Cost benefit analysis of a long-term care prevention program in Japan

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February 28, 2017

CONTENTS

0 Abstract

Objective: To undertake a cost benefit analysis of a long-term care prevention program that consists of physical exercise, oral care, and nutrition education for elderly people.

Design: Cost benefit analysis of a randomized controlled trial.

Subjects: A total of 778 participants. Participants were recruited from people aged 65 and over living in 10 municipalities in Japan. They were selected based on a survey on their health status, and were either eligible for secondary care prevention programs or frail elderly people. These people had lowered physical functionality but did not have big challenges with their daily activities.

Intervention: The intervention was conducted once or twice a week in 1.5-4.5 hour classes over a period of three months in 2009, 2010, or 2011. The intervention consisted of physical exercise, oral care, and nutrition education. The class content was designed and managed by specialists such as public health nurses, dietitians, and dental hygienists.

Methods: The monetized quality-adjusted life years (QALY) gained is compared with the sum of program cost and time cost of participants.

Results: In the baseline scenario, the benefit over three months (JPY 20.61 million) is lower than the cost (JPY 35.56 million). However, the benefit which extends over one year (JPY 78.94 million) exceeds the cost (JPY 68.20 million). Although the baseline scenario including the benefit over one year shows the positive result of the program, there is uncertainty in the analysis. The combination of the level of time cost, assumption on the monetization of QALY and longitudinal change of SF-6D can change the conclusion about the cost-effectiveness.

Conclusion: The cost-effectiveness of a comprehensive long-term care prevention program depends on the level of time cost and assumption on the monetization of QALY and longitudinal change of SF-6D. In order to make the program cost-effective, the time cost should be lower than JPY 905.25 when considering the long-term effect of the program over one year. When the effects are limited to a three-month consideration, the acceptable level of time cost is JPY 166.5. It is difficult to say the program is cost-effective only within three months, but there is a chance that it becomes cost-effective over one year. Even if the time cost is higher than JPY 905.25, a different assumption on the monetization of QALY or longitudinal change of SF-6D may justify the implementation of the program. Further research on time cost of elderly people and the longitudinal change of SF-6D is needed.

Key Words: cost benefit analysis; long-term care prevention programs; physical exercise; oral care; nutrition education; randomized controlled trial.

1 Introduction

1.1 Long-Term Care Prevention Programs in Japan

The number of people who use the long-term care insurance services is dramatically increasing in Japan. As of 2016, July 31, a total of 5.60 million people used long-term care services (Ministry of Health, Labor, and Welfare, 2016a). This figure is projected to go up as the number of elderly people increases. Without any reforms, it is estimated to reach 6.63 million in 2025 (Ministry of Health, Labor, and Welfare, 2013).

Although it is natural for human beings to get old, have lowered physical functionality, and depend on others to live a daily life, it is desirable to delay the need for long-term care services and enable elderly people to live a healthy life. Long-term care prevention programs are a solution to achieve the long-term well-being of elderly people. With that perspective, Japan has a variety of long-term care prevention programs such as physical exercise, nutrition education, oral care, cognitive function management, comprehensive program, homebound prevention, and depression prevention.

The prevention programs may help the Japanese government reduce social expenditures. The Japanese government struggles with the huge expenditure for the long-term care system: a total expenditure for the long-term care system in 2016 was JPY 10.4 trillion, financed half by contributions from national and local governments (Cabinet Office, 2016b). It is estimated to almost double by 2025 (Ministry of Health, Labor, and Welfare, 2013), which will make public debt unsustainable in the future. If the prevention programs successfully reduce the number of elderly people who use long-term care services, it will reduce the government's financial burden. However, it is possible that the prevention programs increase the total expenditure if they do not work well.

The Japanese government has reviewed the effectiveness and efficiency of social services in the Comprehensive Reform of Social Security and Tax[1]. While the government has not considered reducing the budget for the long-term care prevention programs, there is a chance that they will start considering it. In that case, it is needed to have evidence on which programs are cost-effective and should be kept.

1.2 Cost Benefit Analysis of Long-Term Care Prevention Programs

[1] Social security includes healthcare, long-term care, public pension, and child care support services.

It is important to see if it is economically justifiable to spend public expenditure on the long-term care prevention programs, and which programs are cost-effective. Answering those questions requires robust analyses using experimental trials that show the cost-effectiveness of the programs. In Japan, there are very few such analyses. While there are some analyses that show the effectiveness of programs, cost-effectiveness analyses or cost utility analyses in this field are not developed enough.

Also, we cannot see cost benefit analyses on the prevention programs. Although there is an ethical issue to monetize health benefit, cost benefit analyses enable the comparison of different programs in the same unit of measurement: monetary unit. In the Comprehensive Reform of Social Security and Tax, the Japanese government has to decide which program's budget should be reduced out of a variety of social services such as healthcare, long-term care, public pension, and child care support services. It is crucial to use the same unit of measurement to compare different programs.

1.3 Objectives of This Paper

The objective of this paper is to undertake a cost benefit analysis of a long-term care prevention program which consists of physical exercise, oral care, and nutrition education for elderly people. Using a randomized controlled trial, this analysis will see if the implementation of the program is economically reasonable.

Also, this paper will be the first cost benefit analysis on long-term care prevention programs in Japan. Thus, it could be a foundation for further cost benefit analyses on long-term care prevention programs. If the number of cost benefit analyses on prevention programs is increased, the Japanese government can understand which programs are cost-effective and which programs are not.

2 Literature Review

This chapter reviews previous studies on the effectiveness of long-term care prevention programs on Quality of Life (QoL), and cost-effectiveness analyses or cost utility analyses of long-term care prevention programs. This literature review focuses on robust evidence derived from randomized controlled trials.

2.1 Effectiveness of Long-term Care Prevention Programs on Quality of Life

2.1.1 Physical Exercise

The effectiveness of physical exercises in terms of QoL improvement is unclear. A systematic review conducted by Van Malderen et al. (2013) identified 15 studies on the effect of physical exercises on QoL. The results of the studies were not consistent. Nine of them showed positive results, but six did not. Overall, the author concluded that whole body vibration, a regular exercise program, tai chi, musical exercise therapy and a moderate group-based multicomponent exercise program, seemed to generate positive results. Another systematic review also found that there is limited economic evidence on the effect of physical rehabilitation on QoL (Crocker et al., 2013).

2.1.2 Oral Care

Oral health is significantly associated with general health, especially among elderly people. Poor oral health can have a significant impact on QoL and the functional ability of them (Porter et al., 2015).

Some interventions of oral care have proved to be effective increasing QoL. A randomized controlled trial conducted by Gil-Montoya et al. (2008) revealed that a mouthwash and oral gel containing the antimicrobial proteins lactoperoxidase, lactoferrin and lysozyme had a positive effect on the Oral Health Impact Profile values, which are the values of oral health-related QoL. Naito et al. (2010) also assessed the impact of dental treatment on the General Oral Health Assessment Index (GOHAI), another oral health-related QoL measure. The treatment group experienced a significant increase in GOHAI scores between baseline and six weeks later (mean difference 6.3, $p = 0.04$). Note that the study of Naito et al. (2010) was a non-randomized controlled trial.

Other oral cares such as information sharing on oral care, oral rehabilitation, and oral health education, have not been proven to improve QoL.

2.1.3 Nutrition Education

A systematic review on the relationship between malnutrition and QoL revealed that malnutrition led to poor QoL (Rasheed and Woods, 2013). Cohort studies showed that people with malnutrition were more likely to have low QoL (OR: 2.85; $p < 0.001$). Interventions designed to improve nutritional status have proved to improve QoL, both physically (standard mean difference 0.23, $p = 0.002$) and mentally (standard mean difference 0.24, $p < 0.001$)[2].

Some studies about nutrition education using randomized controlled trials indicate the positive effect of nutrition education on QoL. Weekes et al. (2009) conducted an intervention lasting six months that consisted of a leaflet containing advice on nourishing snacks and drinks, encouraging food fortification, a package of dietary counseling by an experienced dietician, and the supply of milk powder. There was a statistically significant change in the Short Form 36 scores, an indicator of QoL (mean difference 19.2, $p = 0.029$).

The conclusions of other studies, however, are different. Milte et al. (2016) combined nutrition therapy with strength and balance exercises. The nutrition therapy included dietary consulting, recommendations of nutrient-rich foods and recipes, referrals to community meal programs, provisions of commercial oral nutritional supplements or commercial protein powders, and visits by a dietitian every 14 days. The treatment group showed a slightly higher mean in utility score, QoL measured on a scale of 0–1 (0 = death and 1 = full health), but the mean difference was not statistically significant. Moreover, in a study by Persson et al. (2007), QoL did not change after nutritional treatments that consisted of personalized counseling sessions and telephone calls by a dietician, liquid supplements (Sempers), and daily multivitamin supplements (Friggss). Finally, a study by Wyers et al. (2013) did not see a statistically significant increase in quality-adjusted life years (QALY) after the intervention of dietetic counseling and consumption of a multi-nutrient oral nutritional supplement.

Note that most interventions include the provision of energy, such as nutritional supplements and milk, and the independent effect of nutrition education is not known.

2.2 Cost-Effectiveness Analyses or Cost Utility Analyses of Long-term Care Prevention Programs

2.2.1 Physical Exercise

Although the results regarding the effectiveness of physical exercises in terms of QoL

[2] The authors note that many of the included studies had poor quality of study design, and

improvement are inconsistent, there is relatively strong evidence that physical exercise programs are cost-effective. A systematic review on cost-effectiveness analyses of physical activity interventions identified 13 studies based on randomized controlled trials, most of which (12 out of 13) were proven to be cost-effective (Garrett et al., 2011). The systematic review concluded that the intervention had a lower cost per QALY, especially when direct supervision or instruction was not needed. Community walking, exercise and nutrition programs, and brief exercise advice were the most cost-effective.

2.2.2 Oral Care

There are very few cost-effectiveness analyses of oral care for older adults that are well designed. Most cost-effectiveness analyses of oral care did not use robust methodology such as controlled trials, or the calculation of cost-effectiveness was not conducted appropriately. Some interventions were targeted at younger generations that have different oral problems than elderly people.

2.2.3 Nutrition Education

There is little evidence on the cost-effectiveness of nutrition education programs. The study of Milte et al. (2016) showed that the incremental cost-effectiveness ratio (ICER) was AUD 28,350 per QALY gained, which was below the cost-effectiveness threshold adopted by regulatory authorities in Australia. Wyers (2013) also asserted that nutritional intervention was unlikely to be cost-effective when QALY was set as an outcome. With a willingness to pay EUR 20,000 per QALY, the probability that the nutritional intervention was cost-effective was 45%. However, when the study separated people aged between 55 and 74 years from those over 74 years, the probability of cost-effectiveness reached 85% for participants aged below 75 while the probability of cost-effectiveness for patients aged 75 years and above only reached 26%.

2.3 Summary of Literature Review

While there are some previous studies that show the effectiveness of physical exercises, oral care, and nutrition education on the improvement of QoL, it is difficult to say that all those interventions are effective because of the inconsistency of the results and lack of evidence on specific interventions. Thus, the effectiveness of the comprehensive program this paper analyzes is unclear based on literature review. The cost-effectiveness of the program is also uncertain due to the limited evidence on oral care and nutrition education. In the next chapter, this paper analyzes the comprehensive program which combines physical activities, oral care, and nutrition education, and see if the program is cost-effective.

3 Methodology

3.1 Overview of Long-Term Care Prevention Programs

Japan has a variety of long-term care prevention programs including physical exercise, nutrition education, oral care, cognitive function management, homebound prevention, depression prevention, and a comprehensive program. Those programs aim to help elderly people at risk of using long-term care services improve their health status and delay the need for long-term care services.

The program this paper analyzes is the comprehensive program which combines a physical exercise program, oral care program, and nutrition education program. The comprehensive program is expected to have a better effect on participants' health status than a single program.

3.2 Overview of the Mitsubishi Research Institute's Study

Mitsubishi Research Institute (2012) conducted an analysis about the effectiveness of the comprehensive program. Using a randomized controlled trial, they compared the treatment group and control group in terms of 15 indicators such as Short Form 8 Health Survey (SF-8), WHO-5, higher-level competence, RSST, GO-HAI, and muscle strength, etc. This paper uses the data and results from the study of Mitsubishi Research Institute (2012) to conduct a cost benefit analysis.

3.2.1 Participants

In the study of Mitsubishi Research Institute (2012), participants were recruited from elderly people aged 65 and over living in 10 municipalities[3]. They were selected based on a survey on their health status, and were either eligible for secondary care prevention programs or frail elderly people. These people had lowered physical functionality but did not have big challenges with their daily activities[4]. After being selected, participants got an information session about the program. Participants were randomly assigned to either a

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[3] 10 municipalities include Fukushima City (Fukushima prefecture), Kusatsu City (Gunma prefecture), Wako City (Saitama prefecture), Yoshimi town (Saitama prefecture), Shima City (Mie prefecture), Ichikawa town (Hyogo prefecture), Kamigori town (Hyogo prefecture), Onan town (Shimane prefecture), Komatsushima City (Tokushima prefecture), and Misato town (Kumamoto prefecture).

[4] Mitsubishi Research Institute does not provide detailed information on the inclusion/exclusion criteria.

treatment group (n=778) or control group (n=778).

3.2.2 Intervention

The intervention was conducted over a period of three months in 2009, 2010, or 2011. Subjects in the treatment group attended the program consisting of physical exercise, oral care, and nutrition education. The frequency, time, class size and content of classes depended on municipalities. According to the study by the Mitsubishi Research Institute (2012), the program was held about once or twice a week in 1.5-4.5 hour classes. Class sizes varied from 15 to 50 participants per class.

The class content was designed and managed by specialists such as public health nurses, dietitians, and dental hygienists. They designed classes based on the manual for a physical exercise program, oral care program, and nutrition education program (Ministry of Health, Labor, and Welfare, 2009a).

The physical exercise included stretching, balance exercises, functional exercises, and muscle strengthening exercises. The oral care program educated participants on how to do oral exercises, helped them clean their mouth on their own, and conducted training on ingesting/swallowing. In the nutrition education program, participants planed and cooked a meal, and had lectures about foods, commercial products, and services for maintaining good nutrition.

3.3 Analytical Framework

3.3.1 Standing

In this paper, national benefits and costs are taken into account. While the long-term care prevention program is conducted at the local municipality level, the benefits and costs are not only enjoyed by those who live in that municipality, but also by the Japanese as a whole due to the fiscal scheme of the program. The 50% of program budget is financed by contributions from national and local governments, primarily through general tax revenue. If the program successfully reduces the expenditure for the long-term care insurance system, the benefits will be shared among Japanese people as a whole. Thus, national benefits and costs should be counted.

3.3.2 Alternatives

The treatment group and control group are compared and analyzed.

3.4 Benefit Components

3.4.1 SF-6D

The benefit is gained QALY. QALY is a measure of the value of health outcomes, and mainly used in cost-effectiveness analyses or cost utility analyses. It combines quantity and quality of life, and the value of QALY is determined by multiplying the health-related quality of life weights with a certain health state by the periods lived in that state. The health-related quality of life weights, namely utilities, are measured on a scale of 0–1 (0 = death and 1 = full health). The utilities can be captured by measuring preference-based scores such as SF-6D and EQ-5D. SF-6D is usually derived from Short Form 36 Health Survey (SF=36) or Short Form 12 Health Survey (SF-12), but there is a study which demonstrates that SF-6D can be generated from SF-8 as well (Wang et al., 2013). While the derivation of SF-6D from SF-8 is still developing, this paper uses the same model developed by Wang et al. (2013) to obtain SF-6D from SF-8:

$$SF6D = 0.5462 - 0.0046 * PCS - 0.0056 * MCS + 0.0003 * PCS * MCS$$

where PCS is the physical component summary and MCS is the mental component summary.

3.4.2 Monetization of QALY

After obtaining the gained QALY, the monetization of QALY is needed. There are two methods to monetize QALY. The first is that professionals determine the threshold of QALY given a healthcare budget. The second is to measure people's willingness-to-pay (WTP) for healthcare. Shiroiwa et al. (2010) use the second method and state the mean and median WTP per QALY is JPY 5 million, which is widely used in Japan. The validity of this figure is also confirmed by Shiroiwa et al. (2013). While there are other previous studies which indicate the WTP per QALY is higher than JPY 5 million (Ohkusa, 2003; Ohkusa, 2006), this paper uses this value and conduct sensitivity analysis on the monetization of QALY later.

3.4.3 Total Benefit

Given the number of participants is 778, the benefit of the program can be obtained by the following equation:

$$Benefit = \left((SF6D_3^{TG} - SF6D_0^{TG}) - (SF6D_3^{CG} - SF6D_0^{CG})\right) * JPY\ 5\ milion * 778 * \frac{3}{12}$$

where $SF6D_3^{TG}$ and $SF6D_0^{TG}$ are the SF-6D value of the treatment group after and before the treatment, respectively, and $SF6D_3^{CG}$ and $SF6D_0^{CG}$ are the SF-6D value of the control group after and before the treatment, respectively.

The image of the QALY gained is illustrated in the Figure 1. Before the intervention, both the treatment group and control group experience the decline of their SF-6D due to aging. However, the intervention increases the SF-6D of the treatment group. The difference between the realized SF-6D and the SF-6D that should have appeared without the intervention is the QALY gained.

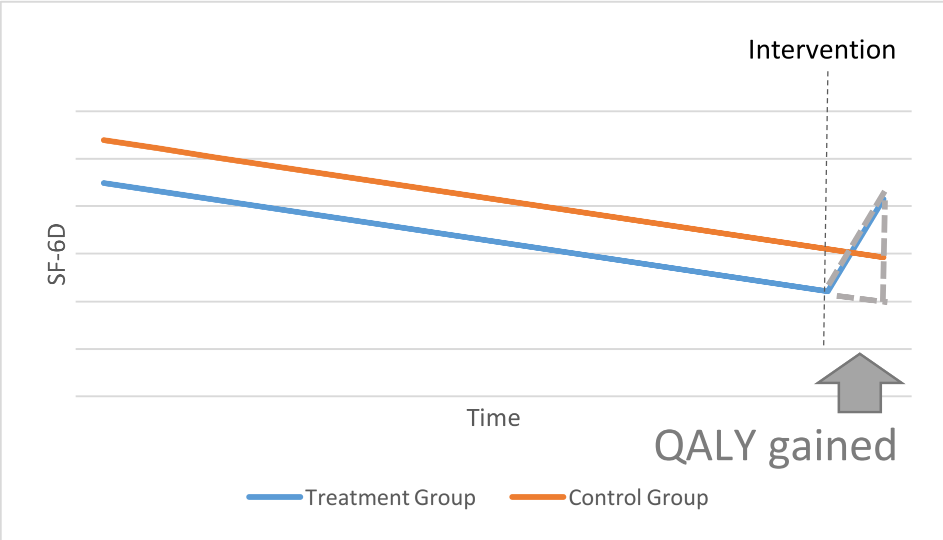

Figure 1: Image of QALY gained (Three Months)

3.5 Cost Components

3.5.1 Program Cost

Cost components consist of program cost and time cost of participants. There is no data for the actual program cost, but that can be calculated using the long-term care insurance system. The insurance system stipulates how much municipalities should pay service providers for each long-term care service. For the comprehensive program, municipalities pay JPY 7000 per person per month[5] (Ministry of Health, Labor, and Welfare, 2011). Define the program cost by the following equation:

$$Program\ Cost = JPY\ 7000 * 3 * 778$$

Note that there is uncertainty in the program cost above because it is just estimated based

[5] The amount of payment varies by region, but most municipalities pay JPY 7000. To simplify the calculation, we assume the payment is universally JPY 7000.

on the insurance system, not on the actual program cost data. Thus, it is possible to conduct sensitivity analysis on the uncertainly (e.g. ±10% change in the program cost). However, such a sensitivity analysis does not affect the conclusion. The fluctuation of the program cost is less important than other uncertainties. Thus, this paper does not conduct sensitivity analysis on the program cost.

3.5.2 Time Cost

Many cost-effectiveness analyses and cost-utility analyses do not include time cost. With an economic point of view, however, it is important to include time cost in the analysis. Time cost of participants can be calculated based on the trade-off method. In this method, time cost equals opportunity cost of additional hours of work. In other words, this paper assumes participants would have been able to work if they did not participate in the intervention, and the wage of that work should be counted as time cost. In this case, the value of time for elderly people aged 65 and over is approximately JPY 1815 per hour, based on the Statistical Survey of Actual Statistics for Salary in the Private Sector (National Tax Agency, 2009; National Tax Agency, 2010; National Tax Agency, 2011) and Monthly Labor Survey (Ministry of Health, Labor, and Welfare, 2009b; Ministry of Health, Labor, and Welfare, 2010; Ministry of Health, Labor, and Welfare, 2011)[6].

However, participants are elderly people with lowered physical functionality and there is a high chance that they did not work in the period of the intervention. If so, their value of time per hour should be lower, and fit into the range between 0 and 1815. It is possible to say their time cost is closer to 0, because the survey on participants' feelings with the intervention showed that they enjoyed the intervention, and did activities as leisure instead of duties. However, there is no previous research which estimates the value of time for Japanese elderly people who do not work.

There are several reference points to estimate the appropriate value of time. The first reference point is the value of non-working time set by governments. Based on the trade-off method, the government of Japan, the United Kingdom (UK), and United States (US) set the value of non-working time for deriving the value of travel time savings. While a question still remains if the value of travel time savings is equal to the value of time for other activities such as the participation in the prevention program, the value of travel time savings can be a good reference point.

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[6] The average of salary for people aged between 65 and 69 was JPY 3.167 million and that for people aged over 69 was JPY 3.099 million between 2009 and 2011. The average yearly working hours was 1745 between 2009 and 2011. With the assumption that they work 1745 hours per year, the after-tax average wage of elderly people is approximately JPY 1815.

In Japan, the value of non-working time is 65.7% of the value of working time (Ministry of Land, Infrastructure, Transport, and Tourism, 2008). In the UK, the value of time for non-work trips except commuting is estimated to be 26.6 % of the value of working time (Department for Transport, 2016)[7]. In the US, the value of non-working time for personal local travel is recommended to be 50 % of the value of working time (U.S. Department of Transportation, 2015). Thus, the value of time for the prevention program is JPY 1192, 483, and 908 based on the data from the Japanese government, UK government, and US government, respectively.

Another way to define the value of time for elderly people who do not work is to see the value of time in weekends. Among the aforementioned three governments, just the UK government shows the value of time in weekends. It is 37.5% of the value of time for work trips in weekdays (Department for Transport, 2016)[8]. With this data, the time cost for the prevention program is JPY 681.

The last method is to undertake a survey on people's WTP for time savings. In 2015, the UK government estimated people's WTP for journey time reductions, and showed that the WTP for non-work trips except commuting was £4.57, which is 26.6% of the average WTP for work trips with car[9] (Department for Transport, 2015). Using this ratio, the value of time is calculated to be JPY 483.

Table 1: Reference Points for Time Cost

Reference Points	Value of Time
Lower bound	0
The value of non-working time (UK)	483
The willingness to pay for time savings (UK)	483
The value of time in the weekend	681
The value of non-working time (US)	908
The value of non-working time (Japan)	1192
Upper bound	1815

Source: Department for Transport (2016); Department for Transport (2015); U.S. Department of Transportation (2015); Ministry of Land, Infrastructure, Transport, and Tourism (2008)

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7 The value of other non-work trips (market price), £6.04, divided by the value of working time (car driver, resource cost), £22.74 is 0.266.

8 The value of time in weekends (car, other), £11.61, divided by the value of working time (car, work), £30.99 is 0.375.

9 The WTP for work trips with car depended on travel distance. With 0-50 km travel distance, it was £10.08. With 50-100 km, it was £16.30. With 100km+, it was £25.12. This paper took an average of them in the analysis.

Taking the average of those reference points, the time cost is estimated to be JPY 750. This paper conducts sensitivity analysis on time cost later, and derives what time cost enables benefit to exceed cost.

Since all the time participants spent was approximately 25630 hours[10], 33 hours per person, (Mitsubishi Research Institute, 2012), the time cost is calculated by:

$$Tme\ Cost = \ 25630 * JPY\ 750$$

3.6 Discounting

3.6.1 Period of Evaluation

Participants do not participate in the program after three months, because the comprehensive program is a three-month-program implemented every year. Whether they continue program-related activities depend on each participant. However, the program is designed to make participants continue the independent activities. Thus, it is reasonable to assume that there is a long-term effect of the program which lasts more than three months.

When the impact and cost of the program extend over periods, future benefits and costs should be taken into account. Also, future benefits and costs have to be discounted to their present values. Then, the net present value of the program can be obtained.

Consider future benefits and costs which last one year. The rationale of choosing one year is as follows: the comprehensive program is a three-month-program implemented every year, and new participants are selected from an annual health status survey. Past participants are included in the survey and are able to join the program again if they have a quality of life that meets the criteria for inclusion in the program. In other words, even if participants experience a decline of SF-6D after the program, they can enroll again if further assistance is needed. It is difficult to predict changes extending more than one year because repeat participants might affect data on SF-6D levels.

In reality, however, the future benefits and costs may last more than one year. As long as participants continue the independent activities, the activities will have positive effects on their quality of life, and incur time costs. Ignoring such effects and costs is one of the problems of this analysis. If the value of the increased quality of life exceeds the time cost after the program, it means that the future benefit of the program is underestimated by

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[10] The data of participants in 2011 shows that the average time per class was 178 minutes, and the average number of classes held was 11.1.

limiting the time range to one year.

3.6.2 One-Year Benefit

When considering one-year benefit, the longitudinal change in SF-6D has to be estimated. It is possible to assume that SF-6D of the control group will keep declining at the same rate as it did during the intervention. However, there is no data on the change of SF-6D for the treatment group after the program. Some assumptions should be made on the change of SF-6D for the treatment group.

In the baseline scenario, this paper assumes that SF-6D of the treatment group will decrease at the same rate with that of the control group. During the intervention, the control group's SF-6D declined, probably because of aging. The treatment group will also face aging issues after the intervention. Thus, it is reasonable to assume that SF-6D of the treatment group will decrease at the same rate with that of the control group.

Table 2: Assumptions on the Long-Term Effect of the Program on SF-6D

Months	Control Group	Treatment Group
0	0.7510	0.7421
3	0.7493	0.7615
6	0.7475	0.7597
9	0.7458	0.7580
12	0.7440	0.7562

Source: Author's calculation based on Mitsubishi Research Institute (2012)

Note: The SF-6D of the control group keep decreasing at a constant rate due to the aging. The SF-6D of the treatment group increases during the intervention, but will decrease after the program at the same rate with that of the control group.

Finally, the present value of the one-year benefit (PVB) can be expressed by the following equation:

$$PVB = \sum_{i} \left(\left(SF6D_i^{TG} - SF6D_0^{TG} \right) - \left(SF6D_i^{CG} - SF6D_0^{CG} \right) \right) * JPY\ 5\ milion * 778 * \frac{3}{12} * \frac{1}{(1+r)^{i-1}}$$

$$(i = 1,2,3,4)$$

where $SF6D_i^{TG}$ and $SF6D_i^{CG}$ are the SF-6D values of the treatment group and control group after i periods (one period is three months) respectively, and r is the discount rate.

Similar to the Figure 1, Figure 2 shows the image of the QALY gained. Before the intervention, both the treatment group and control group experience the decline of their SF-6D due to aging. However, the intervention increases the SF-6D of the treatment group. After three months, the treatment group experiences the decline of their SF-6D again. The difference between the realized SF-6D and the SF-6D that should have appeared without the intervention is the QALY gained.

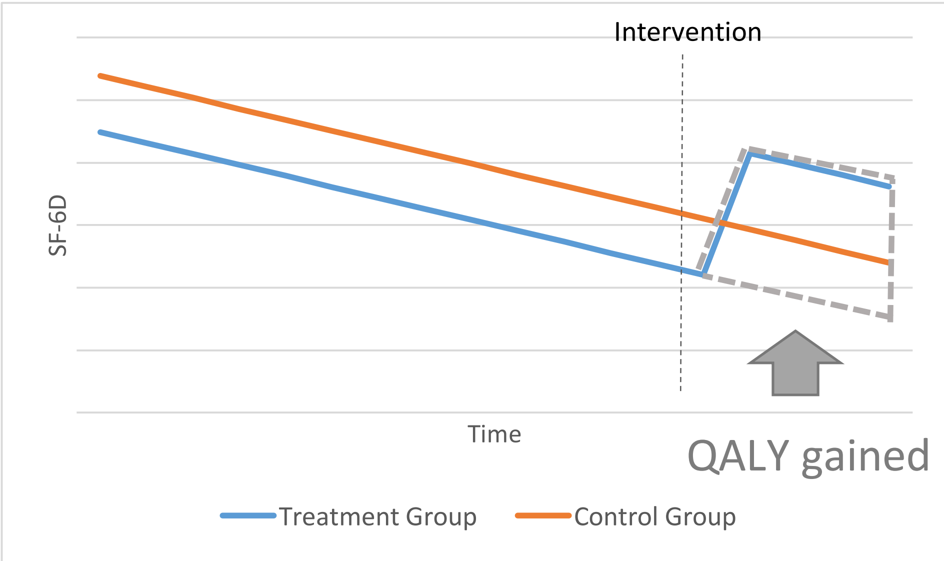

Figure 2: Image of QALY Gained (One Year)

3.6.3 One-Year Cost

The one-year cost of the program is the time cost of those who continue their independent activities. The program aims to motivate elderly people to continue the physical exercise, oral care, and nutrition management activities even after the program. It is reasonable to assume that a certain number of participants will continue the activities, and the time spent should be counted as the one-year cost. According to the study by Mitsubishi Research Institute (2012), approximately 60% of participants keep spending their time on the activities. The total of 15378 hours (=25630 * 0.6) is supposed to be the time spent every three months.

The present value of one-year cost (PVC) can be obtained as follows:

$$PVC = \sum_{i} \left(JPY\ 7000 * 3 * 778 + 25630 * JPY\ 750 + 15378 * JPY\ 750 * \frac{1}{(1+r)^{i-1}} \right)$$

$$(i = 2,3,4)$$

3.6.4 Discount Rate

The discount rate is 3% per year based on the guideline of cost-benefit analysis from the World Health Organization (Hutton & Rehfuess, 2006). Assume the interest is compounded continuously, four times a year. With that assumption, the discount rate can be calculated as:

$$\left(1 + \frac{r}{4}\right)^4 = 1.03$$

$$r = 0.0296682896351052 \ldots$$

3.7 Net Benefit and Benefit Cost Ratio

In order to show the effectiveness of the program, it is necessary to calculate the net benefit and benefit cost ratio. Net benefit equals benefit minus cost, and should be positive to justify the implementation of the program.

$$Net\ Benefit = Benefit - Cost$$

Benefit cost ratio is benefit divided by cost, and should be greater than 1.

$$Benefit\ Cost\ Ratio = \frac{Benefit}{Cost}$$

3.8 Sensitivity Analysis

3.8.1 Monetization of QALY

A sensitivity analysis is conducted for the monetization of QALY, time cost, and long-term effect of the program on SF-6D. For the monetization of QALY, this paper evaluated three cases: 1QALY is equal to (1) JPY 5 million (Shiroiwa et al., 2010), (2) JPY 6.7 million (Ohkusa and Sugawara, 2006), and (3) JPY 11.72 million (Hata et al, 2013). Shiroiwa et al (2010) used the contingent valuation method and estimated that WTP for the respondent's additional QALY was JPY 5 million. Using the same method, Ohkusa and Sugawara (2006) asked whether respondents agree that the society pay for a certain medical care with a hypothesis about cost, duration, number of patients, and health status. They concluded that WTP per QALY gain was JPY 6.35 to 6.7 million. The methodology Hata et al (2013) used was the statistical value of life year approach. This approach is often used in economic analysis about the value of life. Based on the Cabinet Office's estimation of the statistical value of life, which is equal to JPY 226 million year, they estimated that the value of one year was JPY 11.72 million.

3.8.2 Time Cost

As mentioned above, the upper bound of the time cost is JPY 1815, and the lower bound is zero. With these two cases and the baseline case, this paper conducts the sensitivity analysis on time cost, and considers the acceptable level of time cost.

3.8.3 Long-Term Effect of the Program on SF-6D

This paper considers four cases regarding the long-term effect of the program on SF-6D. In any case, the control group is supposed to decline their SF-6D at the same rate as it did during the intervention.

In case 1, SF-6D of the treatment group will decrease at the same rate with that of the control group. This is the same assumption with the baseline case. In case 2, SF-6D of the treatment group is expected to improve at the same rate as it did during the intervention. In case 3, SF-6D will not change over time after the program.

Table 3: Assumptions about the Long-Term Effect of the Program on SF-6D

Months	Control Group	Treatment Group <Case 1>	Treatment Group <Case 2>	Treatment Group <Case 3>
0	0.7510	0.7421	0.7421	0.7421
3	0.7493	0.7615	0.7615	0.7615
6	0.7475	0.7597	0.7809	0.7615
9	0.7458	0.7580	0.8004	0.7615
12	0.7440	0.7562	0.8198	0.7615

Source: Author's calculation based on Mitsubishi Research Institute (2012)

Note: Three cases make different assumptions on the SF-6D of the treatment group after the program. In case 1, SF-6D of the treatment group will decrease at the same rate with that of the control group. This is the same assumption with the *baseline case. In case 2, SF-6D of the treatment group is expected to improve at the same rate as it did during the intervention. In case 3, SF-6D will not change over time after the program.*

4 Analysis and Results

4.1 Benefit

4.1.1 SF-6D

The SF-6D values of the treatment group and control group before and after the treatment are illustrated in the Table 4.

Table 4: SF-6D values

	PCS	MCS	SF-6D
Treatment Group (Before)	45.6	50.2	0.7421
Treatment Group (After)	46.5	51.4	0.7615
Control Group (Before)	46.3	50.4	0.7510
Control Group (After)	45.9	50.7	0.7493

Source: Mitsubishi Research Institute (2012)

4.1.2 Benefit

Based on the equation in 3.4.3, the benefit of the program over three months is JPY 20.61 million.

4.2 Cost

The equations in 3.5 show the program cost is JPY 16.34 million, and the time cost over three months is JPY 19.22 million. Thus, the total cost over three months is 35.56 million.

4.3 Discounting

Table 5 shows the results of discounting. The benefit over one year is JPY 78.94 million, and the cost is JPY 68.20 million.

Table 5: Discounting

	SF-6D (Treatment Group)	SF-6D (Control Group)	Benefit (million)	Cost (million)
0	0.7421	0.7510		
3	0.7615	0.7493	20.61	35.56
6	0.7597	0.7475	20.01	11.20
9	0.7580	0.7458	19.44	10.88
12	0.7562	0.7440	18.88	10.56
Sum			78.94	68.20

Source: Author's calculation

4.4 Net Benefit and Benefit Cost Ratio

Table 6 demonstrates the net benefit and benefit cost ratio of the program. While the net benefit for three months is negative, the net benefit for one year is positive. This suggests that the program is not cost-effective within three months, but considering the long-term effects of the program justifies the implementation of the program.

Table 6: Net Benefit and Benefit Cost Ratio

	Three Months	One Year
Benefit	20.61	78.94
Cost	35.56	68.20
Net Benefit	-14.95	10.73
B/C	0.58	1.16

(million yen)

Source: Author's calculation

4.5 Sensitivity Analysis

4.5.1 Monetization of QALY

Tables 7 and 8 illustrate the effect of the monetization of QALY on the benefit, cost, net benefit, and benefit cost ratio.

The monetization of QALY affects the conclusion of the cost-effectiveness of the program. When assuming the value of 1 QALY is JPY 11.72 million, the program is cost-effective even within three months.

Table 7: Sensitivity Analysis on the Monetization of QALY (Three Months)

	1QALY= 5 million	1QALY= 6.70 million	1QALY= 11.72 million
Benefit	20.61	27.62	48.31
Cost	35.56	35.56	35.56
Net Benefit	-14.95	-7.95	12.75
B/C	0.58	0.78	1.36

(million yen)

Source: Author's calculation

Table 8: Sensitivity Analysis on the Monetization of QALY (One Year)

	1QALY= 5 million	1QALY= 6.70 million	1QALY= 11.72 million
Benefit	78.94	105.78	185.03
Cost	68.20	68.20	68.20
Net Benefit	10.73	37.57	116.83
B/C	1.16	1.55	2.71

(million yen)

Source: Author's calculation

4.5.2 Time Cost

The different assumptions on time cost change the conclusion about the cost-effectiveness of the program as illustrated in the Table 9 and 10. When assuming the value of time for participants is zero, the program is cost-effective even within three months. With the assumption that time cost is JPY 1815, however, the program is not cost-effective even considering the long-term effect over one year.

Table 9: Sensitivity Analysis on Time Cost (Three Months)

	JPY 0	JPY 750	JPY 1815
Benefit	20.61	20.61	20.61
Cost	16.34	35.56	62.86
Net Benefit	4.27	-14.95	-42.25
Benefit Cost Ratio	1.26	0.58	0.33

(million yen)

Source: Author's calculation

Table 10: Sensitivity Analysis on Time Cost (One Year)

	JPY 0	JPY 750	JPY 1815
Benefit	78.94	78.94	78.94
Cost	16.34	68.20	141.85
Net Benefit	62.60	10.73	-62.92
Benefit Cost Ratio	4.83	1.16	0.56

(million yen)

Source: Author's calculation

Consider what time cost enables benefit to exceed cost. Time cost should be lower than JPY 166.5 to make the program cost-effective even within three months. Taking the long-term effect into account, time cost lower than JPY 905.25 will make benefit exceed cost. The chapter 5 discusses if these figures are plausible.

4.5.3 Long-Term Effect of the Program on SF-6D

Table 11 shows the results of the sensitivity analysis on the long-term effect of the program on SF-6D. In any case, net benefit is positive, but the values of net benefit vary. The case 2 produces the largest net benefit in case 2, when assuming SF-6D of the treatment group will keep increasing at the same rate as it did during the intervention. In the case 1, the baseline case, the net benefit is the smallest.

Table 11: Sensitivity Analysis on the Long-Term Effect of the Program on SF-6D

(One Year)

	Case 1	Case 2	Case 3
Benefit	78.94	194.46	88.52
Cost	68.20	68.20	68.20
Net Benefit	10.73	126.26	20.31
B/C	1.16	2.85	1.30

(million yen)

Source: Author's calculation

Note: Three cases make different assumptions on the SF-6D of the treatment group after the program. In case 1, SF-6D of the treatment group will decrease at the same rate with that of the control group. This is the same assumption with the baseline case. In case 2, SF-6D of the treatment group is expected to improve at the same rate as it did during the intervention. In case 3, SF-6D will not change over time after the program.

4.5.4 Summary of Sensitivity Analysis

Combine three sensitivity analyses. The range of time is one year, and the long-term effect of the program is taken into account. This paper sets four cases for benefit and three cases for cost. With regard to benefit a high benefit case (1) is where 1 QALY is JPY 500 million and the assumption is made so that SF-6D keeps increasing at the same rate as it did during the intervention. A high benefit case (2) is the case where 1QALY is estimated to be JPY 11.72 million with the same assumption about the SF-6D as the baseline case. A middle benefit case is when adopting 1QALY = JPY 6.7 million and assuming SF-6D does not change over time after the program. A low benefit case is the same with the baseline case. For cost, this paper regards a low cost case as the case when time cost is zero, a middle cost case as the case when time cost is JPY 750, and a high cost case as the case when time cost is JPY 1815.

In the Table 12, the slots shaded with light blue are the cases when the program is cost-effective. Benefit exceeds cost whenever time cost is estimated to be zero or JPY 750. However, when time cost is JPY 1815, only the high benefit cases make the program cost-effective. Otherwise, it is not economically reasonable to implement the program.

Table 12: Summary of Sensitivity Analyses (One Year)

	Low Cost	Middle Cost (Baseline)	High Cost
High Benefit (1)	Benefit = 194.46 Cost = 16.34 Net Benefit = 178.12 B/C = 11.90	Benefit = 194.46 Cost = 68.20 Net Benefit = 126.26 B/C = 2.85	Benefit = 194.46 Cost = 141.85 Net Benefit = 52.61 B/C = 1.37
High Benefit (2)	Benefit = 185.03 Cost = 16.34 Net Benefit = 168.69 B/C = 11.32	Benefit = 185.03 Cost = 68.20 Net Benefit = 116.83 B/C = 2.71	Benefit = 185.03 Cost = 141.85 Net Benefit = 52.61 B/C = 1.37
Middle Benefit	Benefit = 106.22 Cost = 16.34 Net Benefit = 89.88 B/C = 6.50	Benefit = 106.22 Cost = 68.20 Net Benefit = 38.02 B/C = 1.56	Benefit = 106.22 Cost = 141.85 Net Benefit = -35.63 B/C = 0.75
Low Benefit (Baseline)	Benefit = 78.94 Cost = 16.34 Net Benefit = 62.60 B/C = 4.83	Benefit = 78.94 Cost = 68.20 Net Benefit = 10.74 B/C = 1.16	Benefit = 78.94 Cost = 141.85 Net Benefit = -62.91 B/C = 0.56

(million yen)

Source: Author's calculation

Note: A high benefit case (1) is where 1 QALY is JPY 500 million and the assumption is made so that SF-6D keeps increasing at the same rate as it did during the intervention. A high benefit case (2) is the case where 1QALY is estimated to be JPY 11.72 million with the same assumption about the SF-6D as the baseline case. A middle benefit case is when adopting 1QALY = JPY 6.7 million and assuming SF-6D does not change over time after the program. A low benefit case is the same with the baseline case. For cost, this paper regards a low cost case as the case when time cost is zero, a middle cost case as the case when time cost is JPY 750, and a high cost case as the case when time cost is JPY 1815.

5 Discussions

5.1 Implications of the Results

In the chapter 4, the results of the analysis show that in the baseline scenario the program is not cost-effective within three months, but the analysis considering the effect extending over one year leads to justification of the program.

Also, the sensitivity analyses imply that the level of time cost is the key. As discussed above, the acceptable time cost is lower than JPY 166.5 for the analysis over three months, and lower than JPY 905.25 for the analysis over one year in the baseline scenario. Based on the Table 1, the time cost for elderly people who do not participate in labor market can be lower than JPY 905.25, but is unlikely to be lower than JPY 166.5. In other words, the program is difficult to be cost-effective within three months, but there is a chance that it becomes cost-effective over one year. However, when using the value of non-working time estimated by the Japanese government or US government, JPY 905.25 is too low, and the program is not cost-effective even when the long-term effect is taken into account. Further research on time cost for elderly people is needed.

The monetization of QALY and longitudinal change of SF-6D also play an important role. Assuming 1 QALY is equal to JPY 11.72 million, the program's benefit cost ratio is greater than one even within three months, or even when the time cost is JPY 1815. The question remains what value should be used for the monetization of QALY. The monetization of the value of life is controversial. It is difficult to discuss what is an appropriate value of life in monetary unit. However, other countries such as the UK and US set the threshold about what cost per QALY is acceptable in the society. They also have a standard for the statistical value of life. Japan should set those standards as well.

Also, when assuming SF-6D of the treatment group will keep increasing at the same rate as it did during the intervention, JPY 1815 will be acceptable as time cost. There is no data about the longitudinal change in SF-6D following the treatment. A follow-up study of the program is needed to understand the long-term effect, and determine whether the program is cost-effective.

5.2 Limitations

There are five limitations of this analysis. First, there may be an issue with randomization, which was conducted by Mitsubishi Research Institute (2012). The score of

SF-6D should be the same between the treatment group and control group before the treatment with a randomized controlled trial, but the score is different. This problem happened because they divided the treatment group and control group before, not after, a baseline assessment. The issue with randomization may bring different results. Secondly, the model used for deriving SF-6D scores is not fully developed. There is not a widely used model for SF-6D calculation from SF-8. The immature model may result in a wrong mean difference of SF-6D scores. Thirdly, even when considering the long-term effect, this paper limits the time range to one year, and ignores the benefits and costs that last more than one year. Since the value of the increased quality of life exceeds the time cost after the program, the benefit of the program is underestimated. Fourthly, the time cost of elderly people is uncertain. The level of time cost is a key to determining if the program is cost-effective, so the uncertainty of time cost is a huge problem in this analysis. The last limitation is the estimation of longitudinal change in QALY as mentioned above. There is no data about the longitudinal change in QALY following the treatment. Thus, this analysis estimates the longitudinal change based on some assumptions, which increases uncertainty in the analysis.

5.3 Policy Implications

This cost benefit analysis on the comprehensive long-term care prevention program has some implications for policymaking. First, if the program is proved to be cost-effective, the program has the positive effect on the society and should be kept. It has the potential not only to improve elderly people's quality of life, but also to allow the government to use tax efficiently and effectively. Especially if cost benefit analyses are also conducted for independent programs, such as physical exercise program, nutrition education program, and oral care program, the effect of combining three programs will be demonstrated. Building up the evidence of cost-effectiveness of the programs will be the key to the effective and efficient government.

Also, the analysis sheds the light on key elements to promote evidence-based long-term care policies. During the research and analysis, one of the challenges was access to data. While the study of Mitsubishi Research Institute (2012), on which this study builds, is government-funded research, its data was not available, even with a disclosure request. There is a number of government-funded data collection and research delivered only to the government, not to the public. The data, results and implications of the research should be shared to contribute to further research.

Finally, the government should provide a guidance on experimental and quasi-experimental studies. As mentioned above, one of the limitations of this study comes from an issue with randomization, which was conducted by Mitsubishi Research Institute (2012). Such a mistake can be avoided with a reliable guidance on experimental and quasi-experimental studies.

6 Conclusion

The cost-effectiveness of the program depends on the level of time cost and assumption on the monetization of QALY and longitudinal change of SF-6D. When assuming the time cost is JPY 750, as the baseline scenario does, the program is not cost-effective within three months, but the analysis over one year shows the positive benefit cost ratio. In order to make the program cost-effective, the time cost should be lower than JPY 905.25 (one-year analysis) or JPY 166.5 (three-month analysis). Considering the value of time used in different countries, JPY 905.25 may be reasonable as the value of time for elderly people who do not work. However, it is unlikely to be lower than JPY 166.5. It is difficult to say the program is cost-effective within three months, but there is a chance that it becomes cost-effective over one year. Even if the time cost is higher than JPY 905.25, different assumptions on benefit components justify the implementation of the program. When using 1QALY = JPY 11.72 million or assuming SF-6D will keep increasing at the same rate as it did during the intervention, the program is cost-effective even if the time cost is JPY 1815.

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