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Medical care cost dynamics during COVID-19 pandemic: financial implications for Japanese health insurance system

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Abstract

Background While the COVID-19 pandemic globally affected healthcare utilization, economic impacts on medical care costs and insurance finances remain underexamined. In Japan, where aging-related medical care cost increases are becoming serious concerns, quantitative evaluation is crucial for sustainable health insurance system design. This study analyzed the economic impact of COVID-19 on medical care expenditure and utilization rates for non–COVID-19 diseases among the working-age population in Japan.

Methods We analyzed continuously enrolled workers aged 20–74 using medical claims data from the Japan Health Insurance Association (May 2015-December 2021). For calculating monthly medical care expenditure, we employed a two-part model of utilization rate and incurred medical care expenditure. Disease-specific allocation for incurred medical care expenditure used Bayesian-based decomposition methods. Using interrupted time series analysis with March 2020 as intervention point, we estimated pandemic impacts on medical care expenditure and utilization rates, stratified by sex, disease group, and type of care.

Results Analysis included 5,826,233 men and 2,971,364 women. During the first state of emergency (April-May 2020), significant decreases in monthly medical care expenditure and utilization rates occurred across most disease groups. For neoplasms, from the second state of emergency (January-March 2021) onward, medical care expenditure increased persistently in outpatient care in both sexes and in inpatient care in men, exceeding utilization rate increases. For diseases of the circulatory system, notable medical care expenditure increases (up to ~40%) occurred in men's inpatient care from the second state of emergency onward, while utilization rate increases remained below 25%, showing differences between the two outcomes. For diseases of the respiratory system, decreases in medical care expenditure persisted throughout the entire period in outpatient care, averaging ~18% (men) and ~27% (women) monthly. For endocrine, nutritional and metabolic diseases, pandemic impacts were minimal compared to other groups.

Conclusions The impact of the pandemic on medical care expenditure and utilization rates varied substantially by sex, disease group, and type of care. These findings provide important policy implications for ensuring the sustainability of health insurance finances during future infectious disease crises and for establishing healthcare delivery systems that consider economic efficiency.

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Introduction

The COVID-19 pandemic that emerged in March 2020 brought about global socioeconomic impacts and imposed severe economic burdens on healthcare systems [1]. Policy responses by various countries aimed at controlling the spread of infection transformed healthcare service delivery systems, and are considered to have brought about substantial changes in medical care expenditure structures. In Japan, multiple states of emergency (SOE) have been declared since April 2020, with reported impacts on healthcare service utilization [2–9]. These impacts are also reflected in national medical expenditure trends, with Japan's national medical expenditure in 2020 reaching 43 trillion yen, a decrease of 1.4 trillion yen (3.2%) from the previous year [10]. Behind this overall reduction in medical care expenditure, while new medical spending related to COVID-19 increased, it is presumed that medical spending for non–COVID-19 diseases decreased substantially due to avoidance of medical visits and treatment delays. Such changes in medical care expenditure structure represent important issues requiring detailed analysis and examination from the perspectives of allocation of medical resources and sustainability of insurance systems.

Japan has entered a super-aged society ahead of the world, and the sustained increase in medical care expenditure has become a serious socioeconomic problem. Japan's total health expenditure accounted for 11.4% of GDP in fiscal 2020, continuing an upward trend with population aging [11]. The COVID-19 pandemic that occurred under these circumstances added new sources of variation to existing medical care expenditure structures and potentially affected the medical care expenditure burden among the working-age population. Analysis of medical care expenditure fluctuations during the pandemic provides important insights for understanding the vulnerability and resilience of healthcare economic systems during emergencies.

However, most existing studies on the impact of the pandemic on healthcare have focused on the number of medical visits and utilization rates, with few analyses from the economic perspective of medical care expenditure [2–9, 12–16]. Changes in the number of medical visits and changes in medical care expenditure do not necessarily occur in the same direction or to the same degree. For example, while avoidance of consultations for mild cases may reduce the number of medical visits, treatment of cases that have become severe may increase medical care expenditure per patient. Such phenomena suggest the risk of "false economy," where short-term medical care expenditure reductions lead to higher treatment costs in the long term, representing an important policy issue from the perspective of health insurance finances. To appropriately evaluate impacts on medical care expenditure, an economic approach that analyzes both utilization rate and incurred medical care expenditure when patients receive medical care is essential [17, 18]. Medical care expenditure is expressed as the product of these two factors, each determined by different economic mechanisms. During the pandemic, these factors are expected to interact in complex ways, showing different impact patterns by disease and patient characteristics.

This study aimed to comprehensively analyze the impact of the COVID-19 pandemic on medical care expenditure and utilization rates for non–COVID-19 diseases among the working-age population in Japan using large-scale health insurance claims data. By employing interrupted time series analysis, we estimated the causal effects of the pandemic and clarified variation patterns in medical care expenditure and utilization rates stratified by sex, disease group, and type of care (outpatient and inpatient care). This study provides important insights in the field of health economics, presents policy implications regarding the economic sustainability of healthcare systems during emergencies, and contributes to healthcare policy formulation for future crisis response.

Methods

Study design and data source

We conducted a quasi-experimental longitudinal observational study using medical claims data managed by the Japan Health Insurance Association (JHIA). JHIA is the largest insurer in Japan's employee health insurance system, providing public health insurance primarily for employees of small and medium-sized enterprises and their dependents. JHIA enrollees account for approximately 40% of Japan's total working population, providing substantial sample size for analyzing medical care utilization trends among the working-age population [19].

The observation period was from May 2015 to December 2021, and the study participants were workers aged 20 to 74 years. To avoid bias in estimating the pandemic's impact on medical care utilization, we excluded participants who discontinued or newly enrolled in JHIA during the observation period, limiting our analysis to those who were continuously enrolled throughout the entire observation period. The JHIA dataset includes comprehensive enrollment records with insurance enrollment and withdrawal dates for all covered individuals. We identified continuously enrolled participants based on these administrative records: individuals whose enrollment date was

on or before May 1, 2015, and whose withdrawal date was on or after December 31, 2021, or who had no withdrawal record. The observation period included the implementation periods of Japan's first SOE (April to May 2020), second (January to March 2021), third (April to June 2021), and fourth (July to September 2021), during which five waves of COVID-19 infections occurred [2]. The data managed by JHIA includes enrollee information such as sex, age, and insurance enrollment/withdrawal dates, as well as monthly medical claim information including International Classification of Diseases, Tenth Revision (ICD-10) codes and outpatient/inpatient classifications.

Outcome measures

The first outcome was medical care expenditure, defined as the medical costs (1,000 JPY) spent on medical services per 1,000 study participants (including both those who received medical care and those who did not) in each month during the observation period. The second outcome was utilization rate, defined as the monthly number of users per 1,000 individuals who utilized medical services at least once per month during the observation period. These outcomes were stratified by sex, major disease groups based on ICD-10 codes (infectious and parasitic diseases (A00-B99), neoplasms (C00-D48), endocrine, nutritional and metabolic diseases (E00-E90), diseases of the nervous system (G00-G99), diseases of the circulatory system (I00-I99), diseases of the respiratory system (J00-J99)), and by outpatient and inpatient care. These six major disease groups were selected based on three criteria: (1) ensuring sufficient sample sizes for stable statistical estimation in each stratum, (2) representing major disease burdens with public health importance in Japan, and (3) capturing diseases with strong associations with lifestyle factors that may have been affected by pandemic-related behavioral changes.

Statistical analysis

Estimation of medical care expenditure using the two-part model

Medical care expenditure data exhibit characteristics of zero-inflated distribution arising from the fact that many individuals do not use any medical care services during the corresponding period, resulting in zero medical care expenditure [18]. To appropriately analyze medical care expenditure data with such zero-inflated distribution, we adopted a two-part model widely used in health economics and actuarial science. This model decomposes medical care expenditure into the following two components:

$$Medical\ care\ expenditure = Utilization\ rate \times Average\ Incurred\ medical\ care\ expenditure$$

Average incurred medical care expenditure was defined as the medical care expenditure per patient when patients receive medical care. Based on this decomposition, we estimated the utilization rate and average incurred medical care expenditure, and then calculated medical care expenditure by multiplying these two estimated values. In Japanese claims data, a single monthly claim typically contains multiple ICD-10 codes. For the allocation of incurred medical care expenditure among patients with comorbidities, we applied a Bayesian decomposition method that we developed [17]. This method appropriately distributes incurred medical care expenditure among diseases through probabilistic inference, overcoming the limitations of conventional simple allocation based on primary diagnosis (which assigns all expenditure to the disease that consumed the most medical resources) [17].

Our model enables identification of whether changes in medical care expenditure are due to healthcare-seeking behavior (how many people utilize medical services) or due to the level of medical care expenditure when receiving care (how much those who utilize medical services spend on average). For example, when medical care expenditure increases while utilization rate decreases during a pandemic, this suggests an increase in treatment intensity due to the rebound effect of disease progression or treatment delays caused by avoidance of medical visits. Conversely, when both change in the same direction, this suggests changes in overall medical demand. By adopting the two-part model, it becomes possible to simultaneously evaluate quantitative changes in medical service utilization and qualitative changes (changes in treatment intensity).

Interrupted time series analysis

For estimating the impact of the pandemic on outcomes, we employed interrupted time series analysis (ITSA) with the WHO COVID-19 pandemic declaration in March 2020 as the intervention point [1]. ITSA is a quasi-experimental method that estimates counterfactual post-intervention predicted values by extending pre-intervention time series patterns into the post-intervention period and calculates the intervention effect as the difference between actual observed values and these predicted values at each time point [20]. This approach allows us to capture dynamic patterns of intervention impacts that evolve over time, which is particularly important for understanding the complex and time-varying effects of the pandemic on medical care expenditure and utilization

rates. We applied Seasonal Autoregressive Integrated Moving Average (SARIMA) models to monthly time series for each stratified group of medical care expenditure and utilization rate. To eliminate arbitrariness in selecting SARIMA model parameters (p: autoregressive, d: differencing, q: moving average), we adopted a two-stage automatic selection process [21]. First, we determined the order of differencing (d) using the Kwiatkowski-Phillips-Schmidt-Shin test, then selected other parameters (p and q) through stepwise search that minimized the corrected Akaike Information Criterion. The pandemic impact was estimated as the difference between observed outcome values and model-predicted values with 95% confidence intervals, and we calculated the percentage impact relative to predicted values. We conducted this estimation separately for both outcomes: medical care expenditure and utilization rates. Statistical significance was defined as cases where the 95% confidence interval of predicted values did not include the observed values ($p < 0.05$). The effects estimated by this method correspond to the Average Treatment Effect on the Treated in the context of causal inference.

All data processing and statistical analyses were conducted using R version 4.3.1 software (R Foundation for Statistical Computing, Vienna, Austria).

Results

Study population and baseline characteristics

The study participants included 5,826,233 men and 2,971,364 women. At the time of pandemic onset (March 2020), the mean age (SD) was 48.3 (10.7) years for men and 48.4 (11.1) years for women. The study participants covered 16.7% of men and 10.3% of women among the total working population aged 20 to 74 years in Japan, providing substantial sample size for analyzing medical care expenditure in Japan's working-age population. Compared to the overall Japanese working population aged 20–74 years based on the national census [22], our study sample had a higher proportion of men (66.2% vs. 54.6% in the census) and a slightly higher mean age (48.3 years for men and 48.4 years for women vs. 47.1 years and 46.3 years in the census, respectively).

Impact of COVID-19 pandemic on medical care expenditure and utilization rates

Figures 1, 2, 3, 4, 5 and 6 show the monthly pandemic impacts by sex for outpatient and inpatient care across each disease group. The estimated values of medical care expenditure in 1,000 JPY (calculated as utilization rate × average incurred medical care expenditure) and utilization rates per 1,000 study participants

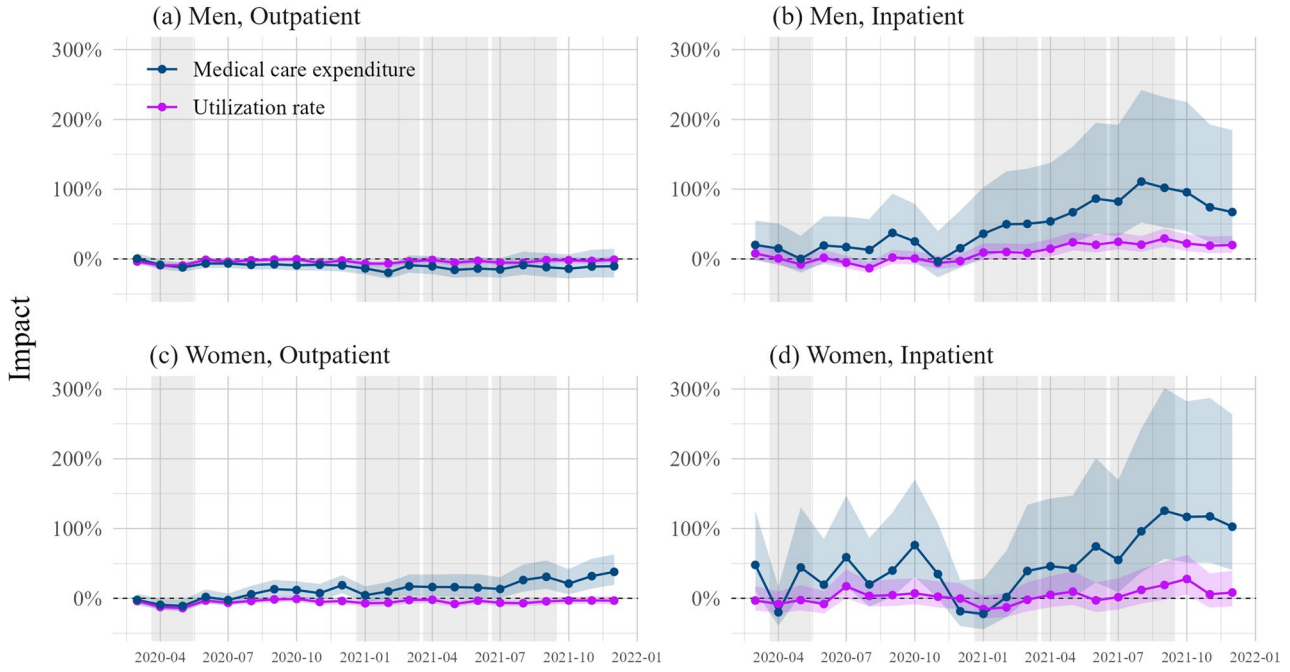

Fig. 1 COVID-19 impact on infectious and parasitic diseases: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

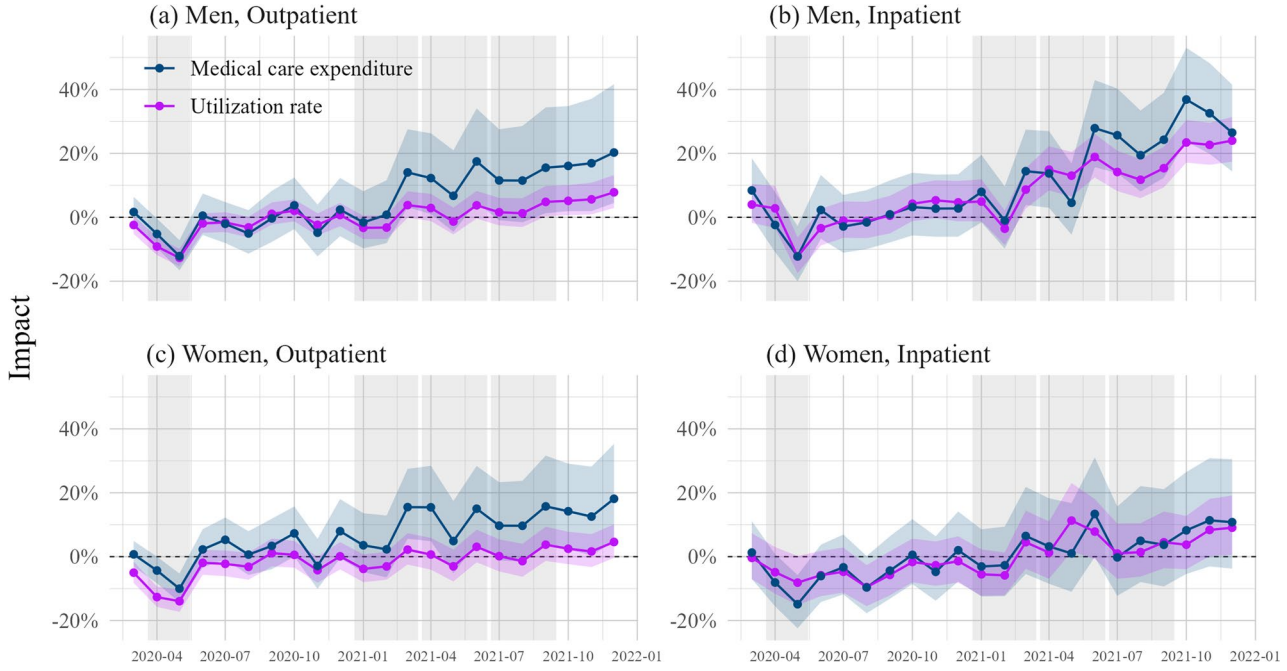

Fig. 2 COVID-19 impact on neoplasms: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

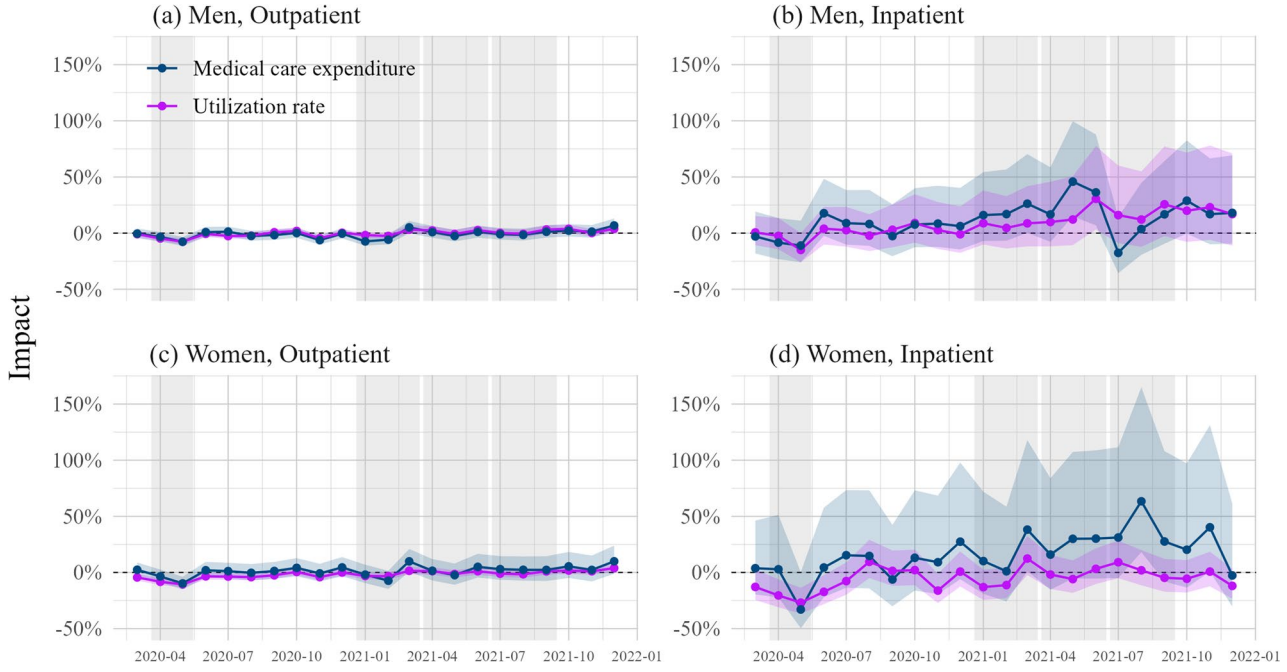

Fig. 3 COVID-19 impact on endocrine, nutritional and metabolic diseases: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

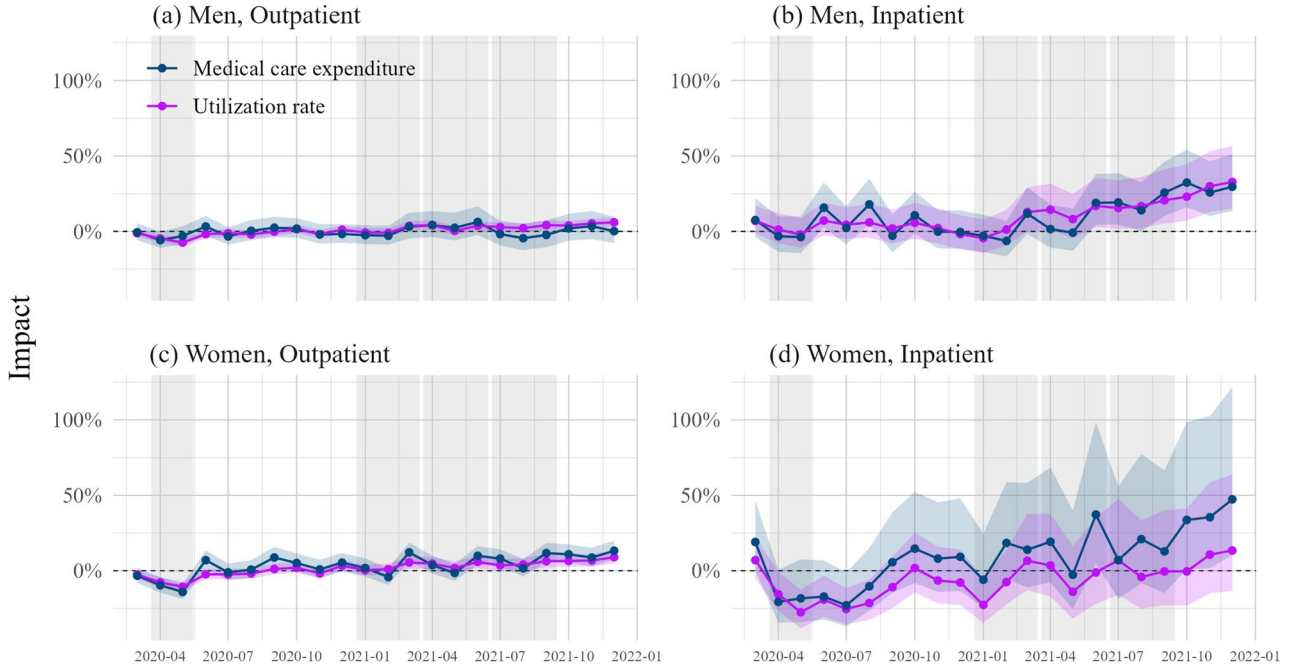

Fig. 4 COVID-19 impact on diseases of the nervous system diseases: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

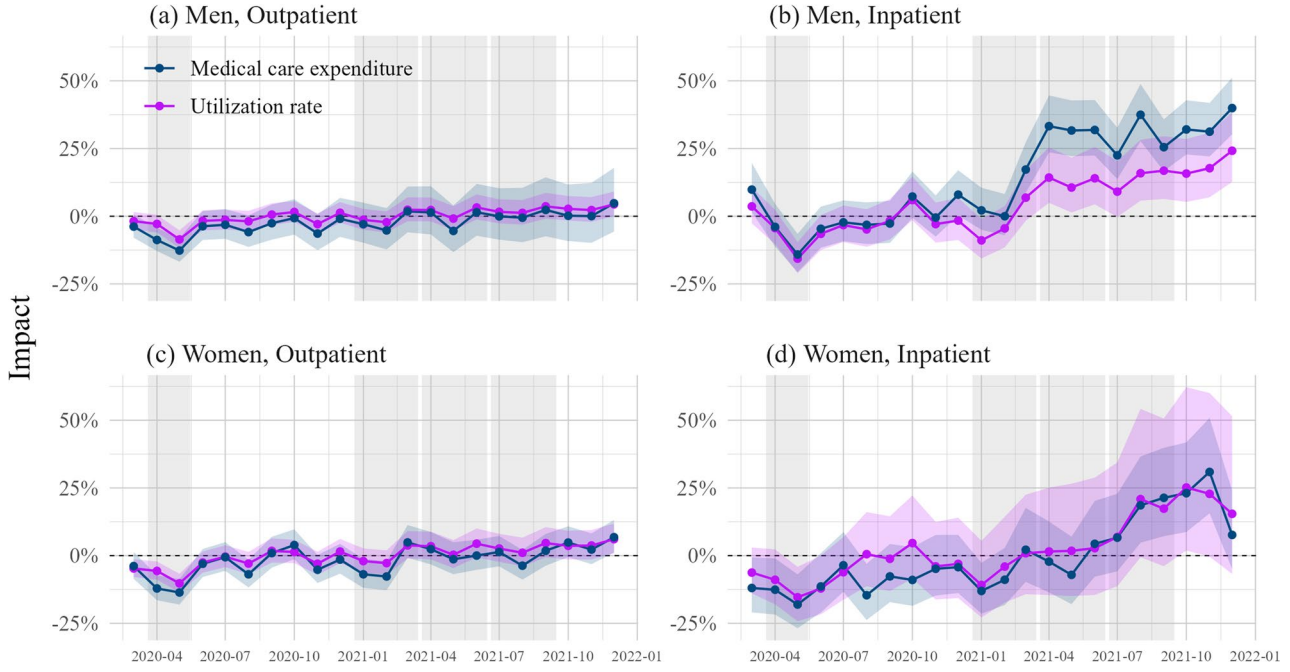

Fig. 5 COVID-19 impact on diseases of the circulatory system diseases: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

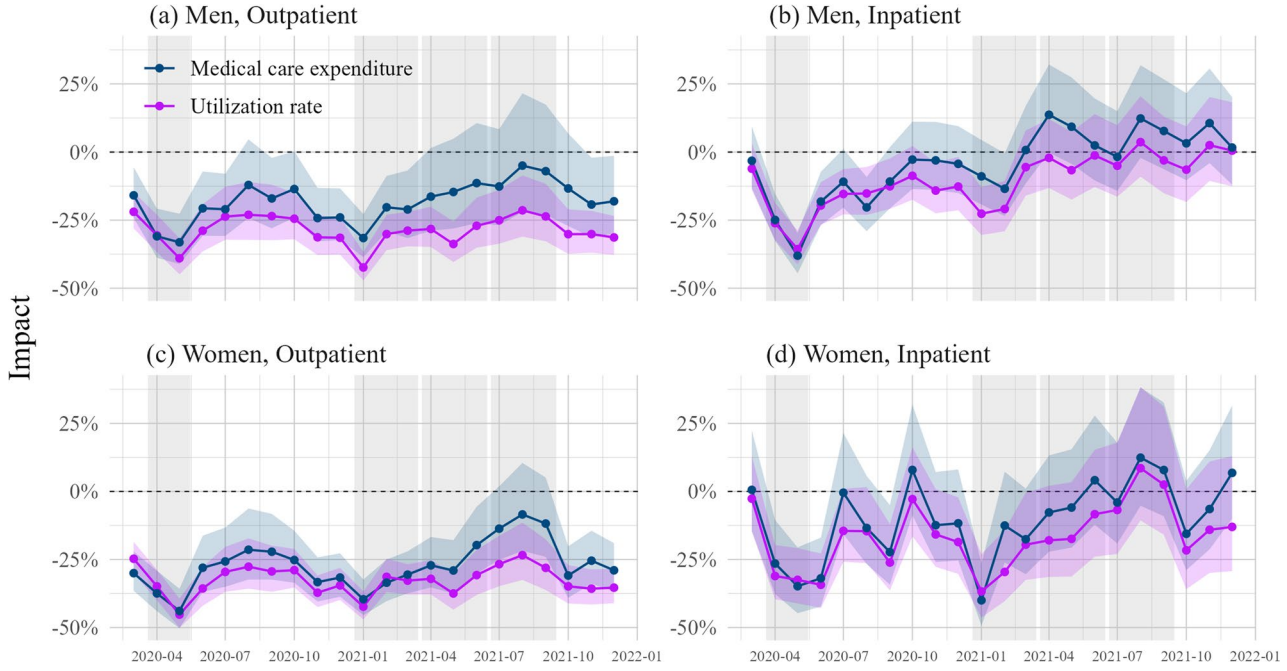

Fig. 6 COVID-19 impact on diseases of the respiratory system diseases: expenditure and utilization rates. Panel **a** Men, Outpatient; **b** Men, Inpatient; **c** Women, Outpatient; **d** Women, Inpatient. The horizontal axes represent the date, and the vertical axes represent the impact of COVID-19. Gray shading indicates the implementation periods for each of four states of emergency. Blue and purple shaded areas indicate 95% confidence intervals for medical care expenditure and utilization rate impacts, respectively

corresponding to each figure, as well as their impact values and 95% confidence intervals, are presented in Supplementary Tables 1 through 6. For reference, these tables also include the values of medical care expenditure and utilization rates for the pre-pandemic period (January 2019 to February 2020).

Infectious and parasitic diseases

In outpatient care, during the first SOE, both medical care expenditure and utilization rates decreased significantly in both sexes ($p < 0.05$), with comparable decreases in both measures (May 2020: medical care expenditure decreased by 12.2% in men and 11.0% in women; utilization rates decreased by 9.3% in men and 14.0% in women). From the second SOE onward, medical care expenditure increased notably in women, recording a 37.9% increase in December 2021, while the utilization rate during the same period decreased by 3.3%, showing a pronounced difference between the two outcomes.

In inpatient care, medical care expenditure increased substantially in both sexes from the second SOE onward. The increases during the fourth SOE period were particularly remarkable, with significant increases of 110.9% in men and 96.0% in women in August 2021 ($p < 0.05$). In contrast, increases in utilization rates remained below 30% at maximum, showing a clear difference from the increases in medical care expenditure.

Neoplasms

In outpatient care, during the first SOE, both medical care expenditure and utilization rates decreased significantly in both sexes ($p < 0.05$), with comparable decreases in both measures (May 2020: medical care expenditure decreased by 12.1% in men and 10.0% in women; utilization rates decreased by 12.7% in men and 13.9% in women). From the second SOE onward, medical care expenditure increased in both sexes, becoming prominent from the fourth SOE onward. In December 2021, medical care expenditure increased by 20.3% in men and 18.1% in women, both exceeding the increases in utilization rates.

In inpatient care, during the first SOE in May 2020, medical care expenditure decreased significantly by 12.2% in men and 14.9% in women ($p < 0.05$). From the second SOE onward, medical care expenditure increased significantly in men ($p < 0.05$), recording a 36.8% increase in October 2021, while the increase in utilization rates during the same period was limited to 23.4%. In women's inpatient care, the impact from the second SOE onward was mild compared to men.

Endocrine, nutritional and metabolic diseases

In outpatient care, during the first SOE, both medical care expenditure and utilization rates decreased significantly in both sexes ($p < 0.05$), with comparable decreases

in both measures (May 2020: medical care expenditure decreased by 7.7% in men and 9.8% in women; utilization rates decreased by 7.7% in men and 10.6% in women). From the second SOE onward, the impact of the pandemic on medical care expenditure was relatively mild compared to other disease groups. In men, the increase in medical care expenditure remained limited to 6.8% even in December 2021, and in women, it remained limited to a 9.9% increase.

In inpatient care, no significant impact on medical care expenditure occurred even during the first SOE, while utilization rates decreased significantly by 15.0% in men and 26.9% in women ($p < 0.05$). From the second SOE onward, medical care expenditure in inpatient care showed fluctuations, but statistical significance was limited, and no sustained increasing trend as seen in other disease groups was present.

Diseases of the nervous system

In outpatient care, differential impacts by sex occurred during the first SOE. While no significant impact on medical care expenditure occurred in men, women showed a significant decrease in medical care expenditure of 14.1% ($p < 0.05$). Utilization rates decreased significantly in both sexes ($p < 0.05$) (7.4% in men and 10.6% in women). From the second SOE onward, medical care expenditure for outpatient care increased sustainedly in women, with a 13.3% increase in December 2021, while the increase in utilization rates remained limited to 9.0%.

In inpatient care, no significant impact on medical care expenditure occurred in May 2020 during the first SOE, but women's utilization rates decreased substantially by 27.5% significantly ($p < 0.05$). From the second SOE onward, medical care expenditure for inpatient care increased in both sexes, with significant increases of 29.6% in men and 47.3% in women in December 2021 ($p < 0.05$).

Diseases of the circulatory system

In outpatient care, during the first SOE, both medical care expenditure and utilization rates decreased significantly in both sexes ($p < 0.05$) (May 2020: medical care expenditure decreased by 12.7% in men and 13.6% in women; utilization rates decreased by 8.6% in men and 10.3% in women). From the second SOE onward, the impact on medical care expenditure in outpatient care was mild, with the increase remaining limited to 4.8% even in December 2021 in men. In women, medical care expenditure increased significantly by 6.8% in December 2021 ($p < 0.05$).

In inpatient care, in May 2020 during the first SOE, medical care expenditure and utilization rates showed comparable significant decreases ($p < 0.05$) (medical care expenditure: 14.2% decrease in men and 18.1% decrease in women; utilization rates: 15.7% decrease in men and 15.4% decrease in women). From the second SOE onward, medical care expenditure increased substantially and persistently in men's inpatient care, recording a 39.9% increase in December 2021, while the increase in utilization rates remained limited to 24.2%, showing a clear difference between the two outcomes. In women's inpatient care, the impact was mild compared to men.

Diseases of the respiratory system

In outpatient care, during the first SOE, both medical care expenditure and utilization rates decreased most substantially among all disease groups and significantly ($p < 0.05$) (May 2020: medical care expenditure decreased by 33.1% in men and 43.9% in women; utilization rates decreased by 39.0% in men and 45.2% in women). Unlike other disease groups, decreases in medical care expenditure for outpatient care persisted throughout the entire period from the second SOE onward, with significant decreases of 18.1% in medical care expenditure and 31.4% in utilization rates in men, and 29.0% in medical care expenditure and 35.3% in utilization rates in women in December 2021 ($p < 0.05$). The monthly average decrease in medical care expenditure was approximately 18% in men and 27% in women throughout the observation period.

In inpatient care, in May 2020 during the first SOE, both medical care expenditure and utilization rates decreased substantially and significantly ($p < 0.05$) (medical care expenditure: 38.0% decrease in men and 34.8% decrease in women; utilization rates: 35.6% decrease in men and 32.5% decrease in women). From the second SOE onward, decreases in medical care expenditure for inpatient care were mild compared to outpatient care.

Discussion

This is the first study to comprehensively analyze the economic impact of the COVID-19 pandemic on medical care expenditure among Japan's working-age population using large-scale health insurance claims data. Our analysis revealed that the pandemic's impact on medical care expenditure varied substantially by sex, disease group, and type of care, showing dynamic patterns that changed over time. These findings provide important policy implications for the sustainability of health insurance finances and medical resource allocation.

Major findings by disease group and heterogeneity of economic impacts

During the early pandemic period (under the first SOE), significant decreases in both medical care expenditure and utilization rates occurred for neoplasms in both outpatient and inpatient care, with comparable decreases in both measures. This suggests that medical

care expenditure decreased primarily due to avoidance of medical visits, indicating that there may have been no major changes in the severity of patients who did receive medical care. However, from the second SOE onward, medical care expenditure for outpatient neoplasm care turned to significant increases in both sexes, with increases in medical care expenditure exceeding increases in utilization rates. This means that medical care expenditure per patient increased. Under the COVID-19 pandemic, avoidance of cancer screening and treatment delays have been reported in many domestic and international studies [14, 23–25], and the increase in medical care expenditure per patient may reflect disease progression and the need for more intensive treatment due to screening avoidance and treatment delays. From an economic perspective, the temporary decrease in medical care expenditure due to initial avoidance of medical visits was offset by subsequent recovery in utilization rates and increased disease severity among patients, potentially leading to increases instead. This suggests that suppression of medical visits during a pandemic may constitute a "false economy" in the long term. This analysis highlights the complexity of medical policy during infectious disease crises. Particularly for progressive diseases such as neoplasms, loss of opportunities for early detection and early treatment causes not only deterioration of patient health outcomes but also serious economic impacts [26]. Understanding both utilization rates and medical care expenditure, as in this study, is essential for designing more effective and economically sustainable medical policies in preparation for future crises. In future infectious disease crises, advance preparation and rapid response of medical delivery systems that do not impair opportunities for early detection and early treatment of neoplasms will be required.

For infectious and parasitic diseases, notable increases in medical care expenditure were observed in inpatient care in both sexes from the second SOE onward. Particularly noteworthy was that the increase in medical care expenditure substantially exceeded the increase in utilization rates. For example, in December 2021, men showed a 67.2% increase in medical care expenditure compared to a 19.9% increase in utilization rates, and women showed a 102.6% increase in medical care expenditure compared to an 8.3% increase in utilization rates. This difference is remarkable compared to other disease groups, suggesting that more severe and costly cases increased in inpatient care for infectious and parasitic diseases. Changes in lifestyle habits, long-term stress, and immune function decline during the pandemic may have acted in combination to bring about increases in opportunistic infections and severe infectious diseases [27]. Additionally, the need for additional screening tests and intensive treatment due to the cautious approach to diagnostic processes resulting from symptom similarity with COVID-19 may have contributed to the increase in incurred medical care expenditure per patient.

For diseases of the nervous system, the impact of the pandemic on medical care expenditure in outpatient care was relatively mild, but in inpatient care, notable increases in medical care expenditure were observed in men from the third SOE onward. In December 2021, men's inpatient care showed a significant 29.6% increase in medical care expenditure, while utilization rates during the same period showed a comparable 32.8% increase. One potential factor for this phenomenon is the relationship between diseases of the circulatory system. While increases in men's inpatient medical care expenditure for diseases of the circulatory system began from the second SOE onward, increases in diseases of the nervous system were observed from the third SOE onward, showing a time lag of several months. This pattern suggests that deterioration of circulatory system diseases due to lifestyle deterioration and avoidance of medical visits during the pandemic may have caused increases in cerebrovascular diseases (such as intracerebral hemorrhage (ICD-10 code: I61) and cerebral infarction (I63)), subsequently leading to increases in cerebrovascular paralytic diseases (such as hemiplegia (G81) and paralytic syndromes (G83)) as sequelae. This finding economically demonstrates the importance of circulatory system disease management during pandemics and its downstream ripple effects, suggesting the necessity of comprehensive medical policy formulation that considers inter-disease relationships.

For diseases of the respiratory system, significant decreases in both utilization rates and medical care expenditure were observed in most months in outpatient care, with larger decreases compared to other disease groups. The impact of pandemics on medical visits for respiratory diseases has been reported in many countries [2, 25, 28–30], consistent with the utilization rate results in this study. Additionally, significant decreases in medical care expenditure, not just utilization rates, were observed in many months, which is new evidence provided by this study. The substantial decreases in both medical care expenditure and utilization rates in outpatient care are considered to suggest that infection prevention measures (mask wearing, hand hygiene, social distancing) reduced the incidence of seasonal infectious diseases such as influenza (J09-J11), which are commonly included in respiratory diseases [2]. However, comparing the decrease patterns of medical care expenditure with utilization rates reveals an interesting phenomenon. In many months, the decrease in utilization rates exceeded the decrease in medical care expenditure. For example, in May 2020, men's medical care expenditure decreased by 33.1% while utilization rates decreased by 39.0%, and in

December 2021, medical care expenditure decreased by 18.1% compared to a 31.4% decrease in utilization rates. This difference between two outcomes suggests that average incurred medical care expenditure per patient for respiratory diseases increased. This may reflect that diagnostic processes became more cautious due to symptom similarity with COVID-19, requiring additional screening tests and differential diagnoses [31]. It is also possible that among the cases that avoided medical visits, many were mild cases, making those who did seek medical care more severe. Such increases in treatment intensity are considered to have been a factor that pushed up medical care expenditure per patient despite substantial decreases in the number of medical visits. This study suggests that approximately 20–30% of outpatient medical care expenditure related to respiratory diseases may have been reduced through appropriate infection control measures, but attention must be paid to bias factors such as potential increases in undiagnosed patients due to avoidance of medical visits during the pandemic and simultaneous screening of seasonal infectious diseases with COVID-19.

For endocrine, nutritional and metabolic diseases, the impact of the pandemic on medical care expenditure and utilization rates was mild in most months regardless of outpatient or inpatient care compared to other disease groups. The decrease rates in medical care expenditure and utilization rates were approximately the same, which was in contrast to the differential patterns observed in other disease groups. This phenomenon indicates that average incurred medical care expenditure per patient remained relatively stable. This stability is considered to result from chronic diseases such as diabetes (E10-E14) and dyslipidemia (E78) comprising the majority of medical care in this disease group. In these diseases, continuous drug treatment and regular monitoring form the foundation of treatment, and deterioration of blood glucose and lipid levels due to treatment interruption carries risks of serious complications, making it necessary for patients to continue medical visits even under SOE. Furthermore, these chronic diseases have characteristics that make them adaptable to pandemics through long-term prescriptions and online medical consultations for prescriptions, as disease control through drug therapy is relatively well established [2, 5]. Additionally, as long as appropriate treatment is continued, disease progression is gradual. In Japan, telemedicine requirements were significantly relaxed from April 2020 onward, and telemedicine was often used for prescription purposes, which may have mitigated the substantial decrease in utilization rates for endocrine, nutritional and metabolic diseases [5, 32]. On the other hand, attention must also be paid to the possibility that potential undiagnosed patients may have increased because diseases that do not rapidly become severe may experience delayed diagnosis due to avoidance of medical visits [7].

Sex differences in economic impacts

For infectious and parasitic diseases in outpatient care, the most notable sex differences were observed. In men, decreases in medical care expenditure persisted throughout the entire period, whereas in women, significant increases in medical care expenditure were observed from the second SOE onward. This contrasting pattern may reflect qualitative differences in the health impacts that the pandemic had on men and women. A potential factor for the increase in medical care expenditure in women may be the impact on immune function due to mental health deterioration during the pandemic, which is consistent with reports that women experienced more severe mental health deterioration during the pandemic [9, 33].

For neoplasms in inpatient care, sex differences in the impact of the pandemic on medical care expenditure were observed. In men's inpatient care, substantial significant increases in medical care expenditure were observed in the later pandemic period, which is considered to be due to both increases in utilization rates and increases in average incurred medical care expenditure per patient. In contrast, the impact on women's inpatient care was relatively mild. This sex difference may reflect differences in health management behavior and healthcare-seeking behavior by sex. The more notable increase in medical care expenditure for neoplasms in men suggests that men are relatively passive in health management and tend to avoid medical visits until symptom progression occurs. On the other hand, in Japan, women have a higher proportion of having regular physicians compared to men and are more active in routine health management and preventive medical visits [34], which may have enabled them to maintain medical access at relatively early stages even during the pandemic. This finding indicates the importance of differentiated approaches that consider sex in medical policy during future infectious disease crises.

Additionally, the notable increase in men's inpatient medical care expenditure for diseases of the circulatory system is particularly noteworthy. From the second SOE onward, men's inpatient medical care expenditure increased persistently, recording a significant 31.7% increase in May 2021. Interestingly, the increase in utilization rates during the same period remained at 10.6%, with the increase rate in medical care expenditure exceeding the increase rate in utilization rates. This difference pattern continuously observed throughout 2021 means an increase in average incurred medical care expenditure per inpatient, which is considered to reflect disease progression due to avoidance of health checkups [23] and medical visits during the pandemic, severity

due to delayed diagnosis, or increased treatment intensity. Furthermore, as pointed out by Suka et al. [35, 36], deterioration of lifestyle habits among working-age men during the pandemic (lack of exercise, increased alcohol consumption, increased stress) may have contributed to the deterioration of circulatory system diseases, potentially increasing cases requiring more expensive and intensive inpatient treatment. Such trends of increasing medical care expenditure among working-age men suggest that pandemic countermeasures should include policies that balance infection control with ensuring exercise opportunities and basic health management.

Long-term impacts on health insurance finances

The findings of this study show complex patterns where the impact of the pandemic on health insurance finances shifts from short-term decreases in medical care expenditure to long-term increases, depending on the disease. The decrease in medical care expenditure due to initial avoidance of medical visits may appear advantageous for insurance finances at first glance, but this appears to constitute a "false economy" in reality. Particularly, delays in diagnosis and treatment for neoplasms and diseases of the circulatory system, combined with deterioration of health outcomes, require higher medical costs in the future and carry the risk of bringing about long-term increases in medical expenditure. To prevent such long-term increases in medical expenditure, ensuring medical access according to disease characteristics is essential even during emergencies. Particularly for diseases such as neoplasms and diseases of the circulatory system, delays in diagnosis and treatment bring about both serious health outcomes and increases in medical expenditure, requiring policy design that balances infection control with continuation of medical care. Additionally, based on the sex- and disease-specific differences in impacts observed in this study, it is important to ensure priority medical access through risk-stratified approaches and to promote continuous disease management through the utilization of telemedicine [5, 32, 37], which is widespread for prescription purposes in Japan but has low prevalence for diagnostic purposes. Furthermore, to prevent the deterioration of health behaviors during pandemics, the strengthening of preventive interventions for lifestyle-related diseases combined with appropriate infection control measures will be important strategies for ensuring the sustainability of health insurance finances during future crises.

Strength and limitations

This study has several important strengths in examining the impact of the pandemic on medical care expenditure. First, by using large-scale medical claims data from the JHIA, we conducted a large-scale analysis covering Japan's working-age population. This scale ensured sufficient statistical power for evaluating the economic impacts of the pandemic and enabled detailed stratified analyses by sex, disease group, and type of care. Second, through long-term longitudinal observation from 2015 to 2021, we were able to comprehensively capture time-series variation patterns from stable pre-pandemic medical care expenditure trends to dynamic changes following pandemic onset. This long observation period enabled us to isolate the true impact of the pandemic after appropriately adjusting for seasonality and annual variations. Third, by adopting a two-part model that decomposes medical care expenditure into utilization rates and average incurred medical care expenditure, we made it possible to simultaneously evaluate both quantitative changes in medical service utilization and qualitative changes (changes in treatment intensity). Furthermore, by applying the Bayesian-based medical care expenditure decomposition method that we developed [17], we appropriately allocated medical care expenditure among disease groups for patients with multiple diseases and precisely estimated disease-specific economic impacts. This decomposition method made it possible to quantitatively demonstrate the important phenomenon of "progression from avoidance of medical visits to severity," representing an important methodological contribution in the field of health economics.

On the other hand, this study has several limitations. First, this study is based on claims data from the JHIA, which primarily covers employees of small and medium-sized enterprises and their dependents. The socioeconomic characteristics of JHIA enrollees, such as income levels, occupational types, and baseline health status, may differ from those of workers covered by other insurance schemes, such as health insurance associations for large corporations or mutual aid associations for public employees. These socioeconomic differences could potentially affect the magnitude and direction of the pandemic's impact on medical care expenditure and healthcare-seeking behavior, which may limit the generalizability of our findings. Second, we were unable to completely identify whether changes in medical care expenditure were due to avoidance of medical visits, actual changes in morbidity rates, or changes in medical supply systems. Third, this study is based on data up to December 2021, and future research is needed regarding more long-term impacts. Fourth, this study analyzed national-level data without examining regional differences in the pandemic's impact on medical care expenditure. Although SOE implementation varied considerably across regions, we were unable to conduct region-specific analyses due to technical constraints of our Bayesian decomposition method [17]. Our analysis already employs multi-dimensional stratification (disease group, sex, and type of care), resulting in some strata with very low utilization rates.

Regional stratification would further reduce sample sizes within these strata, causing our incurred medical care expenditure decomposition calculations to fail to converge. This problem was particularly pronounced in disease groups with low utilization rates for inpatient care. Future research using larger datasets or alternative analytical methods more robust to smaller sample sizes would be valuable for elucidating regional variation in medical care expenditure patterns during pandemics.

Conclusion

The COVID-19 pandemic had complex impacts on medical care expenditure among Japan's working-age population. Short-term decreases in medical care expenditure turned to long-term increases, with notable increases in medical care expenditure observed particularly for neoplasms and diseases of the circulatory system. These findings highlight the importance of the policy challenge of balancing infection control measures with continuous provision of medical services during infectious disease crises while maintaining the sustainability of health insurance finances. For building resilience of medical systems in preparation for future crises, the development of comprehensive and economically sustainable response strategies that consider disease characteristics and patient attributes is essential.

Abbreviations

SOE	State of emergency
JHIA	Japan Health Insurance Association
ICD-10	International Classification of Diseases, Tenth Revision
ITSA	Interrupted Time Series Analysis
SARIMA	Seasonal Autoregressive Integrated Moving Average

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13561-026-00753-9.

Supplementary Material 1. Supplementary Table 1. Detailed values for COVID-19 impacts on infectious and parasitic diseases. Values represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

Supplementary Material 2. Supplementary Table 2. Detailed values for COVID-19 impacts on neoplasms. Values represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

Supplementary Material 3. Supplementary Table 3. Detailed values for COVID-19 impacts on endocrine, nutritional and metabolic diseasesValues represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

Supplementary Material 4. Supplementary Table 4. Detailed values for COVID-19 impacts on diseases of the nervous system. Values represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

Supplementary Material 5. Supplementary Table 5. Detailed values for COVID-19 impacts on diseases of the circulatory system. Values represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

Supplementary Material 6. Supplementary Table 6. Detailed values for COVID-19 impacts on diseases of the respiratory system. Values represent monthly medical care expenditure (1,000 JPY per 1,000 study participants) and utilization rates (per 1,000 study participants) with percentage impacts and 95% confidence intervals. SOE indicates state of emergency periods (1: April-May 2020; 2: January-March 2021; 3: April-June 2021; 4: July-September 2021). Bold values indicate statistically significant impacts ($p < 0.05$).

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Authors' contributions

YH and HI designed the study and interpreted the findings. YH curated the data, conducted the statistical analyses, and drafted the manuscript. HI reviewed the manuscript. YF provided administrative support. All authors have read and approved the final manuscript.

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Data availability

The datasets from Japan Health Insurance Association (JHIA) that were used in the analysis of this study are available upon reasonable request and approval from JHIA (https://www.kyoukaikenpo.or.jp/). Requests for access to the datasets should be directed to the corresponding author, Yuji Hiramatsu (yuji.hiramatsu.pari@gmail.com).

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethics committee of the Institute for Future Initiatives at The University of Tokyo (Approval No. 23–122). The requirement for informed consent was waived by the same ethics committee because the research data were anonymized. All study methods were implemented in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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