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Impacts of health checkup programs standardization on working-age self-employed and unemployed: Insights from Japan's local government response to national policy

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Abstract

This study analyzes the effects of the expansion of municipal per capita expenses on health checkup programs, following the introduction of the Specific Health Checkups and Specific Health Guidance (SHC-SHG), on the health outcomes and behaviors of self-employed and unemployed populations, which have been largely overlooked by previous research. To address this, we applied a dosing difference-in-differences (DID) estimation method, exploiting variation in treatment intensity across municipalities. The DID estimation reveals that the SHC-SHG introduction led to a reduction in the proportion of people diagnosed with lifestyle-related diseases in the municipalities that required significant increases in per-capita health checkup program expenses to comply with the new program, with a more pronounced impact on those with multiple diagnoses compared to those with a single diagnosis. A subgroup analysis indicates that health improvements following the SHC-SHG introduction were observed among self-employed workers and homeowners, whereas such improvements were not evident among the unemployed and renters. Moreover, we identify significant behavioral changes among the population in the high-expansion municipalities following the policy introduction. A back-of-the-envelope calculation demonstrates the municipal response to the SHC-SHG introduction is cost-effective.

Keywords: health checkup; lifestyle-related diseases; health outcomes; health behaviors; cost-effectiveness
JEL Classifications: I10; I12; I18; K32

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1 Introduction

The recent rapid aging of populations in high- and middle-income countries is exerting significant pressure on government budgets and threatening the sustainability of social security systems. A key driver of this financial strain is the rising medical expenditure associated with lifestyle-related diseases (LRDs), such as diabetes and hypertension.[1] The increasing prevalence of these conditions is exacerbating further the economic burden. For instance, the global economic burden of diabetes among adults was estimated to be USD 1.3 trillion in 2015, accounting for 1.8 % of the global GDP, and is projected to rise to USD 2.1-2.5 trillion by 2030 (Bommer et al., 2018). Beyond the economic implications, the COVID-19 pandemic underscored an additional health risk for individuals with LRDs. Patients with conditions such as diabetes and hypertension were at heightened risks of severe outcomes or mortality when infected with COVID-19, compared to those without these conditions (e.g., Ando et al., 2021; Holman et al., 2020; Tang et al., 2021). Furthermore, numerous studies have documented that lower socioeconomic status is significantly associated with risky health behaviors and a higher likelihood of being diagnosed with LRDs (e.g., Braveman et al., 2010; Hiscock et al., 2012; Li et al., 2023; Marmot, 2005; Stringhini et al., 2010). Therefore, reducing the prevalence of LRDs is a critical policy priority, not only to alleviate the economic burden but also to enhance public health resilience among socioeconomically vulnerable individuals in the midst of future health crises.

As LRDs are often incurable once acquired, the importance of preventive measures has garnered increasing attention.[2] Regular health checkups and screening programs are crucial in preventing LRDs, as these conditions are often referred to as the "silent killers." Patients in the early stages of LRDs or those at high risk often exhibit no subjective symptoms, making early detection through screenings essential. In many countries, including Austria (Hackl et al., 2015), China (Zhao et al., 2013), Japan (Fukuma et al., 2020; Hanaoka, 2023; Iizuka et al., 2021; Inui et al., 2017; Kang et al., 2020; Oikawa, 2024), South Korea (Kim et al., 2019), and the United States (Alalouf et al., 2024; Jones et al., 2019; Oster, 2018), economists have studied the effects of an exogenous variation in how individuals are informed about their current health status and the risks associated with their behaviors. However, there remains no consensus on the overall effectiveness of these interventions.[3]

[1] According to the World Health Organization (WHO), approximately 422 million adults worldwide were estimated to have diabetes in 2014, with a prevalence rate of approximately 8.5 % of the global population — nearly double the rate in 1980 (World Health Organization, 2016), which was nearly double compared to that in 1980. In the United States, estimates from 2013 to 2016 indicated that approximately 26.8 % of people aged 65 years and older had diabetes (US Department of Health and Human Services, 2020).

[2] For instance, during the 2008 United States presidential election, candidates emphasized the importance of preventive health measures to control rising medical expenditure (Cohen et al., 2008). This focus on prevention was later reflected in the Affordable Care Act (ACA) of 2010, which was enacted by the election's winner President Barack Obama, and strongly emphasized public health and prevention (Chait and Glied, 2018; Chung et al., 2015; Obama, 2016).

[3] Some studies have found evidence that individuals' awareness of their health status through checkups or screening programs can improve health outcomes (e.g., Fukuma et al., 2020; Iizuka et al., 2021; Kim et al., 2019; Oikawa, 2024), whereas others have found no such impact (e.g., Alalouf et al., 2024; Hackl et al., 2015; Jones et al., 2019). Regarding

First, a significant issue in the existing literature is its predominant focus on salaried or employed workers (Alalouf et al., 2024; Fukuma et al., 2020; Hackl et al., 2015; Hanaoka, 2023; Iizuka et al., 2021; Jones et al., 2019). This focus may overlook the impacts of health checkups on LRD diagnoses and health-related behaviors among self-employed or unemployed populations and their dependents, who are often socioeconomically vulnerable, in poorer health, and, therefore, incur higher medical expenses (Blanchflower, 2000; Benach et al., 2014; Diamond and Schaede, 2013; Nemoto et al., 2022). The literature specifically addressing the effects of health checkups on self-employed or unemployed individuals is relatively sparse compared to studies on salaried workers , leaving the impacts on these groups unclear. In particular, it is important to assess the impacts of health checkups on these populations in the Japanese context. Local governments offer these health checkups as part of their responsibility to administer the National Health Insurance system (NHI) for the self-employed and unemployed. This responsibility provides municipalities with a strong incentive to maintain and improve the health of these insured populations, thereby enhancing the financial sustainability of the NHI under their management. Nevertheless, health checkups are not compulsory for the self-employed or unemployed; their participation in programs offered by their municipalities is voluntary. By contrast, the Industrial Safety and Health Act of 1972 mandates that employers provide health checkups for all employees, regardless of age, thereby obligating salaried workers to participate in annual health checkups. Consequently, the participation rate in health checkups is generally higher among employed individuals compared to that in self-employed and unemployed, although employees are not subject to legal penalties for opting out of health checkups (see Figure D.1 in Appendix D).

Second, one possible explanation for the mixed findings in previous studies is the nature of the regression discontinuity design (RDD) employed by most of them. Such studies apply RDD by focusing on biomarker thresholds for diagnosing health conditions such as high blood pressure (Zhao et al., 2013), diabetes (Alalouf et al., 2024; Iizuka et al., 2021; Kim et al., 2019), hyperlipidemia (Kim et al., 2019), obesity (Kim et al., 2019), and waist circumference (Fukuma et al., 2020).[4] While RDD is a robust identification strategy in these contexts, its estimates are often highly localized, capturing short-term effects, and can be somewhat myopic. This approach primarily assesses the impact of a diagnosis on individuals whose biomarker levels are near the specified cutoff. Additionally, results from RDD-based studies that use biomarker thresholds may underestimate the absolute effects of health checkups or screening programs. This underestimation occurs when participants are informed not only about their disease diagnoses but also of their biomarker values. Knowing that their biomarker levels are just below the disease threshold, individuals may change their behavior

the effects on health behaviors, studies such as Kang et al. (2020), Oikawa (2024), Oster (2018), and Zhao et al. (2013) have observed statistically significant changes in behaviors, whereas Alalouf et al. (2024), Jones et al. (2019), and Kim et al. (2019) have not.

[4] As biomarkers can be affected by various exogenous factors, including the timing of the test, measurements just above and below a threshold are likely to be random. Thus, the effect of a diagnosis on subsequent health outcomes and behaviors is estimated specifically around that threshold.

to mitigate disease risk. Consequently, it remains unclear whether insignificant results genuinely indicate null effects or reflect strategic behavioral changes. To more comprehensively evaluate the effectiveness of health checkups and screening programs, additional evidence is needed, utilizing not only RDD but also other empirical strategies.

Against this backdrop, this study aims to comprehensively assess the effects of health checkups or screening programs on health outcomes, medical expenditure, and behaviors among self-employed and unemployed populations. This contrasts with previous studies that have primarily focused on salaried or employed workers, often examining the program's role mainly in informing individuals about their health status and risks. The limited research on the self-employed and unemployed is likely due to data unavailability and the legally complex definitions of self-employed and freelance workers. However, in Japan, these populations are easily identified because they are not covered by occupation-based health insurance and are mandated to enroll in the NHI administered by municipalities under the universal health care system. Consequently, we employ the introduction of the Specific Health Checkups and Specific Health Guidance (SHC-SHG) implemented by the Japanese government in 2008 as an exogenous shock to municipal financial efforts, serving as a unique identification strategy for this study. Confronted with the world's fastest population aging and rising medical expenditures on LRDs, Japan implemented the SHC-SHG to standardize health checkups or screening programs for effective disease prevention among majority of residents aged 40 to 74 who are at high risk of LRDs. Even prior to 2008, health checkup programs for self-employed and unemployed residents, which local government had provided since the 1980s, varied significantly across municipalities, leading to substantial differences in financial investments. In response to these circumstances, the SHC-SHG mandated that all municipalities provide a standardized checkup and guidance program that incorporated financial incentives to improve health outcomes for eligible residents.

Therefore, as detailed in Section 2, the incremental financial efforts required to implement the new program varied depending on the public resources allocated by each municipality before 2008. Utilizing this regional variation in incremental efforts, we classify municipalities that required significant increases in per-capita health checkup program expenses to comply with the new SHC-SHG program as the treated group and the remaining municipalities as the control group. To assess the impact of the new program on various outcomes for self-employed and unemployed residents aged 40 to 59 years, we employ a dosing difference-in-differences (dosing-DID) estimation based on treatment intensity. We conduct a subgroup analysis using cross-sectional survey data to explore the heterogeneity of the effects on LRD diagnoses based on individual characteristics.

The DID estimation reveals that the introduction of the SHC-SHG program led to a reduction in the proportion of these populations diagnosed with LRDs in the treated municipalities, with more pronounced effects on individuals with multiple diagnoses compared to those with a single diagnosis. This finding suggests that the SHC-SHG program is more effective in reducing the number of patients with severe conditions rather than merely lowering the overall prevalence of

LRD patients. A subgroup analysis indicates that health improvements following the introduction of the SHC-SHG program were observed among self-employed individuals and homeowners—who tend to be wealthier—whereas such improvements were not evident among the unemployed and renters. Additionally, we identified statistically significant behavioral changes among self-employed and unemployed residents in the treated municipalities, including increased smoking cessation rates, reduced alcohol consumption, and higher physical activity levels, as measured by the number of daily steps counts, following the SHC-SHG introduction.

Furthermore, this study provides evidence of the cost-effectiveness of health checkups and screening programs. Given that not all preventive health measures, including health checkups or screening programs, are inherently cost-effective (Cohen et al., 2008), understanding their cost-effectiveness is crucial for policymakers. Despite its importance, only a few studies have addressed this issue.[5] This study's back-of-the-envelope calculation demonstrates that the municipal response to SHC-SHG introduction is cost-effective: the reduction in medical expenditures outweighs the additional costs incurred from implementing the SHC-SHG program. Preventive health services, such as health checkups and screening programs, are critical in improving public health outcomes for self-employed and unemployed residents who face higher risks of LRDs, thereby mitigating the future financial burdens on local governments. Therefore, accumulating comprehensive evidence on the cost-effectiveness of such programs is imperative to support policymakers in developing sustainable social security systems.

The remainder of this paper is organized as follows. Section 2 provides an overview of the institutional background of the health checkup programs in Japan. Sections 3 and 4 explain the data and the estimation strategy, respectively. Sections 5 and 6 present and discuss the estimation results, respectively. Finally, Section 7 concludes the paper.

2 Institutional Background

2.1 Local Governments' Health Checkup Systems for Self-employed and Unemployed before 2008

Figure 1 presents a conceptual diagram of municipalities' financial efforts in Japan's health checkup system, detailing the changes before and after the introduction of the SHC-SHG program. Since the 1980s, municipalities have provided health checkup programs for residents not covered by occupation-based health insurance, such as the self-employed and unemployed, under two primary laws: the Health and Medical Service Act for the Aged (HMSAA), which legally mandated these

[5] Iizuka et al. (2021) examined the cost-effectiveness of Japan's health checkup program and concluded that the improvement in health conditions resulting from early diabetes diagnosis justified the increased medical spending on other preventive care associated with the diagnosis. Hackl et al. (2015) found evidence supporting the cost-effectiveness of health checkup programs for younger populations (approximately aged 60 or younger), but not for older individuals. Similarly, Kang et al. (2020) analyzed the effects of Japan's health checkup program and determined that the increase in annual income resulting from health-related behavioral changes offsets the program's cost.

programs, and the National Health Insurance Act (NHIA),[6] which encouraged them as a 'duty of effort.'

First, the basic checkup program under the HMSAA included approximately 20 general examinations, such as assessments for subjective symptoms, measurements of height and weight, and urine and blood tests. Additional tests, such as a test for Hemoglobin A1c and 12-lead electrocardiogram, were performed if deemed necessary by the attending physician. Health guidance, which was provided based on the results of these basic examinations aimed at identifying and addressing health issues at an early stage. Individuals with concerning test results received tailored health guidance, while those with significantly elevated values were advised to consult a physician. For instance, a person with a systolic blood pressure exceeding 160 mmHg would be recommended to see a doctor,[7] whereas those with values between 140 and 159 mmHg would receive health guidance, including general information about the disease for which they were at high risk.

In addition to the legally mandated programs under the HMSAA, municipalities had the option of offering supplementary services as part of a 'duty of effort' initiative under the NHIA and the Health Promotion Act (HPA). For instance, some municipalities included additional checkup items beyond the standard examinations, while others implemented programs targeting individuals at high risk for LRDs, encouraging them to adopt healthier lifestyle habits (e.g., Municipalities A and C in Figure 1). Conversely, some municipalities provided only the legally mandated HMSAA-based program without any additional services (e.g., Municipality B in Figure 1).[8]

Consequently, according to the Local Government Financial Survey conducted by the Ministry of Internal Affairs and Communications (MIC), the per capita annual expense for public health services under the NHIA ranged from JPY 0 to 4,211 (USD 42.1)(Figure 2).[9] The average per capita expenditure for NHIA-based public health services in the municipalities within the bottom 25% of the distribution was approximately 70% lower than the average in other municipalities. Additionally, the coefficient of variation (CV) for the NHIA-based public health services was approximately 33% higher than the CV for the per capita expense of public health services commissioned by health

[6]The target population for health checkups under the NHIA was aligned with that covered by the HMSAA.

[7]https://www.wam.go.jp/wamappl/bb14GS50.nsf/0/98e6f3f836572e8b4925716f0006b833/$FILE/20060512siryou1-1.pdf(in Japanese)(accessed on December 14, 2022)

[8]Since 2002, these initiatives have been part of the NHI Health Promotion Program (*Kokuho Health Up Jigyo* in Japanese). The health guidance provided in these programs was similar to the SHG discussed later. For example, Inagi City in Tokyo Prefecture identified individuals at high risk for LRDs based on the results of the HMSAA basic health checkup program and recruited participants for a program focused on improving eating habits and engaging in physical activity (https://www.fukushihoken.metro.tokyo.lg.jp/kensui/plan21/sinkouki.files/7.pdf, in Japanese, accessed on December 14, 2022).

[9]We calculated the average per capita annual expense for public health services based on the NHIA within each municipality from 1995 to 2007, as shown in Figure 2. Details regarding the per capita expenses are explained in Appendix A. We restricted the analyses to cities and wards, excluding municipalities with high within-municipality variation (81 municipalities with the top 10% of within-municipality variation) between 1995 and 2007.

and hygiene departments, including health checkup programs based on the HMSAA.[10,11] These results suggest that the variations in NHIA-based public health services could influence the content of municipal health checkup programs.[12,13,14]

Despite the implementation of publicly provided checkup programs over several decades, there were notable deficiencies in health improvements by the early 2000s. According to the mid-term evaluation of the nationwide health promotion initiative "Health Japan 21" conducted in 2000, lifestyle-related health conditions, such as diabetes and obesity, had increased. Given that a significant portion of public health expenditures is devoted to treating these diseases, the issues with health checkups were investigated and summarized in a Council of Governments report.[15]

First, the financial efforts—and consequently, the content of health checkup programs for the self-employed and unemployed—varied significantly across municipalities, largely due to region-specific management practices. Second, participation rates in health checkup programs were notably lower among the self-employed and unemployed compared to salaried workers (Figure D.1). Third, a key challenge of traditional health checkup programs is that, despite evidence suggesting that screening is most effective for undiagnosed high-risk individuals (Schellenberg et al., 2013),[16] these programs often targeted individuals already in the early stages of disease. Furthermore, research has shown

[10] Most municipalities outsourced the implementation of health checkup programs under the HMSAA to medical institutions. Therefore, the commission fees paid by the health and hygiene department of each municipality included the costs associated with these health checkup programs. However, specific data on the commission fees for public health services by the health and hygiene department are not directly available. Therefore, we estimated these fees using the annual supply and service expenses (encompassing commission fees) for health and hygiene services, along with the ratio of commission fees to the total supply and service expenses for hygiene services. Noteworthy, health and hygiene services are a sub-category within hygiene services. A detailed explanation of the estimation process is provided in Appendix A.

[11] The CV of the per capita expense of the NHIA-based public health service is 0.554, while the CV for the per capita expense of commission fees for public health services managed by municipal health and hygiene departments is 0.408.

[12] The budget reported by some municipalities offers insights into the variations in per capita expenses for NHIA-based public health services. For instance, Suginami Ward in Tokyo Prefecture, which had a per capita expense in the bottom 10% of its distribution, budgeted only for managing recreation facilities for the insured in 2007. By contrast, Kurayoshi City in Tottori Prefecture, with a per capita expense in the top 10%, allocated funds for comprehensive medical examinations (*ningen dock* in Japanese). Additionally, both Suginami Ward and Kurayoshi City budgeted for health checkups managed by the health and hygiene department. This suggests that municipalities with relatively low per capita expenses did not offer additional health checkup programs for their residents unlike those with higher per capita expenses who did.

[13] The health and hygiene department has provided checkup and screening programs, such as cancer screenings and dental checkups, since the 1980s, which were not affected by the introduction of SHC-SHG.

[14] The differences in the costs of the checkup program content across municipalities possibly influenced the per capita expenses. For instance, doctors in a municipality may have the political influence to negotiate higher prices with the municipality. We cannot disregard the possibility that the differences in per capita expenses shown in Figure 2 include variations in price levels. However, assuming that factors specific to each municipality remained constant over the sample period, these price differences would not affect the interpretation of the estimation results, as we controlled for municipality-fixed effects.

[15] For additional details, refer to the information available in Japanese via the following link: `https://www.wam.go.jp/wamappl/bb14GS50.nsf/vAdmPBigcategory40/98E6F3F836572E8B4925716F0006B833?OpenDocument` and `https://www.mhlw.go.jp/shingi/2005/09/s0915-8.html` (accessed on September 25, 2024)(in Japanese).

[16] The Schellenberg et al. (2013) is a systematic review that finds no evidence that intervention is effective for those who already have Type 2 diabetes, but is effective for those at high risk of acquiring it.

that lifestyle interventions are more effective than medication treatment in preventing the onset of diabetes (Knowler et al., 2002); yet, traditional programs provided insufficient lifestyle guidance and inadequate follow-up for high-risk individuals. To address these shortcomings in traditional health checkup programs, a comprehensive reform of the system is necessary to ensure a substantial and equitable nationwide intervention targeting high-risk individuals.

2.2 Specific Health Checkups and Specific Health Guidance (SHC-SHG)

To address the various challenges described in the previous section, a new health checkup program (SHC-SHG) was introduced in April 2008.[17] This reform was uniformly implemented for all individuals covered by public health insurance, including both the employed who are enrolled in occupation-based health insurance, as well as the self-employed and unemployed who are enrolled in the NHI operated by municipalities, along with their dependents aged between 40 and 74. Under the SHC-SHG, the Ministry of Health, Labour and Welfare of Japan (MHLW) issues guidelines for health checkups and health guidance to insurers, ensuring standardized content across providers and addressing discrepancies in checkup program offerings.

While previous checkup programs also aimed at preventing LRDs, they primarily targeted patients already in the early stages of these conditions, thereby limiting the effectiveness of interventions. The SHC-SHG is divided into two components. First, it includes a health checkup focusing on metabolic syndrome, a condition characterized by a cluster of biomarkers such as excess body fat, high blood pressure, and high blood sugar that collectively identify individuals at high risk for LRDs (e.g., Gami et al., 2007; Lakka et al., 2002; Mendrick et al., 2018). Second, face-to-face health guidance interventions then follow for the identified high-risk individuals and are expected to be most effective. These interventions are provided by professionals, including doctors, public health nurses, and dietitians, and are aimed at disease prevention through lifestyle modifications. This approach is expected to enhance the overall effectiveness of the health checkup program. Therefore, as illustrated in Figure 1, with the legally mandated health checkup program standardized under the SHC-SHG,[18] each municipality is required to increase its financial efforts to meet the program's requirements. Prior to 2008, these incremental financial efforts (as indicated by the orange arrows in Figure 1) varied depending on the public resources allocated by each municipality. For instance, municipalities A and C, which had allocated budgets for the NHIA-based program in addition to the legally mandated HMSAA-based program before 2008, are required to exhibit incremental financial efforts that are lower than those of municipality B, which had not provided any additional health checkup services as part of its 'duty of effort' initiative.

[17]The SHC-SHG is founded on the Act on Assurance of Medical Care for Elderly People, a revised version of the HMSAA.

[18]Under the SHC-SHG, the checkup is grounded in medical and scientific evidence for identifying metabolic syndrome and includes body measurements, blood tests, and questionnaires covering topics such as smoking habits and medication history. As excess body fat is a key indicator of metabolic syndrome, the program has introduced a measure of abdominal girth to estimate visceral fat.

Moreover, the SHC-SHG program incorporates financial incentives to encourage insurers to improve health outcomes among individuals covered by the NHI, including the self-employed and unemployed. Therefore, the responsibility for municipal health checkups has shifted from the department of health and hygiene to the department of NHI. The MHLW sets specific numerical targets for insurers, such as increasing participation rates in health checkups and health guidance, as well as reducing the prevalence of metabolic syndrome within their insured populations. In Japan, as municipalities are required to contribute approximately 7-8% of the total medical expenses for individuals aged 75 and older, the incentive structure under SHC-SHG links the financing amount municipalities must contribute to healthcare expenditure to their attainment of these targets.[19] Specifically, insurers who fail to meet these numerical targets are required to contribute more financial support than those who achieve higher levels of compliance.[20] It is designed to address the low participation rates in health checkups among self-employed and unemployed, thereby improving health outcomes for these groups.[21] Insurers that initially invest insufficient effort in promoting the health of their insured populations are strongly incentivized to enhance their efforts under the SHC-SHG, as illustrated in Figure 1 and Figure 2. Employing data on municipal expenditures for public health services, including health checkups, we analyzed how municipalities responded to the introduction of the SHC-SHG and its impact on health outcomes and behaviors, while focusing specifically on the self-employed and unemployed individuals insured by the NIH, which is administered by municipalities.

3 Data

This section provides a brief overview of the three datasets used in the analysis, along with the sample restrictions and the descriptive statistics.

3.1 Comprehensive Survey of Living Conditions

The Comprehensive Survey of Living Conditions (CSLC) is a nationally representative, repeated cross-sectional survey conducted by the MHLW every three years.[22] Respondents are selected through stratified random sampling from Census survey districts across Japan. The sampling process involves: (1) randomly selecting over 5,000 Census survey districts from the entire population

[19] The total medical expenses for individuals aged 75 and older (approximately JPY 18.4 trillion in 2024) are funded through the following structure: 10% is contributed by premiums paid by the insureds themselves; 50% is funded by general tax revenues collected by the central, prefectural, and municipal governments; and the remaining 40% is covered by insurance premiums paid by individuals under 75 years of age. A summary of the medical care system for the latter-stage elderly is available at https://www.mhlw.go.jp/english/wp/wp-hw3/dl/2-003.pdf (accessed September 25, 2024).

[20] This incentive scheme was implemented in 2013.

[21] A summary of the SHC-SHG program is available at https://www.mhlw.go.jp/english/wp/wp-hw3/dl/2-007.pdf (accessed September 25, 2024).

[22] The large-scale survey of the CSLC is conducted every three years, while the basic survey of the CSLC is conducted every year.

of Census districts; and (2) including all households and household members within these selected districts in the CSLC sample. The survey collects data on demographic characteristics, such as age, gender, marital status, type of residence, and prefectures of residence, as well as health-related characteristics, including self-report disease diagnoses, health checkup participation, type of health insurance, and lifestyle habits. For this analysis, CSLC data from six survey years (2001 to 2016) were utilized. We merged this individual-level repeated cross-sectional data with municipality-level public health service expenditure per capita.

The CSLC provides information on the municipality of residence only for respondents living in government ordinance-designated cities (*Seirei Shitei Toshi* in Japanese), a total of 12 as of 2001. Fortunately, as the CSLC survey districts are a subsample of the Census survey districts, and all households within the CSLC survey districts are sampled, we can probabilistically match the CSLC survey districts with the Census survey districts using the household characteristics of these districts. As the Census and the CSLC have no common survey district identifiers (IDs), we implemented a probabilistic matching process. Following the methodology of Fu et al. (2023), we matched the CSLC and Census survey districts and used the municipality IDs, which identify the location of a survey district in the Census, to merge the CSLC data with municipality-level data.[23]

3.2 National Health and Nutrition Survey

In addition, we used the National Health and Nutrition Survey (NHNS), a nationally representative, repeated cross-sectional survey conducted by the MHLW. The respondents were sampled using stratified random sampling from CSLC survey districts, following these steps: (1) 300 NHNS survey districts were randomly selected from the entire population of CSLC districts; and (2) all households and household members within these selected districts were then included in the NHNS sample. The survey collected data on health status, nutrition intake, and health behaviors, such as the number of daily steps taken. As the CSLC and NHNS share common household IDs, we were able to directly match households between the two datasets using these common IDs. However, as there are no common household member (or individual) IDs, we matched household members using gender and age as matching keys. For this analysis, we used NHNS data from the five survey years between 2001 and 2013, as the 2016 NHNS was sampled based on Census survey districts, rendering it incompatible for merging with the 2016 CSLC.[24]

3.3 Statistics of Medical Care Activities in Public Health Insurance

The Statistics of Medical Care Activities in Public Health Insurance (SMCA) survey is a nationally representative annual survey conducted by the MHLW. The SMCA collects medical claim data for the patients who used hospitals and clinics in June of the survey year through a two-stage stratified

[23] Appendix C provides detailed explanations of this procedure.

[24] As certain information from the CSLC is essential for the analysis, we decided not to use the 2016 NHNS.

random sampling process. First, medical institutions are sampled from all institutions in Japan, followed by the sampling of medical claims from the selected institutions. This approach allowed us to access data on the patient's status regarding injuries and illnesses during that month. Additionally, the SMCA provides information on monthly expenditures for healthcare services covered by health insurance. Using the SMCA, we aggregated total healthcare expenditures by municipality and year, constructing municipality-level panel data.

However, we did not have access to patients' residential addresses; instead, we used medical institutions addresses as proxies. We obtained these addresses by merging the SMCA with the Survey of Medical Institutions, using medical institution IDs as the matching key.[25] To construct municipality-level panel data, we had to address issues such as the frequent municipal mergers that occurred in the 2000s,[26] which is explained in detail in Appendix B. We used the SMCA from the eleven years between 2002 and 2010, as the data were only available up to 2010.

3.4 Sample Restriction

In the analysis, we focused on self-employed and unemployed individuals aged 40-59 who are insured by municipal NHI. Local governments provide health checkups to all residents insured by NHI aged 40 and older; thus, we set 40 as the lower age limit for our sample. Typically, the minimum retirement age is 60, especially for employees, who have had the legal option, since 2013, to continue working in the same company if they choose. Assuming those who retire at 60 may be less healthy than those who continue working, a potential discontinuity in the characteristics of individuals joining municipal NHI at age 60 may occur. To avoid this potential confounding factor, we restricted our sample to those aged 40-59.

We implemented three sample restrictions for the municipalities included in this analysis. First, we limited the sample to cities (*shi*) and special wards of Tokyo, which have relatively large populations. Towns and villages were excluded due to their generally lower number of medical institutions, which often leads residents to seek medical care outside their municipalities.[27] Given that we used medical institutions addresses as proxies for patients' residential addresses in the SMCA, this restriction was necessary to reduce the likelihood of cross-border outpatient visits. Second, we excluded municipalities with high within-municipality variation in per capita public health service expenses, based on NHIA data from 2007 or earlier. This exclusion was crucial because instability in per

[25] If patients visit medical institutions located in municipalities where they do not reside, the medical expenditures recorded in a municipality may not accurately reflect the healthcare costs of its residents. To minimize the impact of cross-municipal visits, we restricted our sample to larger municipalities, cities, and wards, with at least five medical institutions during the analysis period. Consequently, nearly all observations (municipality $\times$ year) had non-missing values for the number of patients. In addition, outpatient visits are less likely to involve crossing municipal borders compared to inpatient visits, which often require more specialized facilities.

[26] The number of municipalities decreased by approximately 45% between April 2000 and March 2009. Changes in the number of municipalities during this period can be viewed in the document available at https://www.soumu.go.jp/main_content/000651406.pdf (in Japanese)(accessed on September 26, 2024).

[27] According to the 2017 Survey of Medical Institutions, the average number of medical institutions was approximately 116 for cities, 461 for wards, 10 for towns, and 3 for villages.

capita expenses complicates the definition of treatment status.[28] Finally, we restricted the sample to municipalities where per capita expenses in the pre-SCH-SHG era were in the bottom 50% of the distribution. We classified the bottom 25% of municipalities as those with a relatively large expansion in per capita expenses, defining them as the treated group, while the next 25% of municipalities served as the control group.[29] These restrictions reduced the potential number of municipalities for the analysis from 1,741 to 366.[30] Due to incomplete coverage of all municipalities in the CSLC, NHNS, and SMCA surveys, the actual numbers of municipalities included in the analysis were 330, 144, and 340, respectively.

3.5 Descriptive Statistics

Tables 1 and 2 show the summary statistics for the individual- and municipality-level data. We focused on LRDs as the main outcome, as the SHC-SHG aims to prevent these conditions. In the CSLC, individuals were classified as having a single LRD diagnosis if they had at least one diagnosis of obesity, high blood pressure, diabetes, hyperlipidemia, stroke, or angina.[31] In the analysis sample, 13% of individuals had a single LRD diagnosis. Additionally, 3% of the sample had multiple LRD diagnoses. On average, the number of LRD diagnoses per individual was 0.16 (Panel A of Table 1). In the SMCA, we focused on high blood pressure and diabetes as the primary lifestyle-related diseases, as hyperlipidemia could not be identified in the SMCA. Among NHI-insured individuals aged 40-59, the average number of outpatient cases per municipality in June was 10.0, and the average total expenditure for outpatient visits was approximately JPY 121,860 (USD 121.9) (Panel A of Table 2).[32]

As indicators of health behaviors, we used four variables from the CSLC and the NHNS: a dummy variable indicating whether a respondent has health checkups; a dummy variable indicating whether a respondent has quit smoking; the amount of alcoholic beverage consumption; and the number of daily steps taken. The proportion of individuals who undergo health checkups and those who have quit smoking are 45% and 3%, respectively. The average amount of alcoholic beverage consumption is 151.51 grams per day. The average number of daily steps is 6718.6, with 33% of individuals walking more than 8,000 steps (Table 1).[33]

The average age of respondents is approximately 50 years, and 53% are female. Approximately 67% of respondents are married, and the average household size is 3.2 members. Additionally, 71% of respondents own their home (Panel A of Table 1). Panel B of Table 2 offers summary statistics

[28] We calculated the standard deviation of per capita expenses within each municipality from 2007 or earlier and excluded the top 10% of municipalities based on this standard deviation.

[29] We conducted a robustness check on the definition of the control group (see Table E.1).

[30] The first procedure reduced the number of municipalities from 1,741 to 813. The second procedure further restricted this number from 813 to 732. Finally, the third procedure narrowed it down from 732 to 366.

[31] The CSLC survey inquires whether respondents visit medical institutions and, if so, for what diseases and injuries they seek medical care. We constructed the diagnosis variables using this information.

[32] We converted all the expenses using a rate of JPY 100 to USD 1.

[33] The Japanese government recommends a minimum of 8,000 steps per day to improve health.

of other municipality characteristics including population, financial index, and measures of medical resources.

As discussed in Section 2, one of the primary objectives of introducing the SHC-SHG was to standardize the contents of health checkup programs, which previously varied significantly across municipalities in the pre-SHC-SHG era. Therefore, municipalities with fewer components than those in the SHC-SHG's standardized program and lower health checkup expenses in the pre-SHC-SHG periods would need to increase their spending. Conversely, municipalities that already had programs comparable to or more comprehensive than the standardized program, and, consequently, higher spending during the pre-SHC-SHG periods, would not need to increase their expenses. In other words, the change in the municipal health checkup program expenses before and after the SHC-SHG implementation is expected to be heterogeneous, depending on the pre-SHC-SHG spending levels.

If there are heterogeneous changes in per capita expenses resulting from changes in the health checkup program menu, this variation could be leveraged to identify the causal effect of the expansion in per capita expenses on residents' health and behaviors. To test the plausibility of this hypothesis, we compared the change in the per capita expense of public health services expenses based on NHIA data across municipalities. Specifically, we compared those municipalities where per capita expenses in the pre-SCH-SHG era were in the bottom 25% of the distribution with those where the expenses were above the bottom 25%.

Table 3 shows the per capita expense of public health services across four groups, categorized by quartiles, and the differences before and after the introduction of SHC-SHG. Columns (1) and (2) display the per capita expenses of public health services based on NHIA data before and after SHC-SHG, respectively.[34] Column (3) shows the difference between Columns (1) and (2), with Column (4) displaying the percentage change.

As shown in Table 3, during the pre-SHC-SHG period, the estimated per capita expense of health checkup programs was 21.3% higher in the "25-50%ile" compared to those in the bottom 25% municipalities (about JPY 2,939.1 (USD 29.4) versus JPY 2,422.1 (USD 24.2)). However, in the post-SHC-SHG period, the disparity between these groups significantly narrowed, with the per capita expense in the "25-50%ile" municipalities being only 0.8% higher than in the bottom 25% (approximately JPY 4,454.6 (USD 44.5) JPY compared to 4,488.7 (USD 44.9)). These results suggest that the SHC-SHG program has effectively reduced the disparity in health checkup program costs among municipalities.

[34]Before the introduction of SHC-SHG, both the NHI department and the health and hygiene department offered health checkup programs. Consequently, by comparing the expenses of NHI-based public health services before and after the introduction of SHC-SHG, we are unable to determine the changes in the municipal financial effort for health checkup programs.

To account for this, we estimated the per capita expense of health checkup programs provided by the health and hygiene department and added it to the per capita expense of NHI-based public health services, thus capturing the overall per capita expense for health checkup programs. The estimated per capita expense of the health checkup programs by the Health and Hygiene department is JPY 1,916.

Additional details on the estimation of per capita expenses for these programs are provided in Appendix A.

Overall, the estimated per capita expense for health checkup programs increased by approximately 46.1% following the SHC-SHG, although the extent of this increase varied depending on the initial per capita expenses in the pre-SHC-SHG period. For municipalities in the bottom 25%, the estimated per capita expense for health checkup programs rose by approximately JPY 2,066.6 (USD 20.7), marking an 85.3% increase compared to the pre-SHC-SHG period. This increase was approximately 65.3% greater than that observed in the "25-50%ile" municipalities (85.3% versus 51.6%). As illustrated in Figure 1, these findings suggest that municipalities with lower per capita expenses for health checkup programs in the pre-SHC-SHG period had to increase their expenses more significantly than those with higher initial expenses.[35]

4 Estimation Model

4.1 Dosing difference-in-differences

The core of the identification strategy involves leveraging the variation in changes in per capita expenses for health checkup programs before and after the introduction of the SHC-SHG. As discussed in Section 3.5, the average expense for these programs increased during the post-SHC-SHG periods. This expansion in funding may have influenced residents' behaviors, encouraging them to take steps to improve their health. Additionally, the magnitude of this expansion varied depending on the pre-SHC-SHG expense levels, potentially leading to heterogeneity in health improvements across residents; municipalities in the bottom 25% before the policy introduction, which experienced the most significant expansion, may have experienced greater health improvements among residents compared to other municipalities. For our analysis, we classified the bottom 25% municipalities as the treatment group with a high dose of the expansion and the "25-50%tile" municipalities as the control group with a low dose of the expansion, comparing the pre- and post-expansion changes between these two groups using a dosing difference-in-differences (dosing-DID) estimation.[36] This method, used when treatment intensity varies across units, has been applied in various fields of empirical economics (e.g., Andersen et al., 2023; Assaad et al., 2023; Cook et al., 2022; Parker and Vogl, 2023). In other words, our dosing-DID estimates can be categorized as a "scaled high-versus-

[35] Arguably, prior to the SHC-SHG, the total expenses related to the health checkup programs were consistent across municipalities. If this were the case, some municipalities might have allocated more funding to the health and hygiene department for the HMSAA-based program, whereas others prioritized the NHI department for the NHIA-based program. This could lead to variations in per capita expenses of NHIA-based programs. We would expect a negative correlation between per capita expenses for health checkup programs managed by NHIA (the NHI department) and those managed by the HMSAA (the health and hygiene department). To test this hypothesis, we examined the per capita expense for public health services under the NHIA and the per capita commission fee for public health services conducted by the health and hygiene department. However, direct access to both sets of per capita expenses for the health checkup programs was not available. As shown in Figure D.2, after adjusting for prefecture fixed effects, there is no statistically significant correlation between these two variables.

[36] We conducted robustness checks to assess the sensitivity of our results to different definitions of the treatment and control groups. The findings confirm that the estimation results remain robust (Table E.1). Additional details of these robustness checks are provided in Appendix E.1.

low (2×2)" two-way fixed effects (TWFE) estimator (scaled 2×2 TWFE), as outlined in (Callaway et al., 2024), utilizing variations in municipal per-capita health checkup expenses.[37]

Then, we conducted a dosing-DID analysis using both individual- and municipal-level data. First, the estimation equation for the analysis using individual-level data is as follows:

$$y_{ijpt} = \beta_0 + \beta_1 T_j + \beta_2 After_t + \beta_3 (T_j \times After_t) + x'_{ijt}\delta + \mu_{pt} + \eta_j + \phi_t + u_{ijt}, \tag{1}$$

where i, j, p, and t index individuals, municipalities, prefectures, and years, respectively. The dependent variable y_{ijpt} represents health-related outcomes, such as the number of LRD diagnoses, a dummy for a single LRD diagnosis, and a dummy for multiple LRD diagnoses. The variable T_j equals one if the municipality's public health services expense per capita in the pre-SHC-SHG period was in the "bottom 25 %," indicating the municipality that considerably increased public health services expenses per capita after the SHC-SHG introduction. The dummy variable $After_t$ takes the value of one after 2008, the year when SHC-SHG was introduced. The vector x_{ijt} includes control variables such as individual and municipality-level characteristics. Individual-level controls include age (modeled as a quadratic function), the number of household members, housing type dummies, a female dummy, and marital status dummies. Municipality-level controls include logged total population, logged population aged 40–74, logged financial index, the ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of hospital beds per capita. Parameters μ_{pt}, η_j, ϕ_t represent prefecture-year fixed effects, municipality fixed effects, and year fixed effects, respectively, while u_{ijt} is an error term. In Equation (1), the parameter β_3 corresponds to the DID estimate and is the primary parameter of interest in this study. The models are estimated using weighted least squares (WLS) with the sampling weight of the CSLC.

Similar to the individual-level regression equation, we estimated a dosing-DID model for the municipality-level data on medical expenditures using the following specification:

$$y_{jpt} = \tilde{\beta}_0 + \tilde{\beta}_1 T_j + \tilde{\beta}_2 After_t + \tilde{\beta}_3 (T_j \times After_t) + x'_{2jt}\tilde{\delta} + \tilde{\mu}_{pt} + \tilde{\eta}_j + \tilde{\phi}_t + \tilde{u}_{jt}, \tag{2}$$

The notations and variable definitions are consistent with those in Equation (1) except for the control variables in vector x_{2jt}. This vector includes municipality-level characteristics such as logged total population, logged population aged 40–74, logged financial index, the ratio of hospitals to total medical institutions, number of medical institutions per capita, and number of hospital beds per capita. The models are estimated using the WLS, with the number of individuals insured by municipal NHI and aged between 40 and 59 in 2007 as the weighting variable.

[37] Due to data limitations, we were unable to directly measure the level of this expansion. Consequently, we defined treatment status using per-capita expenses of public health services under the NHI Act during the pre-SHC-SHG period, rather than the actual expansion level.

4.2 Validation of the Estimation Model

To test the validity of our empirical settings, we conducted the following analyses. First, we verified that municipal characteristics in the pre-SHC-SHG period were not significantly different between the treatment and control groups, except for the total population. Table 4 summarizes the municipal characteristics during this period by treatment status. Columns (1) and (2) show the mean values of municipal characteristics for the control and treated municipalities, respectively. Column (3) reports the differences between these means, while Column (4) shows the differences after adjusting for prefecture-fixed effects. In Column (4), we also control for the logged municipal population, except in the first row, which reports the municipal population.

The treated group had a significantly larger population than the control group, suggesting the necessity of controlling for the population in the analysis. After adjusting for population and prefecture-fixed effects, no significant differences were observed between the two groups in terms of demographic composition, accessibility to healthcare services, and financial conditions.[38,39]

Second, relying solely on the standard parallel trends assumption is insufficient to ensure the causal interpretation of the DID estimates in the dosing-DID specification (Callaway et al., 2024). According to Callaway et al. (2024), under the standard parallel trends assumption, DID estimates may be contaminated by "selection bias." To achieve a causal interpretation and eliminate this bias, we must invoke the "strong parallel trends assumption." This assumption requires that the treated group (high-dose expansion) and the control group (low-dose expansion) would have experienced identical developments in outcome variables if they had received the same level of the expansion dose.

To the best of our knowledge, no established methods exist to directly test the validity of the strong parallel trends assumption. However, we addressed its validity by examining two key points. First, we examined the pre-trends of the outcome variables using an event-study model. If the trajectories of outcome variables differ between treated and control groups during the pre-SHC-SHG period, it would suggest that the strong parallel trends assumption may not hold.

Figure 3 summarizes the results of the event study model for LRD diagnoses and outpatient medical expenditure due to LRD. Panels (a), (b), and (c) present results from the 2001–2016 CSLC, while Panel (d) shows results from the 2002–2010 SMCA. In all panels, diamond symbols represent the point estimates of the interaction terms between the treatment and year dummies, while the red bars denote the 95% confidence intervals for the estimates, which are calculated using standard errors robust to municipality-level clustering. The reference year is set as 2007. Figure 3 demonstrates

[38] We observed a statistically significant difference in the proportion of individuals aged between 40 and 74; however, the effect size is negligible, at only 1.0%.

[39] We conducted a robustness check to control for heterogeneous trends based on pre-SHC-SHG population levels. This was done by incorporating the interaction terms of four categorical dummy variables representing quartiles of the population level during the pre-SHC-SHG period, along with year dummy variables and the control variables of the baseline model. The robustness check confirmed that our results are robust when controlling for the heterogeneous trends based on the pre-SHC-SHG population level (Figure E.1).

that for all four outcomes, point estimates prior to 2008 are statistically insignificant, indicating that before the introduction of SHC-SHG, the differences in the outcome variables between the treated and control groups were not statistically different from those in the reference year.

Second, we examined the relationship between the dose of the expansion and municipality characteristics. If municipalities in the treated group possess rich financial resources that enable them to sustain policies enhancing the expansion's impact, the development of outcome variables could differ between the treated and control groups, even after controlling for municipality fixed effects. A correlation between the expansion dose and municipality characteristics could undermine the credibility of the strong parallel trends assumption. As discussed, the treated (high-dose expansion) and control (low-dose expansion) groups have similar population composition, accessibility to healthcare services, and financial resources (Table 4). Additionally, we examined the relationship between the proxy for the expansion dose (per capita expense of public health services based on the NHI Act during the pre-SHC-SHG periods) and observable characteristics, following a method similar to Cook et al. (2022). Figure D.3 presents the results of regressing observable characteristics on the per capita expense of NHI Act-based public health services during the pre-SHC-SHG periods. The estimates show no systematic relationship between the proxy of the expansion dose and observable characteristics, indicating no clear violation of the strong parallel trends assumption.

5 Results

5.1 Effects on Lifestyle-Related Disease Diagnoses and Outpatient Medical Expenditure

This subsection presents the results of the effect of the expansion of per capita expenses of health checkup programs on LRDs and outpatient medical expenditures related to LRDs. Panel (a) of Figure 3 shows that the estimate of the interaction terms between the treatment and year dummies is negative and statistically significant at the 5% level in 2016, eight years after the policy introduction. The point estimate of -0.047 suggests a 28.9% reduction in the number of LRD diagnoses when we compared to the pre-SHC-SHG mean among the treated group (as indicated by "pre-SHC-SHG mean among the treated" in Table 5). Similarly, Panels (b) and (c) of Figure 3 show statistically significant negative estimates for interaction terms of the treatment and 2016-year dummies at the 5% and 10% levels for dummy variables, indicating at least one LRD diagnosis and two or more LRD diagnoses, respectively. Specifically, the estimates indicate a 22.2% reduction in the proportion of individuals with at least one diagnosis and a 42.6% reduction in the proportion of those with two or more diagnoses, compared to the pre-SHC-SHG mean among the treated group. For multiple LRD diagnoses, we observed declines—although statistically insignificant—of 10.6% in 2010 and 28.4% in 2013. These results, along with the 2016 estimate, suggest a gradual decrease in the number of individuals with severe LRDs following the introduction of the SHC-SHG.

In 2010, the medical expenditure on LRD-related outpatient visits for the treated group was significantly lower than that of the control group, with a difference significant at the 5% level, compared with the reference year (as shown in Panel (d) of Figure 3). The estimate of JPY -27323.1 (USD -273.2) reflects a 17.6% reduction in LRD-related outpatient expenditures relative to the pre-SHC-SHG mean among the treated. This reduction is likely associated with the observed gradual decrease in severe LRD cases following the introduction of the SHC-SHG (Panel (c) of Figure 3).

The results from the dosing-DID model align closely with the event study model. Table 5 provides a summary of the dosing-DID estimation results based on Equations (1) and (2). The table includes the estimated coefficient for the DID term ("Treat×After"), number of observations, average dependent variable for the treated group during the pre-SHC-SHG period, and additional data for each dependent variable.

From Table 5, the dosing-DID estimates are -0.0260 for the number of LRD diagnoses, -0.0131 for the proportion of individuals with at least one LRD diagnosis, and -0.0101 for the proportion of individuals with two or more diagnoses (Columns (1)–(3)) and represent reductions of 16.0%, 10.4%, and 35.8%, respectively, relative to the pre-SHC-SHG mean among the treated. These estimates are statistically significant at 5 and 10% levels. These results indicate that the reduction in LRD patients with multiple diagnoses is three times greater than the reduction for those with a single diagnosis. This suggests that the SHC-SHG introduction is more effective in reducing the number of patients with severe conditions rather than the overall number of LRD patients. Additionally, the estimate for outpatient medical expenditure due to LRDs is also negative and statistically significant at the 1 % level, reflecting a 9.9% reduction compared to the pre-SHC-SHG mean among the treated.[40]

To assess the validity of our estimation results and eliminate the possibility that other factors differently influenced health outcomes based on our treatment status, we conducted placebo regressions using sample and outcome variables less related to the SHC-SHG. First, we re-estimated the event study model using individuals insured by the Employees' Health Insurance (EHI), who were not eligible for municipal health checkup programs.[41] Unlike the results observed in the main analysis (Figure 3), we found no systematic reduction among the individuals residing in the treated municipalities after the introduction of SHC-SHG (Figure E.2). Second, we estimated the event study model using diagnosis and subjective symptoms related to injuries. As the SHC-SHG focuses on LRDs, diagnosis and symptoms related to injuries should not exhibit the same trends as in the main analysis. This estimation result supports this hypothesis (Figure E.3).[42]

[40] The estimation results are robust to variations in the definition of treatment and control groups. Details of these robustness checks are discussed in Appendix E.1.

[41] The EHI plans to provide healthcare services not only for the insured people but also for their dependents.

[42] A potential threat to our identification strategy is systematic migration related to the introduction of the SHC-SHG. Specifically, individuals with a heightened health consciousness might have been deterred from moving to the treated municipalities owing to their previously lower levels of the health checkup programs. Following the introduction

5.2 Effects on Health Behaviors

One potential mechanism for the observed health improvements in the treated group following the introduction of the SHC-SHG is a change in health behaviors. To investigate this channel, we estimated the dosing-DID model with various health behaviors as dependent variables. These dependent variables include the indicator for having health checkups, smoking cessation dummy, logged amount of alcoholic beverage consumption in grams per day, and indicator for whether an individual's daily steps exceed 8,000. Table 6 summarizes the results of these estimators, consistent with Table 5.

We found statistically significant changes in smoking cessation, alcoholic consumption, and daily steps (Columns (2), (3), and (4), respectively, of Table 6). Specifically, the dosing-DID estimates indicate that, compared to the pre-SHC-SHG mean among the treated, the proportion of individuals who ceased smoking increased by 50.1% and the proportion of individuals taking 8,000 or more steps per day rose by 163.5% (Columns (2) and (4), respectively). Additionally, alcohol consumption per day decreased by 91.0% (Column (3)),[43] from an average of approximately 175.5 grams to 15.7 grams per individual.[44] Conversely, the dosing-DID estimate for the health checkup participation dummy is statistically insignificant.[45] This suggests that the introduction of the SHC-SHG did not significantly affect participation rates in health checkups. Nevertheless, the health improvements observed in Table 5 are likely attributable to the enhanced content of the revised programs, rather than an increase in the number of participants.[46]

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of the SHC-SHG, these individuals might have been more inclined to relocate to the treated municipalities. Such a migration could increase the proportion of health consciousness among the municipality population, potentially explaining the observed health improvements without attributing them directly to the SHC-SHG. In other words, the dosing-DID estimates might reflect changes in population composition rather than the actual impact of the health checkup program expansion. To examine the possibility of systematic migration, we estimated the dosing-DID with migration and the target population for the SHC-SHG as dependent variables. The results, presented in Table E.3, indicate no statistically significant effects on the number of migrants or the target population for the SHC-SHG, suggesting that systematic migration is unlikely to account for the observed changes. Further details on the estimation and results are provided in Appendix E.4.

[43] To interpret the estimate from the log-level model with a dummy independent variable, we converted the estimate, β, to $exp(\beta) - 1$, where $exp()$ denotes the exponential function with base e (approximately 2.71828).

[44] The value of 175.5 grams represents the average amount of alcohol consumption among the individuals residing in the treated municipalities before the introduction of the SHC-SHG.

[45] We also noted that the participation rates in the treated and control groups were nearly identical in the pre-SHC-SHG period.

[46] A potential mechanism behind the observed health improvements in the treated group following the introduction of the SHC-SHG is the enhanced quality of municipal health checkup programs. The SHC-SHG targets individuals at high risk of LRDs, offering tailored health guidance interventions from professionals such as doctors. By contrast, prior programs primarily addressed individuals with existing diseases, for whom interventions may have been less effective. Consequently, people at high risk may have modified their health behaviors in anticipation of the interventions. Therefore, the SHC-SHG appears to be more effective in preventing LRDs compared to previous programs. The observed health improvements among the treated group following the SHC-SHG introduction can likely be attributed to this enhancement in the quality of municipal health programs.

5.3 Heterogeneity Analysis

We conducted a subgroup analysis using the CSLC to explore the heterogeneity of the effects on LRD diagnoses based on individual characteristics. This study focused on three key characteristics: labor force status (LFS),[47] homeownership (as a proxy for economic conditions),[48] gender, and age. Table 7 presents the results of the subgroup analysis for LRD diagnoses.

Our findings reveal a heterogeneous impact based on LFS and homeownership (Columns (1) versus (2) and Columns (3) versus (4)). Among self-employed individuals, we observed statistically significant negative impacts across all three LRD diagnoses, with declines of 18.5%, 12.8%, and 36.6%, respectively, as shown in Panels A-C in Column (1). By contrast, no significant impacts were observed among the unemployed (Column (2)). These results suggest that unemployed individuals—those in poor health—[49] did not benefit from the policy introduction.

For homeowners, the dosing-DID estimates are negative and statistically significant across all three LRD diagnosis variables, corresponding to a decline of 21.1%, 19.3%, and 30.9%, respectively, as shown in Panels A–C in Column (3). By contrast, no statistically significant DID estimates were observed among renters, and the DID estimates for the number of LRD diagnoses and the single diagnosis dummy are even positive in Panels A–C in Column (4). These results indicate that health improvements following the SHC-SHG introduction are observed only among homeowners, who are relatively wealthier individuals, consistent with the finding of Zhao et al. (2013).

Although socioeconomic conditions influence the impacts of the policy introduction, we did not observe systematic differences in the estimation results by gender (Columns (5) versus (6)) or age (Columns (7) versus (8)).

6 Discussion

We conducted a dosing-DID estimation to compare changes in LRD diagnoses and health behaviors among individuals insured by municipal NHI across different municipalities. Specifically, we compared municipalities that significantly increased their per capita expenses on health checkup programs with those that did not, aiming to assess the impact of the SHC-SHG introduction on

[47] We defined "self-employed" as individuals insured by the municipal NHIs who were working at the time of the survey, and "unemployed" as individuals insured by the municipal NHIs who were actively seeking job opportunities. This is due to employees enrolling in EHIs. Due to data limitations, we used the 2004-2016 sample for the "unemployed" group.

[48] The CSLC conducted a survey on income and savings for the subsample of the main survey, which focused on households and health. In the 2016 CSLC, the income and savings survey included 24,604 households, representing 11% of the total sample size of the main survey, which surveyed 217,179 households. To incorporate a larger number of survey participants, we utilized the homeownership variable from the main survey as an indicator of economic conditions. According to the 2016 CSLC, the proportion of households with savings of USD 0.1 million or more is 2.5 times higher among homeowners than renters (37.5% among homeowners and 15.1% among renters), suggesting that homeowners are generally wealthier than renters.

[49] In our data, the unemployed have 1.5 times more LRD diagnoses than the self-employed among the treated in the pre-SHC-SHG period (20.7% versus 14.0% in Panel A in Columns (1) and (2)).

residents' health outcomes and behaviors. The results indicate a reduction in the number of individuals with LRD diagnoses and alterations in health behaviors among the treated population following the SHC-SHG implementation.

In this section, we address two key issues related to our dosing-DID estimates: 1) the interpretation of the DID estimates, and 2) the calculation of cost-effectiveness.

6.1 Interpretation of The DID Estimates

Our DID estimates are derived by comparing individuals insured by municipal NHI in the treated areas with those in the control areas. As the SHC-SHG introduction is unlikely to significantly affect individuals not participating in health checkups and because our estimation sample includes such less-affected individuals due to the non-universal participation rate in health checkups, our DID estimates may be smaller in absolute value than the true impact of the policy. In other words, these estimates could represent a lower bound of the actual impacts.

One approach to infer the true magnitude of the impact is to restrict the sample to those who were "exposed" to the SHC-SHG introduction — specifically, individuals who participated in health checkups. A subsample analysis based on health checkup participation at the time of the survey (Table E.2) shows that the DID estimates for participants are negative and statistically significant, consistent with the overall sample results, but with larger magnitudes. Conversely, there are no significant impacts among those who did not participate in health checkups. These findings support our interpretation that the DID estimates capture the impacts of the SHC-SHG introduction, albeit as a lower bound of the true effects. However, unlike the CSLC, this approach cannot be applied to the analysis of medical expenditures, as the SMCA does not include information on individual health checkup participation status.

Another option is to assume that everyone who underwent health checkups is "exposed" to the SHC-SHG introduction and adjust the DID estimates by dividing them by the health checkup participation rate, 44.15% (Column (1) of Table 6). Therefore, the true impact on the number of LRD diagnoses could be estimated as -0.0589 by dividing the DID estimate of -0.026 (Column (1) of Table 5) by 44.15%. This calculated magnitude is close to the estimate for individuals who participated in health checkups, -0.044 (Column (1) of Table E.2), which translates to a 36.3% decline compared to the pre-SHC-SHG mean among the treated group, supporting the plausibility of this approach. Additionally, the true impact on outpatient medical expenditure due to LRD could be estimated as approximately JPY -34696.17 (USD -347) by dividing the parameter estimate of JPY -15318.36 (USD -153.2) (Column (4) of Table 5) by 44.15%. This translates to a 22.4% decline compared to the pre-SHC-SHG mean among the treated group.

It is important to carefully interpret the DID estimates because the control group also expanded public health services in response to the policy introduction, as shown in Table 3. In other words, this DID strategy compares changes in outcome variables between groups with high and low treatment intensities. Consequently, the estimated effects may be lower than the true treatment effects on the treated group in absolute value, particularly if the effects have the same direction in both the treated and control groups.[50] While we suspect that the expansion of health checkup programs improves residents' health outcomes rather than worsening them, we cannot completely eliminate the possibility of no effects due to insufficient policy content. Therefore, it is plausible to interpret the DID estimates as the lower bounds of the policy's effects. To further explore the economic interpretations of our findings, we conduct a cost-effectiveness analysis in the following subsection.

6.2 A Back-of-the-Envelope Calculation: How Much the Policy Introduction Could Reduce the Medical Expenditures

In this subsection, we assess the cost-effectiveness of expanding the per capita expense on health checkup programs using a back-of-the-envelope calculation, as summarized in Table 8. We used an official statistic from the Estimates of National Medical Care Expenditure (ENME) to estimate the reduction in medical expenditures resulting from the increased per capita expense in the treated municipalities due to the introduction of the SHC-SHG. The ENME provides estimates of annual total medical expenditures in Japan for major diseases by outpatient visits and hospital admissions, segmented by age group (0–14, 15–44, 45–64, 65+). For 2007, the estimate of annual medical expenditures on outpatient visits for individuals aged 45-64 with LRDs was JPY 778.4 billion ((1) in Panel A).[51,52,53]

Assuming constant prevalence and severity of diseases across municipalities and health insurance types for people aged 45-64, we estimated the total medical expenditures for this age group insured by municipal NHI in the treated municipalities. We multiplied the total medical expenditures by the ratio of the people aged 45-63 who are insured by municipal NHI in the treated municipalities to the total population: JPY 96.7 billion ((2) in Panel A).[54] Then, we proceeded to multiply the estimated total medical expenditures for individuals aged 45–64 insured by the municipalities' NHI ((2) in Panel A) by the estimated effects of the expansion of the per capita expense of the health check programs on outpatient medical expenditures ((3) in Panel A). This calculation yielded a

[50]If the expansion of health checkup programs worsened residents' health outcomes, the DID estimate could overestimate the true impact.

[51]We calculated the annual medical expenditures due to LRD by summing those for hypertensive diseases (ICD-10:I10-I15) and diabetes mellitus (ICD-10:E10-E14)). The estimates for outpatient visits due to hypertensive diseases and diabetes mellitus are JPY 481.6 and 296.8 billion (approximately USD 4.8 and 3.0 million), respectively.

[52]The data can be accessed from the e-Stat web page (https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00450032&tstat=000001020931&cycle=8&tclass1=000001032180&stat_infid=000004485743&tclass2val=0(in Japanese)(accessed December 12, 2022)).

[53]The total medical expenditure encompasses costs for medical treatment (outpatient and inpatient services) and excludes dental and pharmacy expenses, amounting to JPY 25.64 trillion (USD 256.4 billion) in 2007. The annual medical expenditures for outpatient visits due to LRD for individuals aged 45-64 (JPY 778.4 billion, which is approximately USD 7.8 million) accounted for approximately 3% of the total medical expenditures in 2007.

[54]In 2007, the ratio of individuals aged 45-64 who were insured by municipal NHI and residing in the treated municipalities to the total population in that age group was approximately 0.124.

reduction in medical expenditures of approximately JPY -21.64 billion (USD 216.4 million) ((4) in Panel A).[55]

As in Table 3, among the treated ("Bottom 25%"), the increase in the estimated per capita expense of municipal health checkup programs was, on average, JPY 750.5 (approximately USD 7.5) more than the increase for the control group. Assuming the DID estimates reflect a JPY 551.0 (USD 5.5) increase in the per capita expense of municipal health checkup programs, we calculated the increase in the total expense of the health checkup program for the treated municipalities by multiplying this amount by the number of individuals aged between 45-64 insured by municipal NHI in the treated municipalities.[56] This results in an estimated increase of JPY 2.37 billion (USD 23.7 million) ((5) in Panel B of Table 8).

According to the back-of-the-envelope calculations, the magnitude of the reduction in medical expenditures is approximately nine times larger than the increase in the cost of health checkup programs ((6) in Panel C). This suggests that the expansion of per capita spending on the health checkup programs provides significant value by improving the health status of residents insured by the municipal NHI in the treated municipalities.[57]

7 Conclusion

This study examines the effects of expanding municipal per capita expenses on health checkup programs owing to the introduction of the SHC-SHG, focusing on residents' health outcomes and behaviors through a dosing-DID estimation method that leverages variations in treatment intensity. The dosing-DID estimation reveals that the introduction of SHC-SHG led to a reduction in the proportion of people diagnosed with LRDs in the treated municipalities, with a more pronounced impact observed among those with multiple diagnoses compared to those with a single diagnosis. This suggests that the SHC-SHG is more effective in reducing the number of patients with severe conditions rather than merely decreasing the overall number of LRD patients.

Subgroup analysis indicates that health improvements following the SHC-SHG introduction are observed among self-employed workers and homeowners (who are generally wealthier), while such improvements are not evident among the unemployed and renters. Additionally, we identify statistically significant behavioral changes among the treated, including increased smoking cessation rates, reduced alcohol consumption, and a higher number of daily steps following the policy introduction.

A back-of-the-envelope calculation demonstrates that the municipal response to the SHC-SHG introduction is cost-effective, aligning with findings from previous studies. Ensuring good health in

[55] We applied the impact magnitude of -22.37%, as discussed in Section 6.1, for our calculations.

[56] The estimated number of individuals aged 45-64 insured by municipal NHI in the treated municipalities is approximately 4,303,786.

[57] If we used the magnitude of the impact of 9.9%, which represents the DID estimate relative to the pre-SHC-SHG mean among the treated (Column (4) if Table 5), instead of the magnitude of -22.37%, the calculated reduction in medical expenditure would be JPY 9.6 billion. This amount is approximately four times larger than the increased cost.

middle age and beyond is crucial for reducing national medical expenditures and preparing for future health challenges. Preventive health services, such as health checkups and screening programs, play a vital role in this respect. Therefore, accumulating extensive evidence on the cost-effectiveness of such programs is essential for guiding policymakers in the development of sustainable social security systems.

Declaration of Interest

This study was partially funded by Waseda University Research Initiatives under the project titled "Empirical and Theoretical Research for Social Welfare in a Sustainable Society: Inheritance of Human Capital Beyond 'an Individual' and 'a Generation"' (PI: Haruko Noguchi). It was also supported by a grant-in-aid for scientific research from the Ministry of Health, Labour and Welfare (19-FA1-013), titled "Empirical Evaluation of Socio-Economic Impacts of Prevention Policies of Lifestyle-Related Diseases across Different Industries and Regions" (PI: Haruko Noguchi). Additionally, the study received funding from a grant-in-aid for challenging research (pioneering) (19H05487), named "Toward the Implementation of Evidence-Based Health Policies: A Trial Using Big Data Analyses through Integration of Arts and Sciences" (PI: Haruko Noguchi). Oikawa also received funding from JSPS (Project Number: 21K20160, 23K12494). This study obtained official approval for the use of secondary data from the Statistics and Information Department of the MHLW under Tohatsu-1005-2 as of October 5, 2020. Furthermore, the Waseda University Ethics Review Committee determined that this study did not require ethical review (Approval No.: 2021-HN010; Date of Approval: May 18, 2021).

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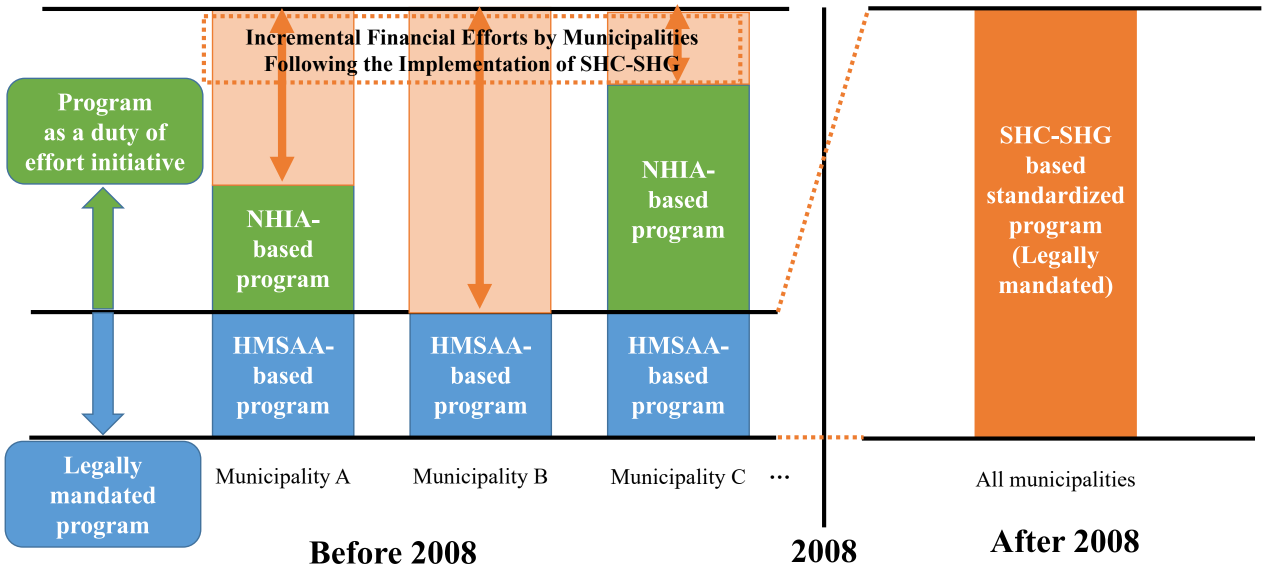


Figure 1: Conceptual diagram illustrating the financial efforts of local governments in Japan's health checkup system for the self-employed and unemployed, before and after the introduction of the SHC-SHG program

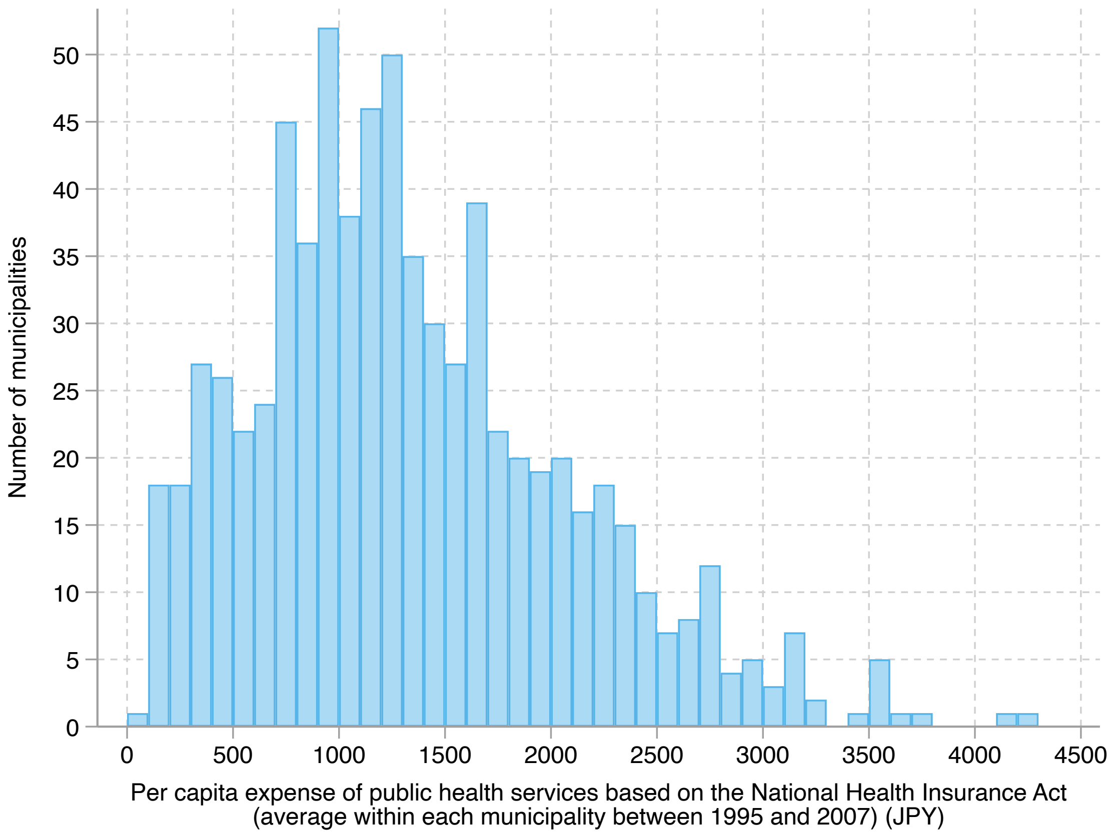
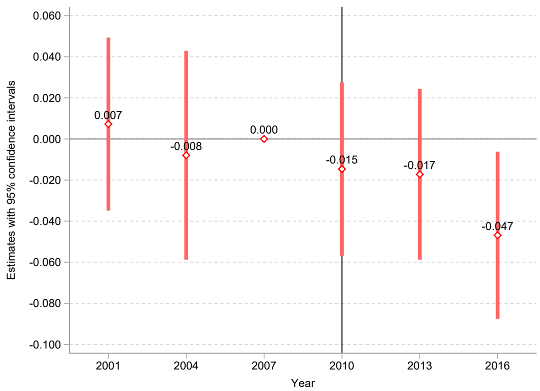
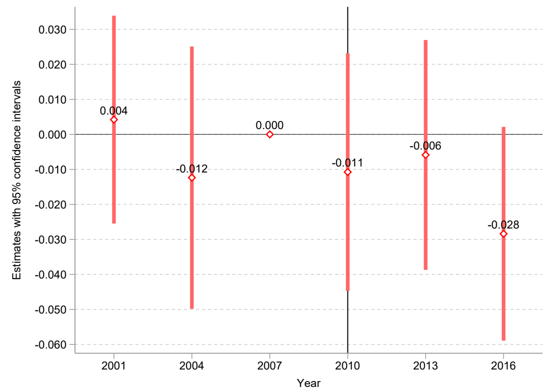


Figure 2: Per Capita Expense of Public Health Services Based on The National Health Insurance Act Before 2008 (JPY)

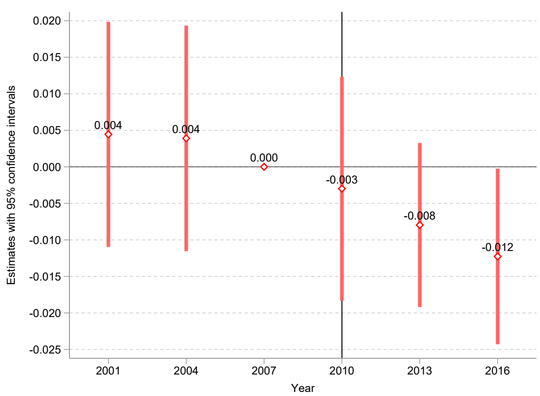
Notes: The analysis was conducted on a sample of 732 municipalities after applying the sample restriction criteria. The average per capita expense within each municipality was calculated for the period between 1995 and 2007. The mean, standard deviation, and coefficient of variation (CV) for the per capita expense were JPY 1,344.1 (USD 13.4), JPY 744.7 (USD 7.4), and 0.554, respectively.



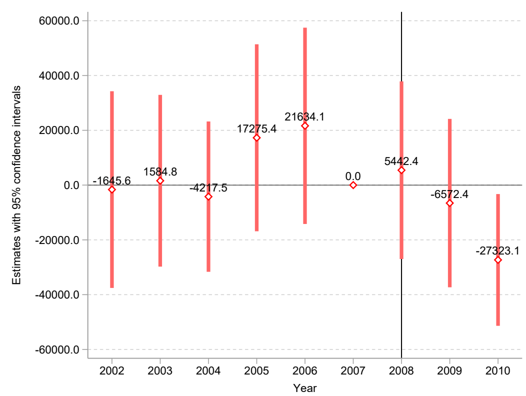
(a) Number of LRD diagnoses



(b) Having at least one LRD diagnosis



(c) Having two or more LRD diagnoses



(d) Medical expenditure: outpatient visits due to LRD

Figure 3: Event Study: impact on LRD diagnoses and medical expenditure due to LRD

Notes: The units of observation are individuals for Panels (a)—(c) and municipalities for Panel (d). For the estimations, we used individuals insured by the NHI aged 40–59. We estimated Equations (1) (Panels (a)—(c)) and (2) (Panel (d)) using the interaction terms of the treatment dummy and the year dummy variables, instead of the DID term. The models estimated for Panels (a)–(c) include both individual- and municipality-level control variables, while the model estimated for Panel (d) includes only municipality-level control variables. At the individual level, the control variables include age (quadratic function), number of household members, house type dummy variables, a female dummy, and marital status dummies. At the municipality level, control variables included the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of beds per capita. The models also incorporate prefecture-year fixed effects, municipality fixed effects, and year fixed effects. We set 2007 as the reference time period. Diamond symbols indicate the estimates of the interaction terms of the treatment dummy and year dummy variables, while red bars represent the 95% confidence intervals for these estimates, calculated using standard errors robust to municipality-level clustering. Panels (a)–(c) utilized the CSLC, and Panel (d) used the SMCA for the estimations. The models for Panels (a)–(c) and Panel (d) are estimated using the WLS with sampling weights from the CSLC and the number of individuals insured by municipal NIH and aged 40 –59 in 2007 as weight variables, respectively.

Table 1: Summary statistics: individual-level data

	mean	sd
Panel A: Comprehensive Survey of Living Conditions		
LRD diagnoses		
Number of diagnoses	0.16	0.48
Having single diagnosis	0.13	0.33
Having multiple diagnoses	0.03	0.17
Injuries Diagnoses	0.01	0.10
Presence of subjective symptoms		
Injuries	0.02	0.13
Having health checkups	0.45	0.50
Currently stop smoking	0.03	0.17
Demographic variables		
Age	50.62	5.90
Female	0.53	0.50
Marital status		
Having partner	0.67	0.47
Never married	0.20	0.40
Widowed	0.04	0.19
Divorced	0.10	0.29
Number of household members	3.20	1.42
Type of residence		
Owned home	0.71	0.45
Private rental housing	0.17	0.38
Company housing or government employee housing	0.00	0.07
Public rental housing managed by such as Urban Renaissance Agency	0.07	0.25
Others	0.04	0.20
Panel B: National Survey of Health and Nutrition		
Alcohol consumption (gram)	151.51	318.75
Number of footsteps	6718.59	4171.96
$\geq$ 8,000	0.33	0.47

The unit of observation is individual. We used the individuals insured by the municipal national health insurance and aged between 40 and 59.

Table 2: Summary statistics: municipality-level data

	mean	sd
Panel A: Statistics of Medical Care Activities in Public Health Insurance		
Number of outpatient visits		
Lifestyle-related diseases	10.00	11.54
Total expenditure spent for the outpatient visits (JPY)		
Lifestyle-related diseases	121860.79	159915.16
Panel B: Other municipality characteristics		
Municipal population		
Total	712220.58	859149.57
40-44	48586.38	61251.98
45-49	43605.19	53090.00
50-54	47547.12	57428.26
55-59	52559.60	62958.21
60-64	47767.26	57423.63
65-69	41843.80	50697.73
70-74	34546.46	41845.55
Municipal financial index	0.81	0.22
Number of beds	9139.40	10787.94
Number of medical institutions	659.80	853.81
Proportion of hospitals to medical institutions	0.08	0.04
Number of medical institutions per capita	0.00	0.00
Number of beds per capita	0.01	0.01

The unit of observation is the municipality-year. We calculated the statistics using the people joining the NHI and aged between 40 and 59. The survey years in which data are available differ across variables, and the number of observations differs across the variables.

Table 3: Change in Per Capita Expense of Public Health Services Based on The National Health Insurance Act

			Difference	
	Before	After	Δ	$\%\Delta$
	(1)	(2)	(3)	(4)
All municipalities	3259.7	4763.5	1503.7	46.1
By quartiles				
Bottom 25%	2422.1	4488.7	2066.6	85.3
25-50%ile	2939.1	4454.6	1515.5	51.6
50-75%ile	3386.3	4809.1	1422.8	42.0
Top 25%	4291.4	5301.5	1010.1	23.5

Units of values for Columns (1)–(3) are JPY. Columns (1) and (2) show the mean of the per capita expense of public health services based on the NHIA before and after the SHC-SHG was introduced, respectively. We calculated the mean values using the average values of the per capita expense within each municipality in each time period. Before the SHC-SHG was introduced, as not only the department of the NHI but also the health and hygiene department provided the health checkup programs, we estimated the per capita expense of the health checkup programs by the health and hygiene department and added it to the per capita expense of the NHI-based public health services to capture the per capita expense of the health checkup programs (Column (1)). The per capita expense of the health checkup programs by the health and hygiene department is JPY 1,916. Column (3) shows the difference between Columns (1) and (2), and Column (4) lists the percentage difference. The first row is the means among all the municipalities. We divided the 732 municipalities into two categories using the distribution of the per capita expense of public health services based on the NHIA within each municipality in 2007 or earlier: the bottom 25% and the others (the second and third rows).

Table 4: The Differences in Municipal Characteristics Between Treatment and Control Groups in the Pre-SHC-SHG Periods

	Mean		Difference		
	Control (1)	Treated (2)	Raw (3)	Adjusted[1] (4)	(4)/(1)*100 (5)
Demographics (2007)					
Municipal population	127945.2	285351.2	157406.0***	145109.0***	113.4***
			(33526.3)	(36676.1)	(28.7)
Proportion of the people aged 0-39	0.4470	0.4654	0.0184***	-0.0012	-0.3
			(0.0046)	(0.0043)	(1.0)
Proportion of the people aged 40-74	0.4547	0.4504	-0.0043*	0.0044*	1.0*
			(0.0024)	(0.0024)	(0.5)
Proportion of the people aged 75+	0.0984	0.0842	-0.0141***	-0.0032	-3.3
			(0.0028)	(0.0024)	(2.5)
Female ratio	0.5096	0.5069	-0.0028**	0.0015	0.3
			(0.0014)	(0.0010)	(0.2)
Accessibility to healthcare service (2005)					
Number of medical institutions	103.4	255.1	151.7***	2.2	2.1
			(33.4)	(21.3)	(20.6)
Number of beds	1783.2	3634.2	1851.0***	237.8	13.3
			(459.6)	(279.1)	(15.6)
Proportion of hospitals to medical institutions	0.0947	0.0805	-0.0142***	0.0046	4.8
			(0.0052)	(0.0051)	(5.4)
Number of medical institutions per capita	0.0007	0.0009	0.0002**	0.0000	6.2
			(0.0001)	(0.0000)	(6.6)
Number of beds per capita	0.0138	0.0134	-0.0004	0.0008	6.1
			(0.0008)	(0.0008)	(6.1)
Financial condition (2007)					
Municipal financial index	0.7675	0.8608	0.0933***	0.0118	1.5
			(0.0288)	(0.0268)	(3.5)

We used the 316 municipalities in 2007. In Columns (3), (4), and (5), robust standard errors are in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

[1] Column (4) shows the differences between Columns (1) and (2) after we controlled for prefecture fixed effects. We also controlled for the logged municipal population except for the first row (municipal population).

Table 5: Effects on lifestyle-related disease (LRD) diagnoses and medical expenditure due to LRD

	Diagnosed as lifestyle-related diseases (LRD)			Medical expenditure due to LRD
	(1) Number of diagnoses	(2) > 0	(3) ≥ 2	(4) Outpatient visit (JPY)
Treat × After	-0.0260**	-0.0131*	-0.0101**	-15318.360***
	(0.0111)	(0.0074)	(0.0045)	(4667.340)
Number of observations	63098	63098	63098	3015
Pre-SHC-SHG mean among the treated	0.1624	0.1261	0.0282	155082.571
Data	CSLC	CSLC	CSLC	SMCA

The units of observation are individuals for Columns (1)–(3) and municipalities for Column (4). For the estimations, we used individuals insured by the National Health Insurance (NHI) aged 40–59. We estimated Equations (1) (Columns (1)–(3)) and (2) (Column (4)). The models estimated for Columns (1)–(3) include individual- and municipality-level control variables, and the model estimated for Column (4) includes only municipality-level control variables. At the individual level, we used age (quadratic function), the number of household members, house type dummy variables, a female dummy, and marital status dummies as control variables. At the municipality level, we used the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of beds per capita as control variables. The models also include the fixed effects: prefecture-year, municipality, and year. Columns (1)–(3) used the CSLC, and Column (4) used the SMCA for the estimations. The models for Columns (1)–(3) and Column (4) were estimated using the WLS with the sampling weight of the CSLC and the number of individuals insured by municipal NHI and aged 40–59 as weight variables, respectively. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Effects on Health Behaviors

	(1) Having checkups	(2) Smoking cessation	(3) Drinking (gram)(log)	(4) Foot steps ≥ 8000
Treat×After	0.0072	0.0185*	-2.4131*	0.5206**
	(0.0141)	(0.0101)	(1.2864)	(0.2553)
Number of observations	62534	22577	495	876
Pre-SHC-SHG mean among the treated	0.4415	0.0369	175.53	0.3185
Data	CSLC	CSLC	NHNS	NHNS

The units of observation are individuals. For the estimations, we used individuals insured by the National Health Insurance (NHI) aged 40–59. We estimated Equations (1) with individual- and municipality-level control variables. At the individual level, we used age (quadratic function), the number of household members, house type dummy variables, a female dummy, and marital status dummies as control variables. At the municipality level, we used the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), the number of medical institutions per capita, and number of beds per capita as control variables. The models also include the fixed effects for prefecture-year, municipality, and year. We used the CSLC for the estimations. The models are estimated using the WLS with the sampling weight of the CSLC as weight variables. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Heterogeneity of Effects on lifestyle-related diseases diagnoses

	(1) Self -employed	(2) Unemployed	(3) Home -owner	(4) Renter	(5) Male	(6) Female	(7) Age 40-49	(8) Age 50-59
A.Number of diagnoses								
Treat × After	-0.026**	-0.016	-0.034**	0.007	-0.024	-0.025*	-0.013	-0.032*
	(0.013)	(0.042)	(0.015)	(0.029)	(0.017)	(0.014)	(0.014)	(0.019)
Pre-SHC-SHG mean among the treated	0.140	0.207	0.162	0.163	0.167	0.159	0.060	0.226
Magnitude in percentage change (%)	-18.5	-7.8	-21.1	4.4	-14.4	-16.1	-21.4	-14.3
B.Single diagnosis								
Treat × After	-0.014*	-0.004	-0.025**	0.028	-0.014	-0.010	-0.008	-0.015
	(0.008)	(0.034)	(0.011)	(0.026)	(0.011)	(0.009)	(0.009)	(0.011)
Pre-SHC-SHG mean among the treated	0.111	0.144	0.128	0.122	0.129	0.124	0.050	0.174
Magnitude in percentage change (%)	-12.8	-2.6	-19.3	23.2	-10.9	-8.3	-15.4	-8.4
C.Multiple diagnosis								
Treat × After	-0.008*	-0.014	-0.008*	-0.012	-0.011*	-0.009	-0.002	-0.015*
	(0.004)	(0.015)	(0.005)	(0.010)	(0.006)	(0.006)	(0.004)	(0.008)
Pre-SHC-SHG mean among the treated	0.023	0.046	0.027	0.030	0.031	0.026	0.008	0.041
Magnitude in percentage change (%)	-36.6	-29.6	-30.9	-41.8	-35.8	-34.1	-23.2	-36.0
Number of observations	43494	7785	48158	14928	29531	33566	26214	36880

The units of observation are individuals. For the estimations, we used individuals insured by the National Health Insurance (NHI) aged 40–59. We estimated Equations (1) with individual- and municipality-level control variables. At the individual level, we used age (quadratic function), the number of household members, house type dummy variables, a female dummy, and marital status dummies as control variables. At the municipality level, we used the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of beds per capita as control variables. The models also include the fixed effects for prefecture-year, municipality, and year. We used the CSLC for the estimations. The models were estimated using the WLS with the sampling weight of the CSLC as weight variables. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: A Back-of-the-Envelope Calculation of the Cost-Effectiveness of the Expansion of the Per Capita Expense of the Health Checkup Programs

Panel A	
Reduction in medical expenditure for LRD-related outpatient services after expansion	
Annual medical expenditures (billion JPY)	
(1) For entire population[1]	778.40
(2) For treated individuals[2]	96.73
(3) Estimated effects of the expansion[3]	-22.37%
(4) Reduced medical expenditure ((2) × (3)) (billion JPY)	-21.64
Panel B	
Municipal expense of the health checkup program by the expansion	
(5) Increased total expense of the health checkup program for the treated (billion JPY)[4]	2.37
Panel C	
(6) Ratio of reduced medical expenditure to increased expense ((4)/(5))	-9.12

[1] Source: the Estimates of National Medical Care Expenditure.
[2] (1) × the ratio of treated individuals (0.124)
[3] See Section 6.1.
[4] Increased per capita expense (JPY 551.0)* × number of treated individuals(4,303,786). * The increase in the estimated per capita expense of the municipal health checkup programs among the treated municipalities compared to that among the control municipalities.

Appendix

A Municipal Per Capita Expense of Public Health Services

We utilized two sources to measure the per capital expenses for municipal public health services: the *Local Government Finance Survey* ("*Chiho Zaisei Jokyo Chosa*" in Japanese, LGFS) and dada on population, vital events, and households derived from the Basic Resident Registration. The LGFS is conducted by conducted by the Ministry of Internal Affairs and Communications (MIC) and covers public finances across 47 prefectures and 1,718 municipalities. This survey collects detailed information on local government revenues and expenditures by type and purpose. Participation is mandatory for all local governments in Japan with some data accessible through the official Japanese statistics portal, e-Stat.[58]

The data from the LGFS include annual expenditures related to the NHI managed by municipalities, such as expenses for services governed by the NHIA. NHIA-based public health services encompass health checkups, health education, and health consultations for NHI-insured individuals, such as self-employed and unemployed. Following the introduction of the SHC-SHG program in 2008, a significant portion of these NHIA-related expenses has been allocated to the SHC-SHG. For einstance, in the fiscal year 2018, 14 out of 21 municipalities, according to their annual financial reports available online, allocated over 80% of their public health services budget to the SHC-SHG. Moreover, half of these municipalities directed more than 90% of their public health services budget specifically to the SHC-SHG budget (Table A.1).[59,60,61]

In the LGFS, a category of expenses is labeled as *hygiene services* (*eisei hi* in Japanese). Within this category, expenditures for health checkup programs governed by the HMSAA are classified under public health services related to health and hygiene. However, detailed nationwide data on specific expense items within this category are not available.[62] Most municipalities contract medical institutions to conduct the HMSAA-based health checkup programs, with the commissions included in the expenses reported for health and hygiene services. Unfortunately, specific commission fees for public health services are not directly disclosed. To estimate these fees, we relied on two variables: the total annual supply and service expenses for *health and hygiene services*, which include commission fees, and the ratio of commission fees to overall supply and services expenses

[58] The data can be downloaded from the following webpage: https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200251&tstat=000001077755&cycle=7&tclass1=000001077756&tclass2=000001077757&tclass3val=0 (accessed October, 2, 2024).

[59] Table A.1 presents the budget amounts allocated to public health services under the NHIA, budget dedicated to the SHC-SHG, and proportion of SHC-SHG expenses relative to total public health services based on the NHIA. The table also summarizes the key statistics.

[60] The data are accessible at https://www.e-stat.go.jp/api/sample2/tokeidb/getMetaInfo?statsDataId=0003173060 (in Japanse)(accessed May 31, 2022).

[61] Please note that the definition of public health service expenses remains consistent before and after the introduction of the policy.

[62] Note that *health and hygiene services* are a subcategory of *hygiene services*.

within the *hygiene services* category. This approach allowed us to estimate the commission fees for HMSAA-based health checkup programs as follows:

$$\widehat{CF_{HHS}} = SSE_{HHS} \times \frac{CF_{HS}}{SSE_{HS}}, \tag{A.1}$$

where $\widehat{CF_{HHS}}$ represents the estimated commission fee for *health and hygiene services*, SSE_{HS} and SSE_{HHS} are the annual supply and service expenses for the entire *hygiene services* and *health and hygiene services*, respectively, and CF_{HS} represents the commission fee for the *hygiene services*.

To calculate per capita expenses, we used population data from each municipality, derived from the counts of population, vital events, and households in the Basic Resident Registration. This dataset provides the population of five-year age groups for each municipality from 1995 onward.[63] We estimated the population insured by the municipalities' NHI, which is the target population for their health checkup programs. Specifically, we calculated the ratio of the population insured by municipal NHI to the total population by prefecture, year, and five-year age groups using the CSLC. As the CSLC was only available every three years from 1995 to 2016,[64] we linearly interpolated and extrapolated the missing years from 1995 to 2017. Then, we multiplied the municipal population by the prefecture-specific ratio of the NHI-insured individuals to estimate the population insured by the municipalities' NHI, stratified by the five-year age groups.

For public health services based on the NHIA and for estimating commission fees for *health and hygiene services* prior to 2007, we used the population aged 40 and over. For NHIA-based public health services from 2008 onward, we used the population aged 40–74.

Frequent municipal mergers in the 2000s made it challenging to construct consistent municipality-level panel data over the long term.[65] For example, due to these mergers, one dataset may aggregate data by pre-merger municipalities, whereas another may aggregate by post-merger municipalities, even within the same year. In such cases, the two datasets could not be directly merged. To address this issue, we constructed municipality-level panel data on per capita public health service expenses using the procedure developed by Kondo (2019) to handle frequent municipal mergers. We aggregated pre-merger municipalities into their post-merger equivalents throughout the study period, resulting in 1,741 municipalities after applying this procedure.

Table A.2 provides summary statistics for municipal expenses related to public health services. For the analysis, we restricted the sample to 732 municipalities, as described in Section 3.4. The statistics for each variable were estimated using the average values within each municipality over the given period. Public health services under the NHIA were JPY 37.8 million in 2007 or earlier,

[63] Data are available at https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200241&tstat=000001039591&cycle=7&tclass1=000001039601&tclass2val=0 (in Japanse)(accessed May 31, 2022).

[64] We utilized the Stata command "ipolate" for interpolation.

[65] The number of municipalities decreased by approximately 45% between April 2000 and March 2009. Details on the change in the number of municipalities can be found at https://www.soumu.go.jp/main_content/000651406.pdf (in Japanese)(accessed on June 1, 2022).

increasing to JPY 113.3 million after 2008. The commission fees for health and hygiene services were much larger, averaging JPY 392.9 million in 2007 or earlier. This higher figure is due to the broader range of public health services provided by health and hygiene departments, which include not only the HMSAA-based health checkup program but also public health programs for mothers and children, vaccination, food hygiene, and antipollution measures.

A.1 Estimating the Per Capita Expense of Health Checkup Programs under the Health and Medical Service Act for the Aged

Figure A.1 presents the average commission fees for *health and hygiene services* by fiscal year. The data show that, on average, the commission fee remained relatively stable between 2001 and 2007, before declining by approximately 15% following the introduction of the SHC-SHG. As discussed in Section 2, this decline coincided with the transfer of responsibility for municipal health checkup programs from the health and hygiene department to the NHI department. Therefore, the observed reduction in commission fees likely reflects this administrative shift. To estimate the per capita expense of health checkup programs under the HMSAA, we employed the following method: First, we defined the expense for HMSAA-based health checkup programs as the difference between the average commission fee in 2008 and the mean of the average commission fee from 2001 to 2007, across all municipalities. Then, we calculated the per capita expense by dividing the estimated total expense by the average population insured by the municipalities' NHI and aged over 40 during the 2001 and 2007 periods. The resulting estimated per capita expense is approximately JPY 1,916.

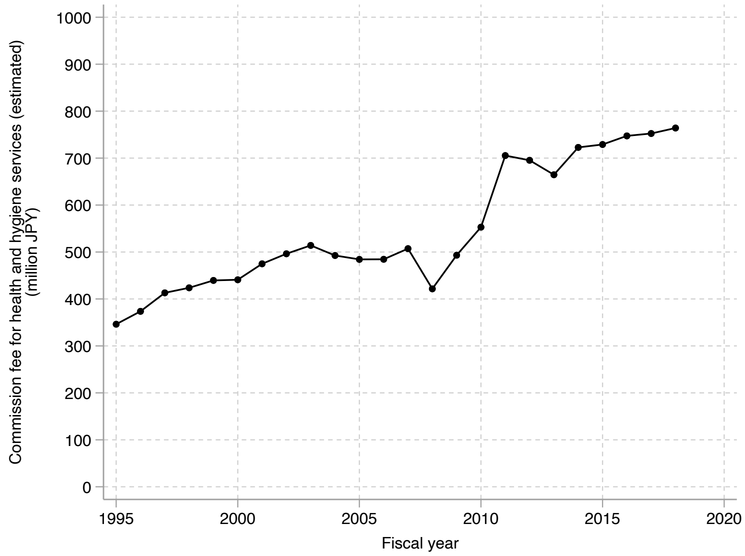


Figure A.1: Changes in Commission Fees for Health and Hygiene Services

Notes: We used data from the 732 municipalities remaining after the sample restriction to calculate the average commission fee for *health and hygiene services* by fiscal year.

Table A.1: The Budget Amounts of Public Health Services Based on the National Health Insurance Act in The Fiscal Year of 2018

	Total	SHC-SHG	% of SHC-SHG
Sapporo	1163.6	795.9	68.4
Sendai	1025.6	946.6	92.3
Saitama	1194.0	1115.0	93.4
Chiba	902.9	822.0	91.0
Setagaya	958.2	948.2	99.0
Suginami	694.5	648.1	93.3
Nerima	744.6	726.6	97.6
Adachi	715.6	712.6	99.6
Katsushika	560.4	560.4	100.0
Edogawa	665.9	494.1	74.2
Hachioji	812.1	775.2	95.5
Tachikawa	179.0	140.1	78.3
Machida	634.9	611.0	96.2
Yokohama	2052.8	1902.7	92.7
Kawasaki	762.2	658.7	86.4
Sagamihara	822.0	544.8	66.3
Nagoya	1427.7	1166.1	81.7
Osaka	1713.3	1145.4	66.9
Sakai	838.2	534.2	63.7
Kobe	1174.4	1094.5	93.2
Fukuoka	889.6	705.0	79.2
Summary statistics			
mean	949.1	811.8	86.1
median	838.2	726.6	92.3
min	179.0	140.1	63.7
max	2052.8	1902.7	100.0

We collected the data on the budget amounts from municipalities' web pages. The unit of the first and second columns is JPY one billion.

Table A.2: Summary Statistics of Municipal Expenses

	mean	sd
Expense of public health services based on the NHIA (million JPY)		
-2007	37.8	52.9
2008-	113.3	145.2
Commission fee for public health services by the HHD (million JPY) (-2007)	392.9	644.1
Population insured by the municipalities' NHI		
aged over 40 (-2007)	35335.6	54917.2
aged between 40 and 74 (2008-)	26212.1	43046.1
Per capita expense of public health services based on the NHIA (JPY)		
-2007	1344.1	744.7
2008-	4763.5	1495.5
Per capita commission fee for public health services by the health and hygiene department (JPY) (-2007)	12334.0	5036.4

We used the 732 municipalities.

B Construction of municipality-level panel data

Due to frequent municipal mergers, some data points were aggregated by pre-merger municipalities, whereas others were aggregated by post-merger municipalities, even within the same year. In such a case, merging the two datasets directly was not feasible. To address this, we constructed municipality-level panel data following the procedure developed by Kondo (2019), which accounts for frequent municipal mergers. This method aggregates pre-merger municipalities into their corresponding post-merger municipalities throughout the study period. For example, if City A (id=001) and City B (id=002) merged into City C (id=003) within a year, Kondo (2019)'s procedure reassigns City C's identifier (id=003) to both City A and City B for the pre-merger periods (Figure B.1). Consequently, City A and City B are treated as City C not only in the post-merger period but also retroactively in the pre-merger period. By applying this procedure, we were able to obtain a panel dataset consisting of 1,741 municipalities.

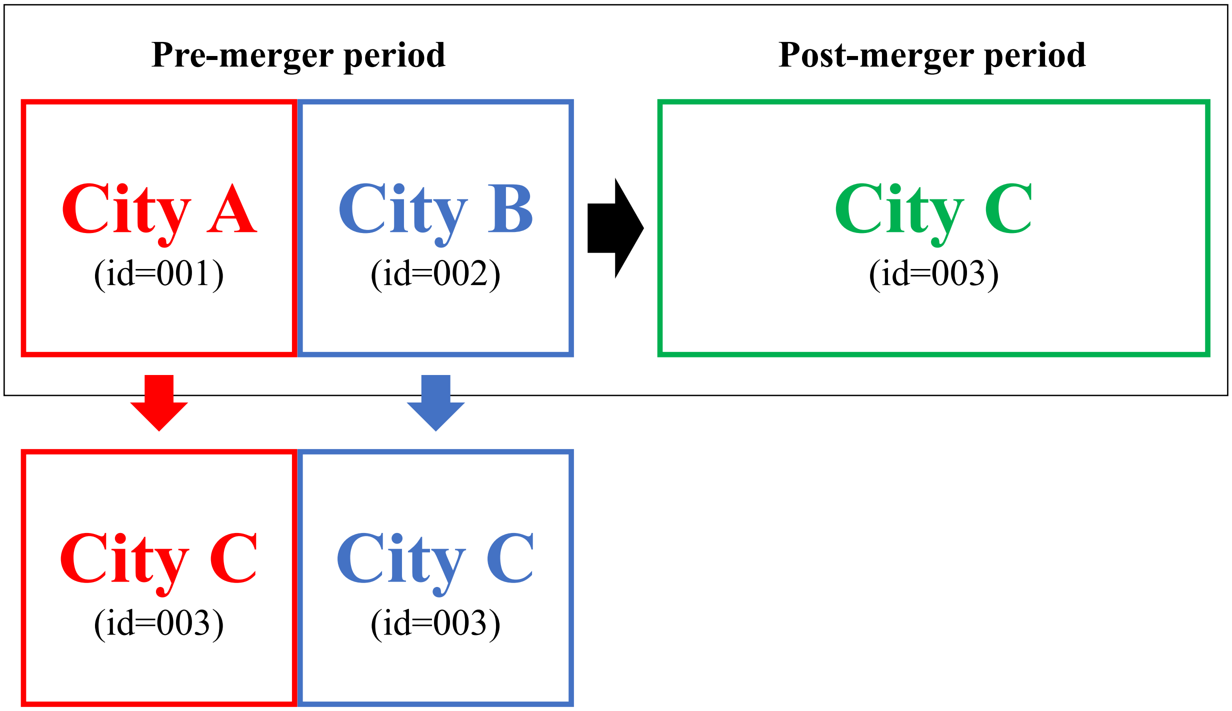


Figure B.1: Image of Kondo (2019)

C CSLC-Census matching

The CSLC does not provide municipality-level residential information for all respondents. To obtain this information, we matched the CSLC with the Population Census, which includes detailed residential addresses, using a probabilistic matching procedure developed by Fu et al. (2023).[66]

As the CSLC survey districts are a subsample of the Census survey districts and include all households within these districts, we matched each CSLC district within a prefecture with the Census district exhibiting the most similar household characteristics. To perform this matching, we utilized the following method: First, we constructed household-level datasets from both the CSLC and the Census. Then, we generated four identifiers (IDs) for each household:

1. Gender and birth cohort (year and month) of the household head,
2. Gender and birth cohort (year and month) of the household head's spouse,
3. Gender and birth cohort (year and month) of the household head's oldest child (if applicable), and
4. Gender and birth cohort of the household head's oldest parent (year and month) (if applicable).[67]

Next, we selected a CSLC survey district from a prefecture and merged the households in the CSLC survey district with those in a Census district within the same prefecture using the four unique IDs. We calculated the "response rate," an evaluation metric for CSLC-Census district matching, as follows:

$$Response\_rate_{ij} = \frac{\text{\# of HHs in Census district } i \text{ that matched to the HHs in CSLC district } j}{\text{\# of HHs in Census district } i}. \tag{C.1}$$

This process was repeated for all Census districts within the prefecture. As the CSLC survey districts are a subset of the Census districts, we identified CSLC-Census district pairs with high response rates. For example, Figure C.1 displays the response rate for the pairs between the 2010 CSLC survey district #6 of Tokyo (Prefecture 13) and the corresponding 2010 Census districts within Tokyo. A CSLC-Census district pair with a significantly high response rate was identified.

To further assess the quality of the matching, we calculated the "match rate," another evaluation

[66] We acknowledge Rong Fu and Yichen Shen for sharing their codes for the probabilistic matching procedures. The details of the procedure are discussed in Appendix B.II in Fu et al. (2023).

[67] We defined the following ID format: $XXXXYYZ$, where $XXXX$ represents the birth year, YY the birth month, and Z the gender code (1 for males, 2 for females).

metric for CSLC-Census-district-matching, defined as follows:

$$Match\_rate_{ij} = \frac{\#\text{ of HHs in CSLC district } j \text{ that matched to the HHs in Census district } i}{\#\text{ of HHs in CSLC district } j}. \quad \text{(C.2)}$$

A high match rate suggests that the CSLC-Census district pairs were accurately matched. Figure C.2 shows the average match rate by prefecture for the 2010-CSLC-2010-Census districts pairs with a response rate of 50% or higher. The average match rate across prefectures is approximately 80%, ranging from 72.07% to 84.30%. To obtain municipality-level residential address data for the analysis, we used district pairs with high response rates.[68]

The years of the Census used for matching with each CSLC are summarized in Table C.1. In each case, we used the Census closest in time to the respective CSLC survey for matching purposes.

[68] We used the CSLC-Census districts pairs with a response rate of 50% or higher, excluding pairs with match rates below 20% and those with fewer than ten households.

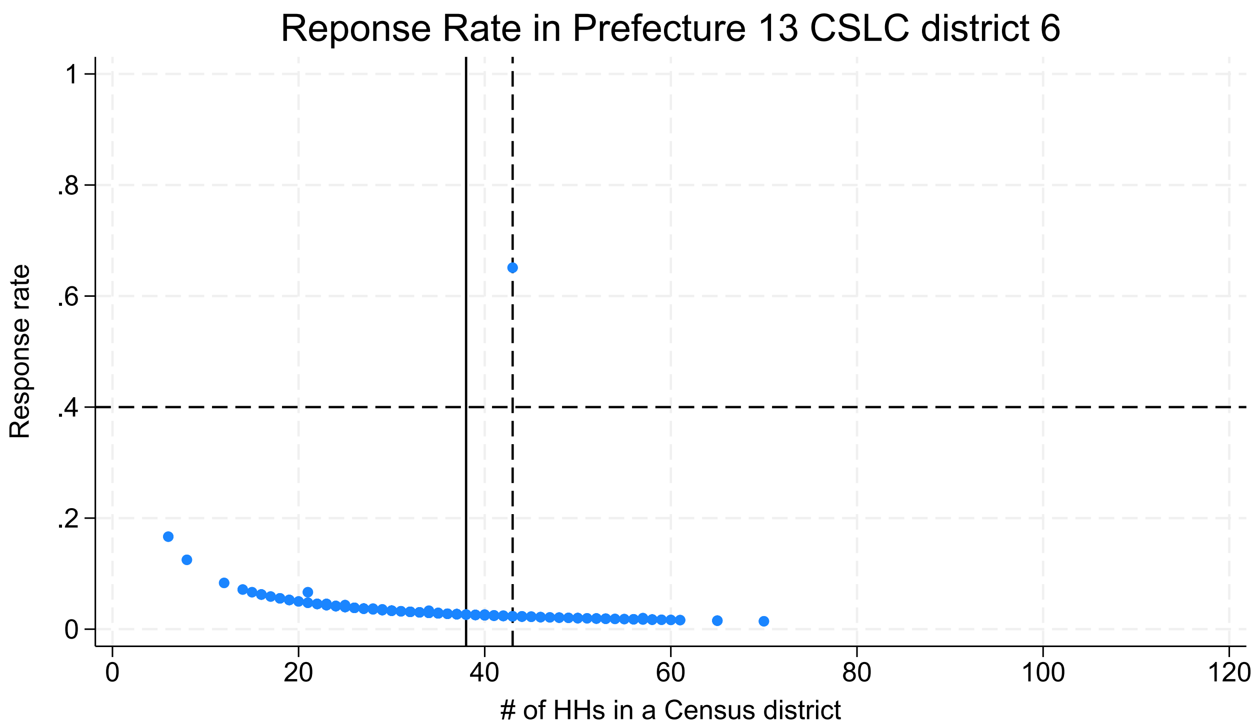


Figure C.1: Response rates of 2010 Census district to the 2010 CSLC district #6 of Prefecture 13 (Tokyo)

Notes: Blue dots represent the response rates of 2010 Census districts to the 2010 CSLC district #6 of Prefecture 13 (Tokyo) for all Census districts in Tokyo. The solid line shows the number of households in CSLC district #6 of Tokyo, while the dashed line indicates the number of households in the Census district with the highest response rate.

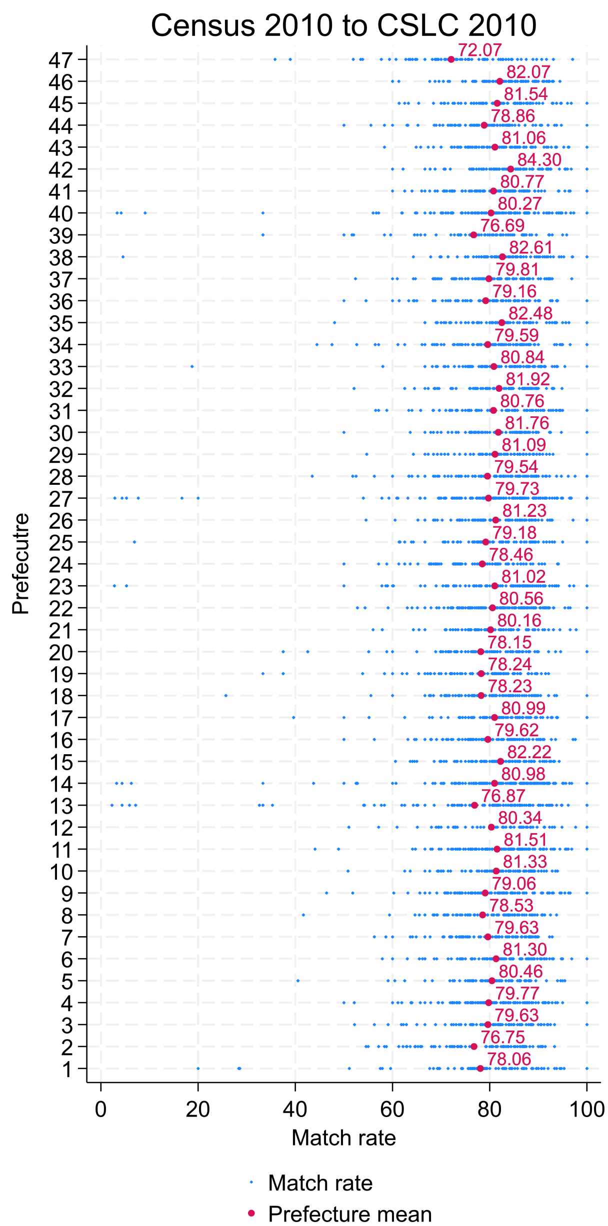


Figure C.2: Matching rates for the 2010 CSLC and the 2010 Census districts pairs

Table C.1: Years of the Census used for matching

CSLC	Census used for the CSLC sampling	Census used for matching
2001	2000	2000
2004	2000	2005
2007	2005	2005
2010	2005	2010
2013	2010	2015
2016	2010	2015

The first and second columns of this table represent the years that the CSLC was conducted and the years of the Census used for the CSLC sampling. This table is adapted from Table B1 in Fu et al. (2023). The third column represents the years of the Census used for the matching.

D Additional descriptive statistics

Figure D.1 represents the change in the health checkup participation rate for the individuals insured by municipal NHI and those insured by EHI using the CSLC.

Figure D.2 presents the relationship between the per capita expense of public health services under the NHIA and the per capita commission fee for public health services provided by municipalities' health and hygiene departments before 2007, adjusted for prefecture fixed effects.

Figure D.3 illustrates the estimation results from regressing observable characteristics on the per capita expense of public health services under the NHIA during the pre-SHC-SHG period. Panel (a) reports the results for municipality-level data, while Panel (b) presents those for individual-level data from the CSLC. All models include prefecture fixed effects and control for the logged total population. The y-axis labels indicate the dependent variables, with both the per capita expense variable and all dependent variables (except for dummy variables) standardized to have a mean of 0 and a variance of 1. The square symbols represent the point estimates of the per capita expense, while the bars indicate 95% confidence intervals. The results indicate no systematic relationships between the proxy of the dose of expansion and observable characteristics.[69]

[69] The estimate for the number of household members is statistically significant at the 5% level, but its magnitude, 0.056, is not economically significant for the following reasons. As both the dependent variable and the per capita expense variable are standardized, a coefficient of 0.056 suggests that a one-unit increase in the per capita expense variable leads to a 0.0003-unit increase in the number of household members ($= \frac{\beta \sigma_{N\_HH\_members}}{\sigma_{pc\_expense}}$, where $\sigma_{N\_HH\_members}$ and $\sigma_{pc\_expense}$ are 1.42 and 311.0, respectively). For instance, if the per capita variable increases by its interquartile range (509.1), the coefficient implies an increase in the number of household members by only 0.131 units, representing just 4% of the total change (3.20).

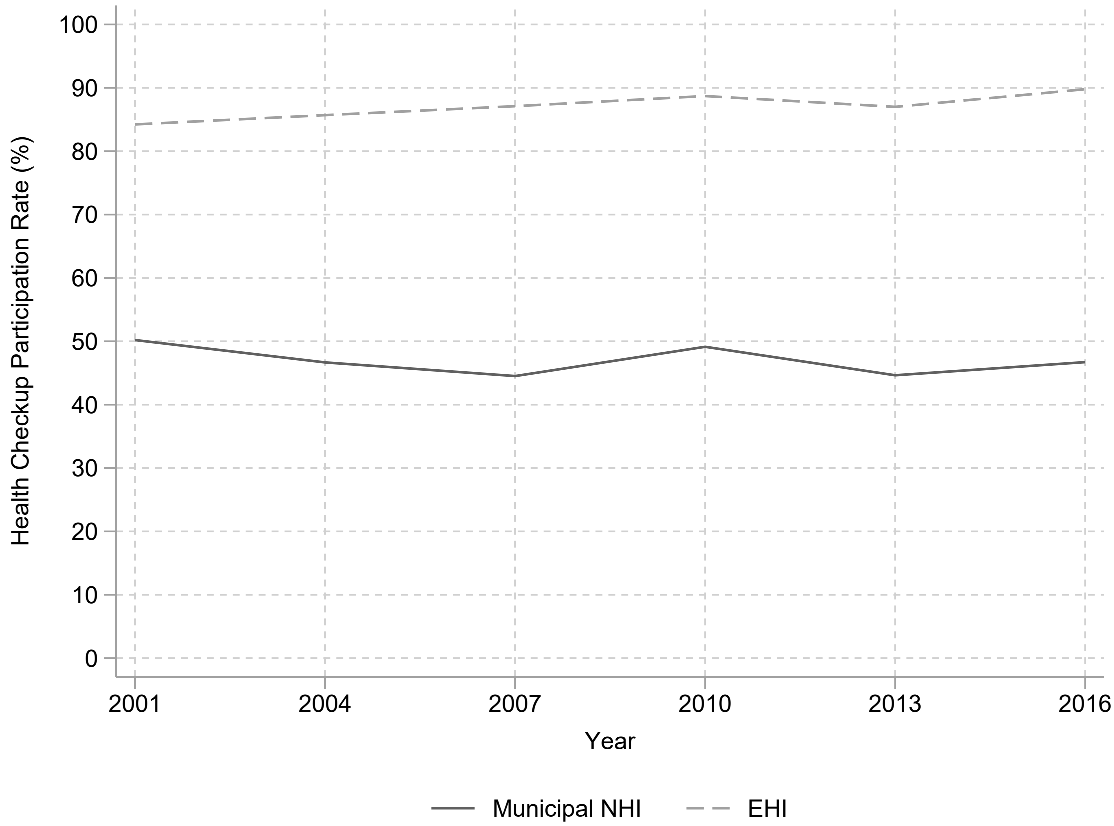


Figure D.1: Health Checkups Participation Rate by Health Insurance Type (Municipal NHI versus EHI)

Notes: The figure is drawn using the individuals aged 40–59 from the CSLC.

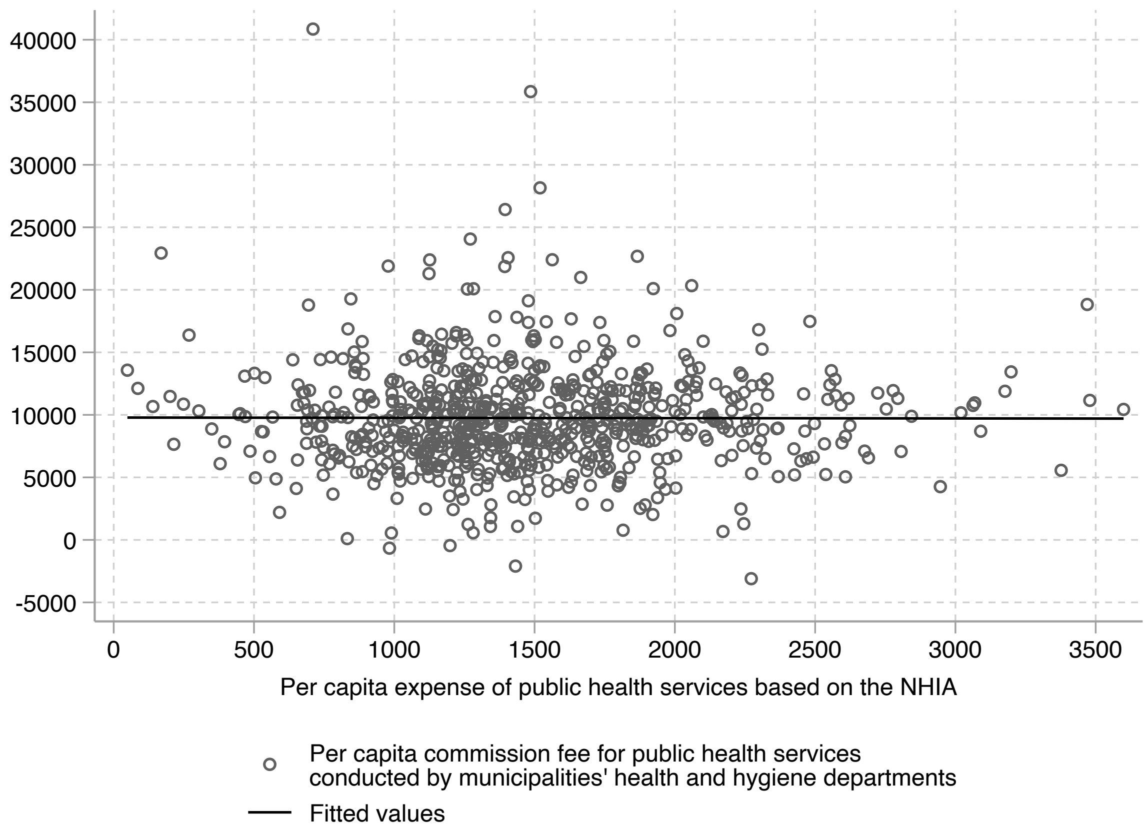
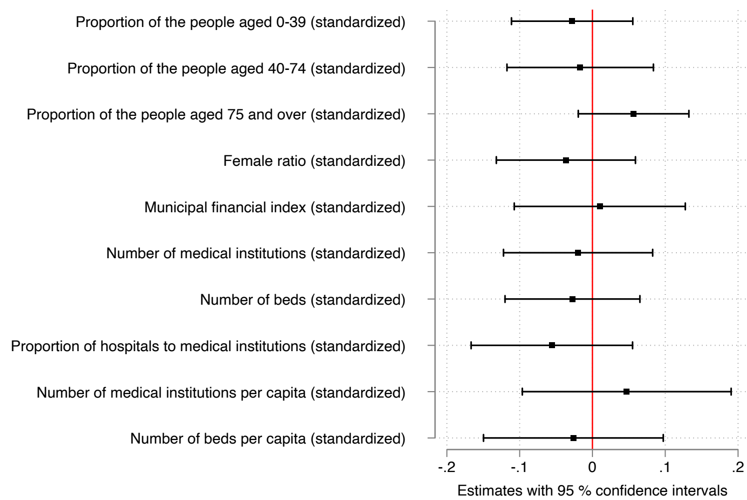


Figure D.2: Relationship between the Per Capita Expense of Public Health Services under the NHIA and the Per Capita Commission Fee for Public Health Services Provided by Municipalities' Health and Hygiene Departments before 2007, Adjusted by Prefecture Fixed Effects

Notes: The figure is based on 732 municipalities that remain after applying sample restrictions. We calculated the average values within each municipality between 1995 and 2007 for both the per capita expense of public health services based under the NHIA and the per capita commission fee for public health services provided by municipalities' health and hygiene departments. The data points are adjusted for prefecture fixed effects by regressing each variable on prefecture fixed effects and using the residuals (with the constant term added) to create scatter plots. The estimated slope coefficient is -0.023 with a p-value of 0.953.



(a) Municipality characteristics

(b) Individual characteristics

Figure D.3: Relationship between pre-SHC-SHG per capita expense of public health services under the NHIA and observable characteristics

Notes: The figure presents the results of regressing each observable characteristic on the per capita expense of public health services under the NHIA during the pre-SHC-SHG periods. Panel (a) reports the results for the municipality-level data, and Panel (b) shows the results for individual-level data from the CSLC. All models include prefecture fixed effects and control for the logged total population. The y-axis labels represent the dependent variables. The per capita expense variable is standardized with a mean of 0 and a variance of 1. All dependent variables, except for dummy variables, are also standardized. The square symbols represent the point estimates for the per capita expense, and the bars show the corresponding 95% confidence intervals.

E Additional estimation results

E.1 Robustness Checks

Figure E.1 depicts the estimation results with and without controlling for heterogeneous trends on the pre-SHC-SHG population levels. The red diamond symbols represent the estimated impact on LRD diagnoses without controlling for these heterogeneous trends (corresponding to Columns (1)–(3) in Table 5). The red bars, along with the white bars within them, denote the 95% and 90% confidence intervals, respectively. By contrast, the blue square symbols show the results after controlling for heterogeneous trends, with the blue and white bars indicating their 95% and 90% confidence intervals. [70] The figure demonstrates that the results remain robust, whether or not the heterogeneous trends based on the pre-SHC-SHG population level are controlled for.

Table E.1 provides a summary of the estimation results for multiple diagnosis dummy variables, examining different definitions of treatment status and control groups. Column (1) displays the main results (corresponding to Column (3) of Table 5), where the treatment status cutoff is set at the 25th percentile ("Cutoff=25") and the control group consists of individuals residing in municipalities where the per capita expense falls between the 25th and 50th percentiles ("CG:25-50"). In Column (2), the control group is expanded to include individuals in municipalities where the per capita expense variable is above the 25th percentile ("CG:25-100"). Column (3) modified the treatment status cutoff to the 20th percentile ("Cutoff=20") while retaining the original control group ("CG:25-50"). Finally, in Column (4), the treatment status cutoff is set at the 50th percentile ("Cutoff=50"), with a control group comprising individuals in municipalities where the per capita expense exceeds the 25th percentile ("CG:25-100"). The results in Table E.1 indicate the findings are robust across variations in the definitions of treatment status and control groups.

E.2 Results of Placebo Regressions

We conducted two types of placebo regressions using variables less related to the SHC-SHG program. First, we re-estimated the event study model for individuals insured by occupation-based health insurance, who are not eligible for municipal health checkup programs. Unlike the results observed in the main analysis, we found no systematic reduction in health outcomes among individuals residing in the treated municipalities following the introduction of the SHC-SHG (Figure E.2)). Second, we estimated the event study model using the diagnosis and subjective symptoms related to injuries. Since the SHC-SHG targets LRD, diagnosis and symptoms related to injuries are expected to show different trends compared to those related to LRDs. The results of this estimation align with this expectation (Figure E.3)).

[70] We incorporated interaction terms between four categorical dummy variables, representing the quartile of the population level during the pre-SHC-SHG period, and year dummy variables, in addition to the control variables used in the baseline models.

E.3 Impacts on LRD diagnoses by checkup participation status

Table E.2 presents the dosing-DID estimations, categorized by individuals' health checkup participation status. Column (1) replicates the results from Columns (1)–(3) of Table 5. Columns (2) and (3) show the dosing-DID estimation results for individuals who do not participate in health checkups, respectively. Panels A, B, and C provide the results based on the number of LRD diagnoses, the presence of a single LRD diagnosis, and multiple LRD diagnoses, respectively.

The subsample analysis based on health checkup participation status indicates that (Table E.2), the dosing-DID estimates for individuals who participated in health checkups are negative and statistically significant, mirroring the results for the entire sample, but with larger magnitudes. Conversely, no significant impacts are observed for individuals who did not participate in health checkups. These findings suggest that the dosing-DID estimates reflect the impact of the SHC-SHG introduction and may represent a lower bound of the true effects.

E.4 Analysis of Systematic Migrations

Table E.3 summarizes using municipality-level panel data on migration patterns and the target population of the SHC-SHG. Note that due to data limitations, the number of migrants from other municipalities represents the overall number rather than just the SHC-SHG target population.[71] In the estimation using the logged number of migrations as the dependent variable, we controlled for the logged municipal population (total and aged 40-74), the logged financial index, municipality fixed effects, year fixed effects, and prefecture-year fixed effects. For the target population analysis, the control variables were the same as those used for migration cases, with the exception of the municipal population aged 40-74. The estimation results reveal no economically significant effects on the number of migrants from other municipalities or the SHC-SHG target population, suggesting that systematic migration is unlikely to be a factor.[72]

[71] The data on the number of migrations from other municipalities is available on e-Stat at: https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200523&tstat=000000070001&cycle=7&tclass1=000001011680&tclass2val=0.

[72] The magnitude of the dosing-DID estimates can be interpreted as follows: in Column (1), there is a 2.4% increase in LRD diagnoses among the treated municipalities after the policy introduction, whereas in Column (2), there is a 0.3% decrease. The dosing-DID estimate in Column (1) is statistically significant at the 10% level.

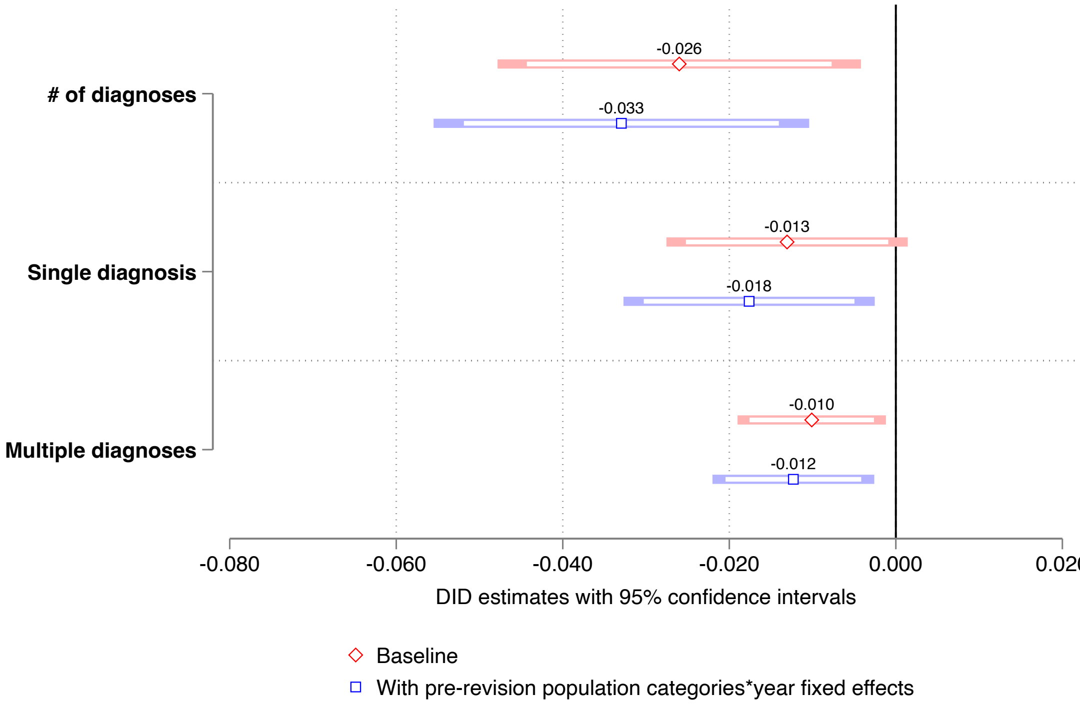
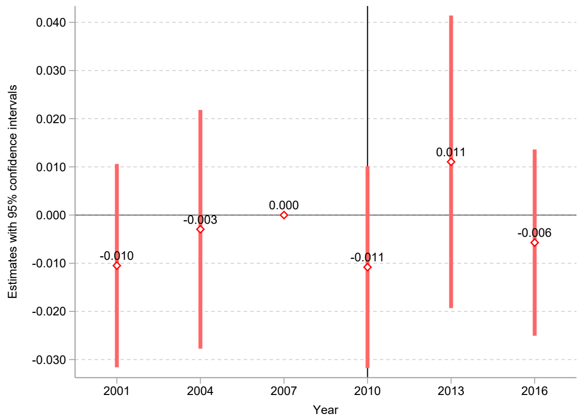
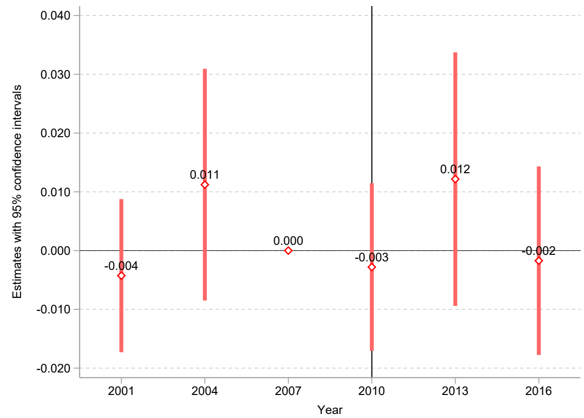


Figure E.1: Robustness check for controlling heterogeneous trends on the pre-SHC-SHG population levels

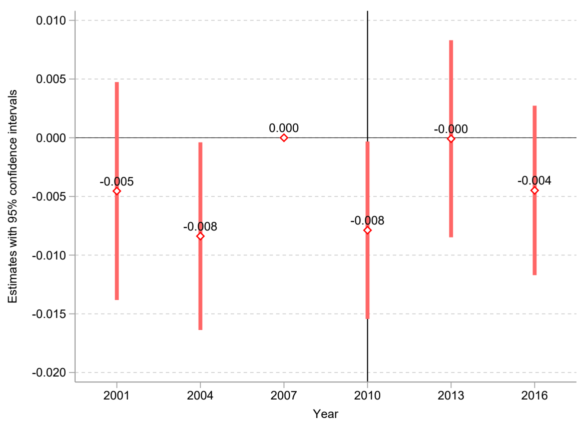
Notes: The units of observation are individuals. For the estimations, we used self-employed and unemployed individuals aged 40–59 insured under the NHI. We estimated Equations (1) using both individual- and municipality-level control variables. At the individual level, control variables included age (modeled as a quadratic function), number of household members, house type dummies, a female dummy, and marital status dummies. At the municipality level, control variables included the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals and clinics combined), number of medical institutions per capita, and number of beds per capita. The models also incorporate the fixed effects for prefecture-year, municipality, and year. The red diamond symbols represent the estimation results of the impact on LRD diagnoses without controlling for heterogeneous trends based on pre-SHC-SHG population levels (Columns (1)–(3) in Table 5). The red and white bars within them indicate the 95% and 90% confidence intervals, respectively. Similarly, the blue square symbols represent the results after controlling for heterogeneous trends based on pre-SHC-SHG population levels, with the blue and white bars indicating the 95% and 90% confidence intervals. Standard errors, clustered at the municipality-level, are used to compute the confidence intervals. The models are estimated using the WLS with CSLC sampling weight.



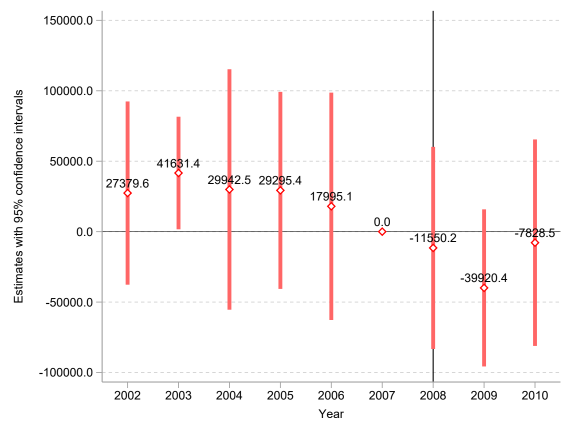
(a) Number of LRD diagnoses



(b) Having at least one LRD diagnosis



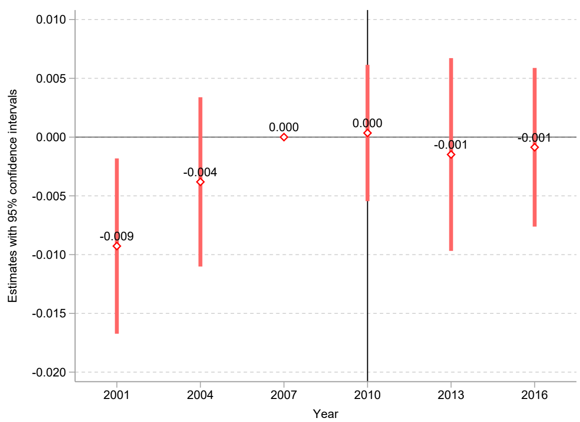
(c) Havint two or more LRD diagnoses



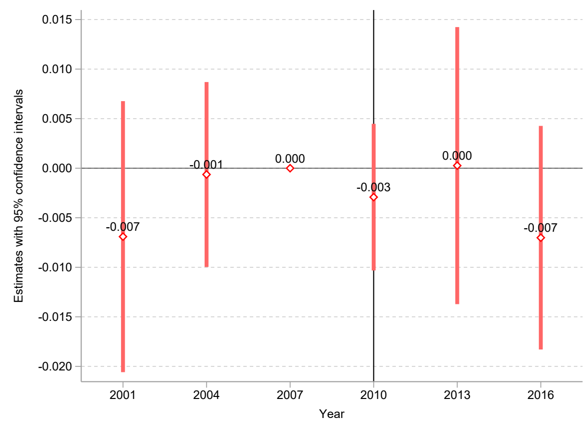
(d) Medical expenditure: outpatient visits due to LRD

Figure E.2: Using the Sample Insured by Occupation-base' Health Insurance

Notes: The units of observation are individuals for Panels (a)—(c) and municipalities for Panel (d). For the estimations, we used individuals aged 40 to 59 insured by occupation-based health insurance. Equations (1) (Panels (a)–(c)) and (2) (Panel (d)) were estimated using interaction terms between the treatment dummy and year dummy variables, rather than the dosing-DID term. The models for Panels (a)–(c) include both individual- and municipality-level control variables, while the model for Panel (d) includes municipality-level control variables only. At the individual level, control variables include age (modeled as a quadratic function), number of household members, house type dummies, a female dummy, and marital status dummies. At the municipality level, control variables encompass the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals and clinics combined), number of medical institutions per capita, and number of beds per capita. The models also include fixed effects for prefecture-year, municipality, and year with 2007 set as the reference period. The diamond symbols represent the estimates of the interaction terms of between the treatment dummy and the year dummy variables. The red bars denote the 95% confidence intervals for these estimates, calculated using standard errors robust to clustering at the municipality level. Panels (a)–(c) use data from the CSLC, whereas Panel (d) uses data from the SMCA. The models in Panels (a)–(c) and Panel (d) are estimated using WLS with CSLC sampling weights and the number of individuals aged 40 to 59 in 2007 as weight variables, respectively.



(a) Diagnosed with injuries



(b) Having a subjective symptom of injuries

Figure E.3: Placebo Regressions 2: Impact on Injuries

Notes: The units of observation are individuals. For these estimations, we analyzed self-employed and unemployed individuals aged 40 to 59 who are insured by the NHI. We estimated Equations (1) using interaction terms between the treatment dummy and year dummy variables, rather than employing the dosing-DID term. The models include both individual- and municipality-level control variables. At the individual level, control variables consist of age (modeled quadratically), number of household members, house type dummy variables, a female dummy, and marital status dummies. At the municipality level, control variables include the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals plus clinics), number of medical institutions per capita, and number of beds per capita. The models also incorporate fixed effects for prefecture-year, municipality, and year, with 2007 as the reference period. The diamond symbols represent the estimates for the interaction terms between the treatment dummy and the year dummy variables. The red bars indicate the 95% confidence intervals for these estimates, with standard errors robust to clustering at the municipality level. The estimation utilized the CSLC dataset, and the models were estimated using WLS with sampling weights from the CSLC.

Table E.1: Robustness Check (Having Two or More LRD Diagnoses)

	(1) Cutoff=25 CG:25-50	(2) Cutoff=25 CG:25-100	(3) Cutoff=20 CG:25-50	(4) Cutoff=50 CG:25-100
Treat × After	-0.010**	-0.009***	-0.009**	-0.006*
	(0.005)	(0.003)	(0.004)	(0.003)
Number of observations	63098	123604	63098	123604
Pre-SHC-SHG mean among the treated	0.028	0.028	0.028	0.028
Magnitude in percentage change (%)	-35.8	-31.7	-30.9	-21.8

The units of observation are individuals. For the estimations, we used individuals insured by the National Health Insurance (NHI) aged 40–59. We estimated Equations (1) with individual- and municipality-level control variables. At the individual level, we used age (quadratic function), the number of household members, house type dummy variables, a female dummy, and marital status dummies as control variables. At the municipality level, we used the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of beds per capita as control variables. The models also include the fixed effects for prefecture-year, municipality, and year. We used the CSLC for the estimations. The models are estimated using the WLS with the sampling weight of the CSLC. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table E.2: Impacts on LRD diagnosis by checkup participation status

		Having health checkups	
	(1)	(2)	(3)
	Whole	Yes	No
A. Number of diagnoses			
Treat × After	-0.026**	-0.044**	-0.015
	(0.011)	(0.020)	(0.015)
Pre-SHC-SHG mean among the treated	0.162	0.216	0.118
Magnitude in percentage change (%)	-16.0	-20.2	-12.8
B. At least one diagnosis			
Treat × After	-0.013*	-0.024*	-0.003
	(0.007)	(0.014)	(0.011)
Pre-SHC-SHG mean among the treated	0.126	0.166	0.093
Magnitude in percentage change (%)	-10.4	-14.7	-3.2
C. Two or more diagnoses			
Treat × After	-0.010**	-0.018**	-0.007
	(0.005)	(0.009)	(0.005)
Pre-SHC-SHG mean among the treated	0.028	0.039	0.019
Magnitude in percentage change (%)	-35.8	-45.0	-35.5
Number of observations	63098	28145	33451

The units of observation are individuals. For the estimations, we used individuals insured by the National Health Insurance (NHI) aged between 40 and 59. Column (1) again shows the estimation results of Columns (1)–(3) of Table 5. Columns (2) and (3) show the results of the DID estimation among individuals having and not having health checkups, respectively. Panels A, B, and C report the results using the number of lifestyle-related diseases (LRD) diagnoses, single LRD diagnosis dummy, and multiple LRD diagnoses dummy, respectively. We estimated Equations (1) with individual- and municipality-level control variables. At the individual level, we used age (quadratic function), the number of household members, house type dummy variables, a female dummy, and marital status dummies as control variables. At the municipality level, we used the logged total population, logged population aged 40–74, logged financial index, ratio of hospitals to total medical institutions (hospitals + clinics), number of medical institutions per capita, and number of beds per capita as control variables. The models also include fixed effects for prefecture-year, municipality, and year. We used the CSLC for the estimations. The models are estimated using the WLS with the sampling weight of the CSLC. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Table E.3: The Effects on the Migration from the Other Municipalities and the Target Population of the SHC-SHG.

	(1) Migration (log)	(2) Target population (log)
Treat × After	0.024*	-0.003
	(0.012)	(0.005)
midrule Number of observations	6137	6137
Pre-SHC-SHG mean among the treated	55264.3	161668.1

The unit of observations is municipality-year. In the estimation using the logged number of migrations as a dependent variable, we controlled for the logged municipal population (total and 40-74), logged financial index, municipality fixed effects, year fixed effects, and prefecture-year fixed effects. In the estimation for the target population, we used the same control variables as those for the number of migrations case, except for the municipal population aged 40–74. The models are estimated using the WLS with the number of individuals aged 40–59 as a weight variable. Standard errors robust against municipality-level clustering are shown in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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