapy (SBRT), for inoperable lung cancer

Treatment for lung cancer is complex and multifaceted, depending on a range of factors including stage, the age and fragility of the patient, the site of the cancer and patient preference. Linear accelerators are a relatively new technology that are used to deliver stereotactic body radiation therapy (SBRT). This is a therapy that consists of focussed, high-energy radiotherapy that can destroy the cancer cells while sparing the surrounding normal tissue. SBRT can be used with or without surgery and chemotherapy. This study investigates a specific use of SBRT: that of salvage therapy for early stage cancers that are inoperable, either because of the morphology of the tumour or perhaps because the patient is unable to undergo surgery (for example because they are too fragile) or chooses not to undergo surgery. Chemotherapy alone tends not to be used for this patient pool, so the control group in this instance receives no treatment.

The estimated net annual benefit during the first year after treatment from SBRT as a stand-alone salvage therapy for early stage non-small cell cancer is ¥1,298,209 ($12,429) per working-age patient, and a benefit of ¥544,811 ($5,216) per non-working age patient. Benefits come from the significant reduction in mortality resulting in reduced lost GDP and reduced need for end-of-life care.

Table 14: Net benefits (costs) of SBRT vs palliative care (2016)

<table>
<tr><th colspan="2">Per Patient / Per year</th><th>Description</th><th>Working age</th><th>Non-working age</th></tr>
<tr><td rowspan="2">Direct</td><td>Cost of intervention</td><td>Additional cost of device use and consultations for six SBRT sessions and in-patient care vs. no intervention</td><td colspan="2">(¥483,812)
($4,632)</td></tr>
<tr><td>Cost of recovery and complications</td><td>Additional follow-up consultations for first year post-treatment vs. no intervention</td><td colspan="2">(¥104,450)
($1,000)</td></tr>
<tr><td rowspan="4">Indirect</td><td>Loss productivity due to hospitalisation</td><td>Time taken for radiotherapy and recovery</td><td>(¥261,710)
($2,506)</td><td>¥0</td></tr>
<tr><td>Absenteeism</td><td>Workdays missed due to outpatient care, additional sick days</td><td>(¥224,254)
($2,147)</td><td>¥0</td></tr>
<tr><td>Caregiver absenteeism</td><td>Cost of end-of-life care, included caregiver absenteeism</td><td colspan="2">¥924,225
$8,848</td></tr>
<tr><td>Early Mortality</td><td>One year survival</td><td>¥1,239,330
$11,865</td><td>¥0</td></tr>
<tr><td colspan="2"></td><td>TOTAL per patient</td><td>¥1,298,209
$12,429</td><td>¥544,811
$5,216</td></tr>
<tr><td colspan="2"></td><td>TOTAL Average benefit per patient</td><td colspan="2">¥448,967 | $4,298</td></tr>
</table>

1USD = 104.45 JPY
EIU Analysis and Primary Research

Patients undergoing stereotactic body radiation therapy for stage one lung cancer can be treated either as an inpatient or outpatient. About 40% of patients are treated as inpatients, 60% as outpatients. Both groups of patients will typically attend six radiotherapy sessions. Inpatients will receive those sessions over a hospitalised period of on average 20 days, the cost of which are assumed at ¥107,792 ($1,032). All patients typically receive five follow-up consultations during the first year post-treatment, at a cost to the healthcare system of ¥104,450 ($1000). The sum of the direct cost to the healthcare system, taking into account the mix of inpatients and outpatients, calculated as ¥588,262 ($5,632).

In terms of the indirect costs and benefits of stereotactic body radiation therapy, the model considered absenteeism, early mortality and end of life care. It is assumed that absenteeism can be caused by a) time taken for treatment and initial recovery (the six sessions described above, and the twenty days in hospital for inpatients), b) the time taken off work for the five follow-up consultations, and c) time off work because of complications arising from the treatment. For complications off-work, an estimated 2% of patients are unable to return to work because of complications. For early mortality, the one year survival rate for patients undergoing treatment is 97%, while for those receiving no treatment have a one year survival of 53%[11].

[11] Zheng X., Schipper M., Kidwell K. et al. "Survival Outcome After Stereotactic Body Radiation Therapy and Surgery for Stage I Non-Small Cell Lung Cancer: A Meta-Analysis." *Int J Radiat Oncol Biol Phys.*, 2014; 90(3): 603-11.

4. Conclusions

A significant proportion of working-age people in Japan are affected by one or more of the diseases outlined in this study. This can have significant social and economic consequences for these individuals, their family caregivers and can impede the productive capacity of the overall workforce and the Japanese economy.

A number of medical technologies have been developed to support people with long-term chronic conditions. The technologies and devices highlighted in this report have all been found to offer savings to the Japanese economy when comparing direct and indirect costs to the costs of the alternative without the use of a medical technology. The savings witnessed have come through the following:

- Avoided downstream healthcare costs
- Improved quality of life and healthy, active aging
- Reduced need for informal and social care and reduced burden on family caregivers
- Increased labour market participation and reduced absenteeism
- Improved work productivity and reduced lost work days
- Effective disease management and reduced mortality

Much of the conversation in Japan and elsewhere about medical technology has focused on the short-term affordability of devices. Our research and the wider literature suggests that attention should also be focused on the savings these interventions may make 1) to the wider economy as a whole, and 2) over the medium to longer-term. Our findings indicate that short-term savings made by not investing in medical technologies may be a false economy.

Comparison to the literature

The results of our broad-based modelling approach echo those of other modelling studies looking at technologies. We describe here four studies that have modelled the economic impact of health technologies across national economies.

A report by the Milken Institute reviewed a range of technologies in diabetes, heart disease, musculoskeletal disease and colorectal cancer[12]. The modelling approach not only investigated current costs and benefits of medical technologies but also modelled the likely impact of future tax and regulatory scenarios. The authors concluded that the medical technologies studied generated economic returns that were substantially greater than their costs. The gains were found through the avoidance of side-effects of uncontrolled disease, reducing hospital stay, and improving survival, workforce participation and productivity.

[12] Milken Institute, "Healthy Savings: Medical Technology and the Economic Burden of Disease". *Santa Monica (CA): Milken Institute*, 2014.

The Work Foundation, part of Lancaster University, also set out to review the overall impact of medical technologies[13]. The first part of their research was a literature review of quantitative studies that assessed the costs and benefits of individual technologies; they then went on to perform qualitative interviews, workshops and focus groups with experts and stakeholders. The Foundation researched a range of technologies, including artificial hip/knee replacements, implantable cardioverter-defibrillators and insulin-pump therapy. The researchers concluded that there were three overall areas that saw benefits from medical technologies 1) improvements in health care, 2) improving quality of life and independent living, and 3) labour market participation and productivity. The authors suggest that the long-term effects of medical interventions are rarely recognised by policymakers, hampering their update.

A working paper from the National Bureau of Economic Research took a different approach to estimating the lifetime costs and benefits of medical technology[14]. The author collected US Medicare data for patients treated for a heart attack in the late 1980s, and followed their outcomes for 17 years after the intervention. The results show that revascularization technology gave over a year of additional life expectancy at a cost of about $40,000. While the author did not quantify the potential economic benefits of that additional year of life, it was noted that medical technology might be a good deal "if it extends the length or quality of life or otherwise results in positive social returns".

Finally, a review of case studies on medical technology in the journal Health Affairs looked at the impact of medical technology in five disease areas[15]. Medical technology costs were identified through the assessment of current and future cost of each disease under study. Future costs were discounted at 3%, though the author reported that the qualitative results were not very sensitive to this discount rate. In four of the five disease areas—heart attacks, low birth-weight infants, depression, and cataracts—the benefits of using technology were found to outweigh the costs. Benefits were calculated to have come from factors such as increased longevity, improved quality of life, and less time absent from work. In the case of the fifth condition, breast cancer, costs and benefits were about even.

The Milken and Work Foundation reports were both at least partly funded by AdvaMed (the sponsors of this report). Nevertheless, the methods used for both reports incorporated reasonable assumptions and cost estimates, and the overall direction of results is consistent with the themes identified in the academic reports. Taken together, the literature and our results support the argument that targeted investment in medical technology offers the opportunities for substantial savings across the wider economy.

[13] The Work Foundation, "Adding Value: The Economic and Societal Benefits of Medical Technology." *Lancaster (UK): Lancaster University*; 2011.

[14] Cutler D.M., "The lifetime costs and benefits of medical technology. Working paper 13478." *Cambridge (MA): National Bureau of Economic Research*, 2007.

[15] Cutler D.M., McClellan M., "Is Technological Change In Medicine Worth It?", *Health Affairs*, 2001; 20(5): 11-29.

Study limitations

All modelling studies necessarily make assumptions and simplifications. While the EIU is confident that the modelling approach used in this study provides fair and illustrative figures of the economic impact of medical technologies in Japan, there remain some limitations. These are outlined below, mapped against the report's mitigating strategies:

- Only four diseases and eight medical devices were modelled. A fully comprehensive study of the entirety of medtech would be both time- and cost-prohibitive. Instead, four diseases were chosen based on carefully screened criteria to ensure significant disease burdens, and the selection of the eight devices was done with broad applicability in mind. The rationale and methodology is explored further in the Appendix.
- Models are non-exhaustive in terms of cost items, externalities or clinical outcome. Similarly, an exhaustive accounting of all the components would be time- and cost-prohibitive. Instead, a comprehensive literature review was conducted to identify key cost components. Details of this is included in the Appendix
- Data was not solely from Japanese sources: While all efforts were made to extract data from peer-reviewed articles using Japanese case studies where possible, a number of line items required the use of international sources. These international sources, primarily from studies from other OECD nations, were validated and localised to the Japanese context via interviews with practicing clinicians and Japanese health economists.
- Selective choice of models. As the objective of the study was to investigate the costs and savings of using medtech, the selection of devices required scenarios where there was a non-medtech alternative. This required a careful additional screening of devices to meet these requirements, and contributed to the narrow scope of some case studies (e.g. the model for the HbA1c test only considered screening, not monitoring)

As a result, the EIU believes that that the approach used in this study offers a valuable assessment of the potential savings, as well as the costs, of medtech in Japan.

Appendix

Disease selection

In order to build a representative model of Japan's healthcare burden using only four diseases, it is imperative that the selection of these four diseases be via filters that ensure they have a large impact on the Japanese population – while there is significant medtech investment in rare diseases, using these is unlikely to provide a broad view of the overall impact of medtech. As a result, the following four diseases were chosen - cerebrovascular disease, lung cancer, diabetes mellitus and musculoskeletal disorders.

To ensure the diseases were representative we used three criteria: large social burden, large economic burden, and public interest. Disability Adjusted Life Years (DALYs) were used to assess the first criteria. DALYs are a time-based summary measure of population health combining the years of life lost (YLLs) from early death and the years of life lost due to the time living with disability (YLDs).

Figure 3: DALYs, YLLs and YLDs

Disability-Adjusted Life Year (DALY)
Burden of disability associated with disease
=
Years of Life Lost
(YLLs)
Total average years of life lost
due to disease
+
Years lived with Disability (YLD)
Total years lived with disability

Table 15: Top 15 diseases / disability by DALY

	2013	DALY	*YLDs*	*YLLs*
1.	Low back and neck pain	2,312,466	*2,312,466*	
2.	Cerebrovascular disease	2,084,506	*256,951*	*1,827,555*
3.	Ischemic heart disease	1,720,158	*357,781*	*1,362,377*
4.	Lower respiratory infections	1,192,792	*7,868*	*1,184,924*
5.	Tracheal, bronchus & lung cancer	1,114,777	*23,251*	*1,091,526*
6.	Diabetes mellitus	1,009,618	*895,085*	*114,533*
7.	Depressive disorders	985,255	*985,255*	
8.	Stomach cancer	952,322	*25,738*	*926,584*
9.	Chronic obstructive pulmonary disease	872,544	*383,464*	*489,079*
10.	Alzheimer disease and other dementias	859,838	*489,137*	*370,701*
11.	Colon and rectum cancer	806,768	*56,805*	*749,963*
12.	Skin and subcutaneous diseases	785,595	*768,479*	*17,116*
13.	Liver cancer	743,183	*10,179*	*733,005*
14.	Falls	722,592	*584,403*	*138,189*
15.	Chronic kidney disease	615496	*241,764*	*374,182*

Source: Institute for Health Metrics and Evaluation (Global burden of disease) – Japan (2013)

Cerebrovascular Diseases
Lung Cancer
Diabetes Mellitus
Musculoskeletal

While burden of disease is a good proxy of the overall impact of disease on a society, this was supplemented by the second criteria: a consideration of the economic burden of disease. This criteria was assessed based on top diseases by healthcare expenditure as well as top diseases by hospital discharges. This ensures the cost models incorporated diseases that have a significant impact on the healthcare budget and captures a significant portion of the healthcare infrastructure.

Table 16: Top 15 diseases / disability by expenditure (JPY m)

		Inpatient	Outpatient	Total
1.	Diseases of the circulatory system	3,159,900	2,500,300	**5,660,200**
2.	Neoplasms	2,341,300	1,133,800	**3,475,100**
3.	Diseases of the respiratory system	855,400	1,258,600	**2,114,000**
4.	Diseases of musculoskeletal system and connective tissue	852,100	1,174,200	**2,026,300**
5.	Endocrine, nutritional and metabolic diseases	505,900	1,476,900	**1,982,800**
6.	Mental and behavioural disorders	1,459,300	499,800	**1,959,100**
7.	Diseases of the genitourinary system	548,000	1,391,000	**1,939,000**
8.	Injury, poisoning and other consequences of external causes	1,293,200	502,600	**1,795,800**
9.	Diseases of the digestive system	857,900	792,400	**1,650,300**
10.	Diseases of the nervous system	805,600	361,000	**1,166,600**
11.	Diseases of the eye and adnexa	246,200	710,900	**957,100**
12.	Infectious and parasitic diseases	265,300	409,000	**674,300**
13.	Diseases of the skin and subcutaneous tissue	93,800	370,400	**464,200**
14.	Symptoms, signs and abnormal clinical and laboratory findings	194,400	213,800	**408,200**
15.	Diseases of the blood and bloodforming organs	122,900	98,500	**221,400**

Source: OECD.Stat, using System of Health Accounts (SHA) Framework

All four of the disease areas chosen are well represented amongst the metrics above and are classified as non-communicable diseases. Commonly known as 'lifestyle diseases', these afflictions have become the chief cause of mortality and morbidity in Japan. This is in part due to aging population, as the burden of chronic health conditions increases steadily with age, and in part due to the greater adoption of a 'Western' diet, and of health-damaging habits such as smoking. Combating these lifestyle diseases has become a key priority of the Ministry of Health, Welfare and Labour, as laid out in its 'Health Japan 21 (second term)' plan, which covers 2013 until the present. Three of the four diseases chosen for the model are targeted by the MHLW as key action areas for prevention of both onset and progression.

Table 17: Top 15 diseases / disability by hospital discharges (2016)

		No. of hospital discharges
1.	Cerebrovascular diseases	692,500
2.	Single spontaneous delivery (birth)	542,000
3.	Pneumonia	481,100
4.	Cataract	452,200
5.	Malignant neoplasm of colon, rectum and anus	404,200
6.	Malignant neoplasm of trachea, bronchus and lung	362,900
7.	Angina pectoris	343,200
8.	Complications of pregnancy in the antenatal period	272,300
9.	Fracture of femur	267,500
10.	Heart failure	256,300
11.	Deforming dorsopathies and spondylopathies	238,400
12.	Diabetes mellitus	218,900
13.	Cholelithiasis	206,300
14.	Renal failure	186,800
15.	Conduction disorders and cardiac arrhythmias	174,700

Source: OECD.Stat, using System of Health Accounts (SHA) Framework

This approach of using three criteria resulted in the four selected disease areas that we believe are a representative cross-sampling of the disease burden in Japan, and should serve as proxies to model out the overall economic impact from medtech. We describe below a brief epidemiological introduction to the four disease areas in Japan.

Cerebrovascular disease

According to the World Health Organisation (WHO), stroke is the leading cause of disability and the second leading cause of death for people over the age of 60 worldwide. Stroke is not just a major public health issue, but it also puts increasing strain on healthcare systems, quality of life and the wider economy. Although most prevalent in individuals over the age of 60, anyone can suffer from a stroke. As well as producing a high mortality burden, strokes also result in a high disability burden. Stroke patients that survive the acute episode are often left with some degree of disability, with many remaining dependent on care-givers because of it.

In Japan specifically, stroke poses a huge burden on the healthcare system. Recent evidence shows that:

- It is the second leading cause of disability in the country which resulted in 256,951 years lived with disability (YLD) in 2013
- In the same year, it was also responsible for 1,827,555 years of life lost (YLL)
- It costs the Japanese government approximately ¥5,600,200 per annum

Figure 4: Health Japan 21 (the second term) targets

Health Japan 21 (the second term)
List of targets
A list of all targets for Health Japan 21 (the second term) has been published
Table 1: Targets for acheiving extension of healthy life expectancy and reduction of health disparities
Table 2: Targets for the prevention of onset and progression of life-style related diseases
(1) Cancer
(2) Cardiovascular disease
(3) Diabetes
(4) COPD
Table 3: Targets for maintenance and improvement of functions necessary for engaging in social life
(1) Mental health
(2) Children's health
(3) Health of elderly people
Table 4: Targets for putting in place a social environment to support and protect health
Table 5: Targets for improvement of everyday habits and social environment relating to nutrition and dietary habits, physical activity and exercise, rest, alcohol, and smoking, and dental and oral health
(1) Nutrition and dietary habits
(2) Physical activity and exercise
(3) Rest
(4) Alcohol drinking
(5) Tobacco smoking
(6) Dental and Oral health

(1) Cancer

Indicators	Current data	Target
1 Reduction in age-adjusted mortality rate of cancer under age 75 (per 100,000)	84.3 (2010)	73.9 (2015)
2 Increase in participation rate of cancer screenings	Gastric cancer Male 36.6% Female 28.3% Lung cancer Male 26.4% Female 23.0% Colorectal cancer Male 28.1% Female 23.9% Cervical cancer Female 37.7% Breast cancer Female 39.1% (2010)	50% (40% for gastric, lung, and colorectal cancer) (2016)

Note: These rates represent individuals who are between 40 and 69 years old (for cervical cancer age of individuals is between 20 and 69 years).

Source: Ministry of Health, labour and Welfare. "Health Japan 21 (the second term)." Available at: http://www.mhlw.go.jp/seisakunitsuite/bunya/kenkou_iryou/kenkou/kenkounippon21/en/kenkounippon21/mokuhyou02.html

- Although the highest prevalence of stroke in Japan is in individuals over the age of 70; 651,621 in 2015, stroke affects almost 600,000 individuals a year between the ages of 15 and 69[16]

Japan's aging population combined with the rising prevalence of conditions such as obesity and diabetes mean that these numbers are only set to increase over the next few years.

Diabetes

Diabetes mellitus is a medical condition that is caused by high blood glucose (blood sugar), either due to inadequate insulin production, or that a person's body cells do not respond properly to insulin, or a combination of both. Diabetes mellitus constitutes a major health burden in terms of mortality and impaired quality of life, and the prevalence of diabetes continues to increase globally.

In recent years there has been rapid growth in diabetes in Japan. It is now one of the nations most affected by the worldwide diabetes epidemic. The rapidly increasing prevalence of type 2 diabetes, particularly due to population aging and sedentary lifestyle, has important consequences. Evidence suggests:

- Approximately 13.5% of the Japanese population has either type 2 diabetes or impaired glucose tolerance with highest prevalence within the working age population (54-65 years)
- 7.2 million Japanese were diagnosed with diabetes in 2015[17]
- Cost to the national health insurance is ~ $4,000 per patient per year
- Diabetes accounts for up to 6% of the total healthcare budget

Lung cancer

Lung cancer is one of the most prevalent and also one of the most serious types of cancer. There are two main types of primary lung cancer: non-small-cell and small-cell. Non-small-cell lung cancer is the more common of the two, responsible for 80% of lung cancer cases. Although less common, small-cell lung cancer tends to be a more aggressive form and spreads faster than non-small-cell cases. This model concentrates on the more common non-small cell form.

It is well documented that smoking is the principal risk factor for lung cancer, said to be responsible for 85% of cases. Evidence suggests that:

- In Japan, in 2010, lung cancer was the fourth leading cause of death
- In 2015, the lung cancer incidence stood at 137,135
- Lung cancer mainly affects the older population; it is rare in individuals below the age of 40 and the rates increase sharply with age. The most commonly diagnosed age group is 70-74.

However, Japan boasts good outcomes for lung cancer. The Japan Foundation for Promotion of Cancer Research recently reported that the five-year survival rate for lung cancer was, by comparison with other countries, one of the best.

[16] Global Health Data Exchange. Seattle (WA): *Institute for Health Metrics and Evaluation*, 2016.

[17] International Diabetes Federation. Brussels, 2015.

Musculoskeletal Disorder

Musculoskeletal disorder (MSD) is an umbrella term used to describe chronic conditions that affects muscles, bones and joints all over the body. MSDs include rheumatoid arthritis, osteoarthritis, osteoporosis, major limb trauma, and spinal disorders. Diseases of the joints resulting in low back, neck, hip and knee pain, are among the leading causes of disability and the prevalence of MSDs increases with age[18]. Given that the population in Japan is aging, this means that the number of Japanese with MSDs will keep increasing. Not only will this impose a substantial burden on an individuals' ability to live independently and continue productive working lives, the increased prevalence of musculoskeletal disorders will also be costly to the economy, detracting from future productivity.

Evidence suggests that:

- MSDs account for more than 10% of years lost to disability globally[19]
- 1.2 million individuals of working age are physically disabled in Japan[20]
- In 2011, the prevalence of chronic musculoskeletal pain in Japan was 15.4%[21]
- Prevalence was highest in people in their 40s (18.6%), followed by those in their 30s (18.3%) and 50s (17%)

As MSDs encompass a wide variety of ailments, with multiple treatments, for the purpose of this report, the model will focus in on osteoporosis and hip pain.

Osteoporosis is a medical condition characterized by a systemic impairment of bone mass, decrease in bone mineral content and microarchitecture that results in fragility fractures. Disorders of the hip joint especially hip fracture is the most serious complication of osteoporosis and has been recognized as a major cause of becoming bedridden in Japan. While osteoporosis is the leading cause of hip pain and hip fractures, other diseases such as rheumatoid arthritis, tendinitis and bursitis can also lead to hip pain. Evidence suggests:

- Number of people in Japan who need support in daily life and long-term care due to Osteoporosis is about 5.5 million, and the number has been increasing steadily[22]
- 13 million people in Japan were affected due to hip fractures
- Incidence rate of hip fracture in Japan were 5.1 in 10,000 men and 18.1 in 10,000 women
- Hip fractures are also associated with a high mortality rate i.e. 15% during one year after the fracture

[18] Anthony D. Woolf and Bruce Pfleger. "Burden of major musculoskeletal conditions", *Bone and Joint Decade 2000-2010*, Bulletin of the World Health Organization, 2003.

[19] World Health Organization, "Death and DALY estimates for 2004 by cause for WHO Member States", Retrieved on 14 March 2011 from http://www.who.int/healthinfo/global_burden_disease/estimates_country/en/index.html.

[20] Ministry of Health, Labour and Welfare (MHLW), "Services and Supports for Persons with Disabilities in Japan", Retrived on 5 April 2012 from http://www.mhlw.go.jp/english/wp/policy/dl/02.pdf.

[21] Zheng X., Schipper M., Kidwell K. et al. "Survival Outcome After Stereotactic Body Radiation Therapy and Surgery for Stage I Non-Small Cell Lung Cancer: A Meta-Analysis." *Int J Radiat Oncol Biol Phys.*, 2014; 90(3):603-11.

[22] H. Orimo et al., "Hip fracture incidence in Japan: Estimates of new patients in 2012 and 25-year trends", *Osteoporosis Int*, 2016; 27: 1777-1784.

Device selection

In addition to disease selection, it is also necessary to ensure that the selection of devices is representative. As 'medtech' is an umbrella term that incorporates a large – and growing – category of interventions, devices were selected that reflect the diversity of medical technology. When selecting devices we considered the following:

- Common vs rare: Commonly used international (and Japanese) standard of care vs. technologies where Japan has set the gold standard of care
- Established vs new: Devices that have withstood the test of time vs. new technologies recently introduced to the Japanese market
- Screening vs treatment: Screening / diagnostic tools vs. intervention / treatment devices
- Large vs small: Large scale capital equipment vs. disposable, single-use devices vs. long-term implants

In addition to the above requirements, due to the approach of the study, another consideration when choosing devices was depth of data. As this study is primarily driven from secondary research, supported by in-field primary research, availability of published literature (English & Japanese) with respect to the economic contribution per medical device was a key requirement for inclusion.

Table 18: Medical Devices Investigated

Disease	Medical Technology (Screening)	Medical Technology (Treatment)
Cerebrovascular disease	Carotid Angiography with catheter	Metal mesh cages: Stent retrievers
Lung Cancer	Low-dose Spiral CT scan (CT scanners)	Linear accelerators for external beam therapy
Diabetes Mellitus	HbA1c test kit	Insulin pump
Musculoskeletal disorders	Dual-energy X-ray absorptiometry	Hip replacement surgery-hip implants

Research program

To assess the impact of each of the devices, a research program that utilised both primary and secondary sources to develop a Japan-specific model was executed. This research program followed a three-phased approach, with the following components:

A. In-depth literature review to build the modelling framework

B. Secondary research of existing international and Japanese-specific literature to complete the model and identify data gaps

C. Primary research to validate findings and to localize international sources

A literature review was conducted to evaluate different modelling approaches which could be used to build the model used in this study. The review used a range of pragmatic and iterative search methods including searching databases, grey literature searches and reference harvesting. There were no search limits on language.

It identified key data inputs to use when modelling the economic costs.

Table 19: Literature review data inputs

Direct medical costs:	
Treatment expenditure	Chatterjee 2014[23] Cutler 2001[24] Skinner 2006[25] Orlando 2013[26] Bevan 2011[27] Baker 2008[28]
Disease management and long-term care	Chatterjee 2014 Cutler 2001 Skinner 2006
Indirect costs:	
Lost work output and productivity (absenteeism)	Chatterjee 2014 Cutler 2001 Skinner 2006 Bevan 2008
Changes in life expectancy (early mortality)	Cutler 2001 Skinner 2006 Orlando 2013
Foregone GDP	Chatterjee 2014 Cutler 2001 Skinner 2006

Using the key data inputs identified in the literature review, potential parameters were chosen to measure economic costs and benefits. The approach used a tailored model to establish the economic contributions of medical technologies on direct and indirect costs and benefits.

Once the data points for the model were finalised, quantification of relevant costs and benefits were based on existing published research. For some data points, international data was identified through desk research. In these cases, in-depth interviews with Japanese experts were used to validate findings. Japanese experts were recruited using a variety of screener questions to identify specialists in the field who would be most useful for insight and validation of costs in Japan.

[23] Milken Institute. "Healthy Savings: Medical Technology and the Economic Burden of Disease." *Santa Monica (CA): Milken Institute*, 2014.

[24] Cutler D.M., McClellan M., "Is Technological Change In Medicine Worth It?" *Health Affairs*, 2001; 20(5): 11-29.

[25] Skinner J., Staiger D., Fisher E., "Is technological change in medicine always worth it? The case of acute myocardial infarction." *Health Affairs*, 2006; 25(2):w34-w47.

[26] Orlando R., Pennant M., Rooney S., et al., "Cost-effectiveness of transcatheter aortic valve implantation (TAVI) for aortic stenosis in patients who are high risk or contraindicated for surgery: A model-based economic evaluation." *Health Technology Assessment*, 2013.

[27] The Work Foundation. "Adding Value: The Economic and Societal Benefits of Medical Technology." *Lancaster (UK): Lancaster University*, 2011.

[28] Baker L.C., Atlas S.W., Afendulis C.C., "Expanded use of imaging technology and the challenge of measuring value." *Health Affairs*, 2008; 27(6): 1467-78.

Figure 5: Parameters in modelling framework

Impact on the healthcare system (direct costs)	• Cost of screening • Cost of diagnosis • Cost of treatment • Cost of hospitalisation • Cost of recovery (long-term care)
Impact on the economy (Indirect costs)	• Reduced absenteeism • Costs avoided from earlier diagnosis • Lost work productivity (disability, mortality) • Impact on informal care

The economic evaluation was undertaken from two perspectives: healthcare system (direct costs) and societal (indirect costs). The societal perspective (indirect costs) was taken into account in order to understand the impact of the intervention on the welfare of society as a whole.

Cost models considered the patient pathways involved in each disease to measure both the direct and indirect impact of each medical technology on the Japanese healthcare system. The model incorporated costs and benefits per device to calculate the economic impact as well as average savings.

The timing of costs and consequences is an important consideration in economic evaluations, especially for health-care programs for which most of the costs are incurred at the present moment and health benefits occur in the future. However, for this study the analytic horizon is of one year and therefore discounting calculations were not undertaken.

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Powered by EIU Canback and developed by experts in economic modelling and forecasting, Market Explorer hones in on markets that match your target demographic both at country and city level. It also allows you to weight those opportunities against the risk inherent in any new investment.

A global online market scanning and forecasting tool that's light years ahead

- Emerging markets focus: With over 140 countries and 1,000 cities at your fingertips Market Explorer puts a particular spotlight on centres of rapid economic growth. Rank and compare countries and cities in terms of their market potential by drawing on EIU Canback's world renowned demographic and income data forecasts. We've incorporated over 2,000 data points per city. No other provider can deliver this level of granularity.

- Plan for today and forecast through to 2030: With data available from 2005 – 2030 Market Explorer helps you form a view on markets over time and access results from past, current and future years.

- Precise outcomes, reliable data: Powered by our rigorous approach to data standardisation, economic analysis and forecasts, Market Explorer offers precise comparisons between potential markets in terms of size and nature of opportunity. Users have the option to view income at purchasing power parity (PPP) in addition to perceived annual market exchange rates.

- Evidence-based, actionable results tailored to your requirements: Adjust rankings according to your appetite for risk or return by refining and weighting results by adding 15 external environment indicators.

- Fast, user-friendly and with a choice of reporting: In just a few simple steps you can have access to tailored market opportunities and forecasts with your choice from a range of reporting options.

- Support from our team of experts when you need it: We'll always be on hand to provide training and customised support when you need it.

For more information please visit eiu.com/market-explorer

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