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Impact of post-COVID-19 changes in outpatient chronic patients' healthcare-seeking behaviors on medical utilization and health outcomes

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Abstract

Introduction This study comprehensively investigates the changes in healthcare utilization among chronic patients with regular outpatient visits to hospitals after the occurrence of Covid-19. The research examines whether patients altered their originally regular medical attendance frequencies due to the pandemic and explores potential negative impacts on the health conditions of those irregular attendees post-pandemic.

Methods Data for this study were sourced from a database at a medical center in Taiwan. The subjects were chronic patients with regular hospital outpatient visits before the Covid-19 outbreak. The study tracked medical utilization patterns from 2017 to 2022 for different patient characteristics and outpatient behaviors, employing statistical methods such as Repeated Measures ANOVA and Generalized Estimating Equation to analyze changes in healthcare utilization and health status during the post-pandemic period.

Results The results reveal that, compared to the regular group, chronic patients with irregular outpatient visits during the post-pandemic period exhibited a decrease of 5.85 annual outpatient visits, a reduction of NT$20,290.1 in annual medical expenses, and a significantly higher abnormality rate in average biochemical test results by 0.9%.

Conclusions The findings contribute to understanding the impact of the Covid-19 pandemic on healthcare utilization and health conditions among outpatient chronic disease populations. In response to the new medical landscape in the post-pandemic era, proactive suggestions are made, including providing telemedicine outpatient services and referral-based medical care to meet the needs of the target population, ensuring a continuous and reassuring healthcare model for chronic patients, and mitigating the operational impacts of public health emergencies on hospitals.

Keywords COVID-19, SARS-CoV-2, Chronic disease, Health economics, Healthcare utilization, Healthcare avoidance

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Introduction

In 2020, the novel coronavirus disease (COVID-19), caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), rapidly spread worldwide, leading to a sharp increase in confirmed cases in various countries. The pandemic may have indirectly influenced a decline in patients' demand for non-COVID-19 healthcare. Apart from the phenomenon induced by home isolation and social distancing policies, individuals' fear of contracting COVID-19 in healthcare institutions also contributed to delayed or forsaken medical care. Research estimates suggest that 40.9% of adults in the United States deferred or avoided medical utilization during the pandemic, with a significant reduction in outpatient visits and preventive examinations [1]. Studies in Hong Kong also indicated that 30.4% of the population avoided seeking medical care during the COVID-19 outbreak. Important factors contributing to the avoidance of medical services included being female, married, having higher education, and the impact of COVID-19 on mental health [2]. Recent research further demonstrates a substantial decrease in the utilization of healthcare services for non-COVID-19 diseases [3, 4].

Taiwan promptly established the Central Epidemic Command Center (CECC) in response to the initial outbreak of COVID-19, implementing control measures for all travelers entering Taiwan from high-risk regions/countries. Despite these efforts, confirmed cases were identified through border screening between March and May 2020, as overseas residents gradually returned to Taiwan. Confirmed cases were subsequently admitted to designated hospital wards for treatment [5]. Amid media reports and public anxiety about confirmed cases in Taiwan, outpatient visits witnessed a decline. According to the healthcare statistics from Taiwan's Ministry of Health and Welfare National Health Insurance, during the pandemic period, most disease categories experienced negative growth in outpatient visits compared to the pre-pandemic period. The three major disease categories most affected were respiratory system (-25.1%), digestive system (-10.3%), and ear and mastoid process diseases (-10.3%) [6]. Research in Taiwan also confirmed a 19% decrease in outpatient visits during the epidemic period from February to May 2020 compared to the pre-epidemic period. Notably, the Taiwanese government did not implement mobility restrictions or close healthcare institutions during this time. The decrease in outpatient visits was primarily attributed to people's fear of infection or preventive behaviors related to COVID-19, leading to a voluntary reduction in healthcare demand [7].

National Taiwan University Hospital (NTUH), a large medical center with over 2,600 beds in Taiwan, experienced a significant decrease in outpatient visits following the admission of overseas COVID-19 confirmed cases in 2020. Using 2019 outpatient visits as the baseline for comparison, NTUH observed a decline of 12.23% in March 2020, 16.46% in April 2020, and 15.42% in May 2020. In May 2021, as sporadic local COVID-19 cases were detected in Taiwan and Taipei City and New Taipei City raised the epidemic alert level to the third stage, NTUH implemented operational adjustments in response to the heightened situation. This led to a second wave of decreases in outpatient visits, with declines of 36.32% in May 2021, 46.21% in June 2021, and 21.54% in July 2021 compared to the 2019 baseline. In late April 2022, Taiwan experienced a widespread community infection of the Omicron variant of SARS-CoV-2. Specialized hospitals continuously opened COVID-19 outpatient clinics and screening stations while expanding designated wards to meet the necessary medical needs of confirmed cases. Similar to the previous comparisons with the 2019 baseline, NTUH witnessed a decrease of 5.42% in outpatient visits in April 2022 and a further decrease of 13.84% in May 2022, as shown in Fig. 1.

The COVID-19 pandemic has exerted significant impacts and challenges on healthcare systems. Factors such as individual health status, adequacy of government-implemented preventive measures, clarity of communication, and the perceived risk of contracting COVID-19 can lead patients to autonomously alter their original healthcare-seeking behaviors, and in some cases, disrupt existing treatment plans. Delays in medical services may result in increased morbidity rates or worsened health conditions, consequently generating higher economic and societal costs [8]. While numerous studies have explored changes in healthcare utilization during the pandemic, there remains a limited focus on patients with different healthcare-seeking regularities and the subsequent impact on their health outcomes. This study aims to address these gaps by investigating chronic patients who should ideally maintain regular healthcare visits. The research uniquely differentiates chronic patients into regular and irregular groups, exploring how their healthcare-seeking habits affect medical behavior and health status during a pandemic. This investigation targets chronic patients who originally sought regular outpatient care at NTUH, analyzing changes in healthcare utilization among patients with different characteristics and disease severities during the COVID-19 pandemic. The study further delves into whether alterations in healthcare-seeking regularity have adverse effects on patients' health conditions. This approach provides insights into how chronic patients adapt to external challenges and elucidates the impact of care continuity on health outcomes during extraordinary circumstances.

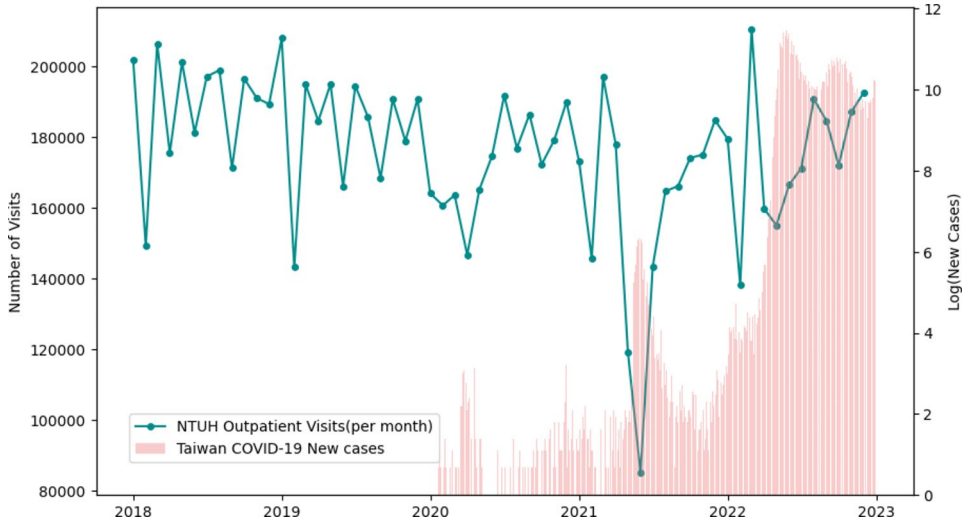

Fig. 1 Daily New COVID-19 Cases in Taiwan and Monthly Outpatient Visits at NTUH. *Note*: (1). Because of the large range of daily new confirmed cases, logarithmic scale is used for better comparison of the severity of the epidemic. (2). This chart was generated using data from Taiwan's Centers for Disease Control and the NTUH Health Insurance claim database

Materials and methods

Data source

The data for this study were derived from the National Taiwan University Hospital (NTUH) health insurance declaration database and the National Taiwan University Hospital-integrative Medical Database (NTUH-iMD). The study obtained approval from the NTUH Research Ethics Committee (REC) with the reference number 202207103RINC. The research adhered to the review criteria and ethical standards, and the entire process followed the specified research regulations. Research personnel organized and analyzed relevant medical records in a de-identified manner to ensure proper handling, preservation, and prevention of any potential data leaks. The study strictly adhered to ethical principles in medical research, emphasizing non-harm and fairness.

This study selected patients with chronic diseases who had regular outpatient visits to NTUH in the two years prior to the Covid-19 pandemic (2018 to 2019). Based on the changes in outpatient visit frequency during the pandemic period (2020 to 2021), the participants were categorized into a regular group and an irregular group. The inclusion criteria for this study were as follows:

(1) Outpatient visits with the same physician, same specialty, and same diagnosis occurring between 6 and 8 times (chronic disease diagnosis codes are provided in Appendix 1).
(2) The total duration of prescriptions within the two years exceeded 18 months.
(3) Physicians conducted regular monitoring of biochemical tests every 3 to 6 months (details of the biochemical test items are provided in Appendix 2).

This study aimed to ensure consistency in the observation period for each study subject. Cases of death within the study period were excluded. In order to eliminate instances of patients seeking medical care across different healthcare institutions during the study period, individuals with records of outpatient transfer were excluded. Participants enrolled in Pay for Performance programs or other healthcare improvement schemes were also excluded to avoid the influence of Pay for Performance plan restrictions on healthcare-seeking behavior.

To mitigate potential biases arising from significant demographic and health characteristic differences between the regular and irregular groups, this study utilized propensity score matching (PSM). Subjects were matched at a 1:1 ratio based on variables such as gender, age, Charlson Comorbidity Index (CCI), and disease categories. Ultimately, the study included a total of 9,058 individuals, with 4,529 in both the irregular and regular group.

Study Design

This study considered the occurrence of the Covid-19 pandemic in January 2020 as the intervention point. The period from 2018 to 2019 was designated as the baseline for medical utilization among patients with chronic diseases who sought regular outpatient care. The study aimed to analyze and investigate the variations in outpatient medical utilization from 2020 to 2022 following the occurrence of the pandemic, considering different characteristics such as gender, age, comorbidity scores, and disease categories. Subsequently, a comparison was conducted between the number of outpatient visits in the two years following the Covid-19 pandemic (observation period) and the two years before the Covid-19 pandemic

(baseline period). Individuals whose outpatient visits during the observation period decreased by more than 25% compared to the baseline period were categorized as the case group (irregular medical users). Conversely, Individuals whose decrease in outpatient visits during the observation period ranged from 0 to 25% compared to the baseline period were classified as the control group (regular medical users), as shown in Fig. 2.

The independent variables in this study include gender, age, comorbidities, and disease categories. Gender is categorized into two groups: male and female. Age is divided into five groups based on previous study results: below 49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and above [9, 10]. Comorbidities are assessed using the Charlson Comorbidity Index (CCI), with classifications based on CCI scores of 0 (none), 1 (mild), 2 (moderate), and 3 or more (severe) [11]. Diseases are categorized based on the primary diagnosis in outpatient, utilizing the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) codes. In addition, the classification of chronic diseases in the National Health Insurance system is referenced (see Appendix 1). The disease categories are further divided into five groups, including endocrine and metabolic diseases, circulatory system diseases, musculoskeletal and connective tissue diseases, cancer, digestive system diseases, and other diseases (such as mental disorders, neurological diseases, respiratory system diseases, urinary system diseases, eye and adnexal diseases, infectious diseases, congenital anomalies, skin and subcutaneous tissue diseases, blood and hematopoietic organ diseases, ear and mastoid process diseases) [6, 12].

The dependent variables in this study include the average outpatient visits, the average outpatient medical expenses, and the proportion of abnormal results in biochemical tests. The average outpatient visits are calculated by dividing the total number of outpatient visits in the study year by the population. The average outpatient medical expenses are calculated by dividing the total declared points for outpatient medical expenses in the study year by the population. Given that Taiwan's health insurance uses a global budget with a fixed value expenditure cap, the declared points are approximately equivalent to 1 New Taiwan Dollar (NT$) [13]. The proportion of abnormal results in biochemical tests is calculated by dividing the number of reported values outside the reference range (abnormal) in the biochemical tests prescribed by physicians by the total number of biochemical tests prescribed in the study year. The evaluation criteria for this study are based on the National Health Insurance Fee Schedule (as detailed in Appendix 2).

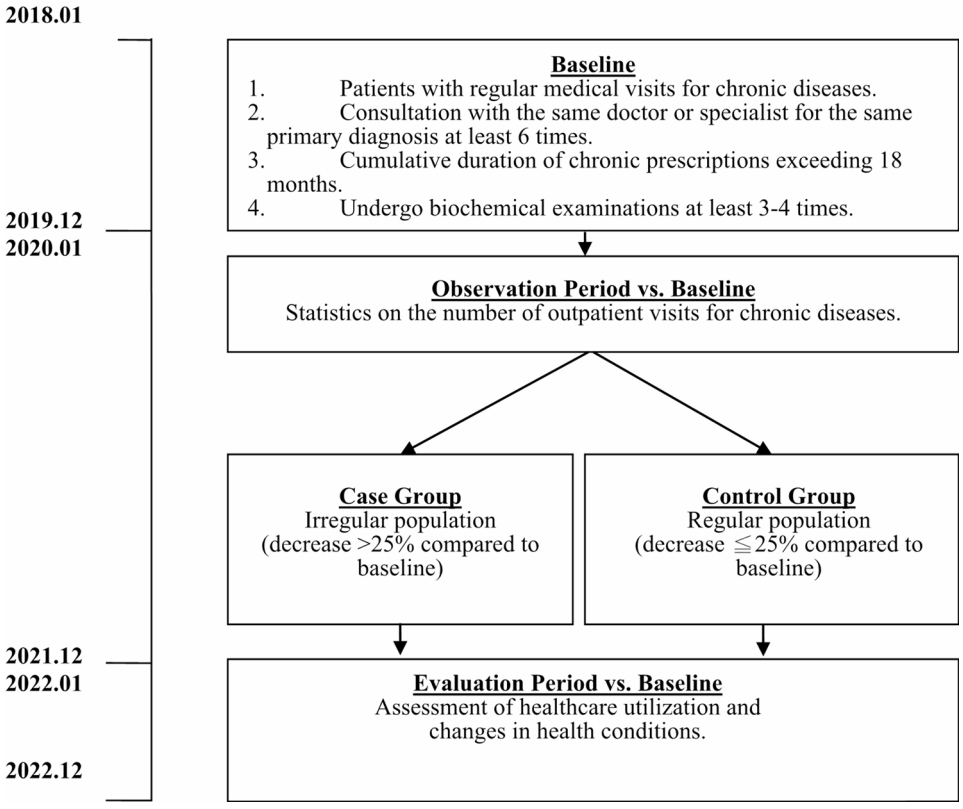

Fig. 2 Research design

Statistical analysis

This study utilized SQL, Python version 3.8, and IBM SPSS Statistics version 29 for data processing, statistical analysis, and graph plotting. According to the study design, sample characteristics were presented using descriptive statistics such as frequencies and percentage distributions. Inferential statistical methods, including Chi-square test, Repeated Measures Analysis of Variance (ANOVA), and Generalized Estimating Equation (GEE), were employed to explore the variations and influencing factors in medical utilization and health conditions between regular and irregular patients.

Results

The baseline characteristics of patients

This study utilized propensity score matching (PSM) to eliminate confounding factors, facilitating the grouping and matching of subjects. Chi-square analysis was conducted to examine whether the two groups of matched subjects exhibited significant differences in other factors. Descriptive statistics, including frequencies and percentages, were used to understand the characteristics and distribution of chronic disease patients. After matching, both the regular and irregular groups comprised 4,529 individuals, totaling 9,058 subjects. Among the study participants, 5,052 (55.77%) were female, outnumbering the 4,006 males (44.23%). There was no significant difference in gender between the two matched groups ($p=0.3411$). Regarding age distribution, the "60–69 years" group was the largest, with 2,673 individuals, constituting 29.51%, while the "80 years and above" group was the smallest, with 883 individuals, accounting for 9.75%. There was no significant difference in age between the two matched groups ($p=0.6223$). Concerning Charlson Comorbidity Index (CCI) scores, the highest proportion was observed in those with a score of 1 (2,974 individuals, 32.53%), while the lowest proportion was in those with a score of 0 (1,788 individuals, 19.74%). There was no significant difference in comorbidity severity between the two matched groups ($p=0.5941$). In terms of specific diseases, endocrine diseases accounted for 2,954 individuals (32.61%), circulatory diseases for 1,481 individuals (16.35%), musculoskeletal diseases for 1,087 individuals (11.77%), cancer for 1,204 individuals (13.29%), digestive diseases for 461 individuals (5.09%), and other diseases for 1,871 individuals (20.66%). However, there were still significant differences between the two matched groups ($p<0.05$), as shown in Table 1.

Outpatient chronic patients Healthcare utilization during the pandemic

This study tracked the differences in healthcare utilization among outpatient chronic patients with regular and irregular healthcare-seeking patterns from 2017 to 2022. A repeated measures analysis of variance (ANOVA) was employed to test whether there were statistically significant differences in healthcare utilization among the study subjects during the pre-pandemic, during the pandemic, and post-pandemic periods, as shown in Table 2.

For all subjects, the average outpatient visits were 13.8 pre-pandemic, 10.8 during the pandemic, and 11.3 post-pandemic. The differences in visit frequency across these periods were statistically significant ($p<0.001$). The regular group demonstrated no statistically significant differences in the average outpatient visits: 12.4 pre-pandemic, 12.6 during the pandemic, and 12.7 post-pandemic ($p=0.177$). However, the irregular group exhibited significant variations in outpatient visits: 15.2 pre-pandemic, 8.9 during the pandemic, and 9.8 post-pandemic ($p<0.001$). For all subjects, average outpatient medical expenses were 52,739.7 points pre-pandemic, 44,800.7 points during the pandemic, and 45,001.3 points post-pandemic, with statistically significant differences in expenditure during these periods ($p<0.001$). The regular group did not show statistically significant differences in average outpatient medical expenses: 52,709.3 pre-pandemic, 55,302 during the pandemic, and 55,020.2 post-pandemic ($p=0.482$). In contrast, the irregular group displayed significant differences in average outpatient medical expenses: 52,770.1 pre-pandemic, 34,252.8 during the pandemic, and 34,955.7 post-pandemic ($p<0.001$). As shown in Fig. 3.

For all subjects, the average proportion of abnormal results in outpatient biochemical tests was 26.2% pre-pandemic, 24.6% during the pandemic, and 23.8% post-pandemic. The differences in the average proportion of abnormal results during these periods were statistically significant ($p<0.001$). Within the regular group, the average proportion of abnormal results was 27.6% pre-pandemic, 25.9% during the pandemic, and 24.7% post-pandemic, with statistically significant differences across these periods ($p<0.001$). The irregular group exhibited significant variations in the average proportion of abnormal results: 24.7% pre-pandemic, 23.3% during the pandemic, and 22.8% post-pandemic, with statistically significant differences observed ($p<0.001$). As shown in Fig. 4.

The average outpatient visits for female patients were consistently higher than those of male patients during different pandemic periods. However, the average medical expenses for male patients were higher than those for female patients across various pandemic periods, as illustrated in Fig. 5. Within the age group of 60 to 69 years, outpatient chronic patients exhibited the highest average number of visits and medical expenses during different pandemic periods. In contrast, those aged 80 and above had the lowest average number of visits and medical expenses, as depicted in Fig. 6. Patients with a CCI

Table 1 The baseline characteristics of patients

Variable	Before Matching				After Matching			
	Total	Regular Group	Irregular Group	*p*-value	Total	Regular Group	Irregular Group	*p*-value
	N(%)	*N*(%)	*N*(%)		*N*(%)	*N*(%)	*N*(%)	
Total	20,662	15,883	4,779		9,058	4,529	4,529	
Sex				< 0.05				0.3411
Female	10,740 (51.98%)	8,061 (50.75%)	2,679 (56.06%)		5,052 (55.77%)	2,503 (55.27%)	2,549 (56.28%)	
Male	9,922 (48.02%)	7,822 (49.25%)	2,100 (43.94%)		4,006 (44.23%)	2,026 (44.73%)	1,980 (43.72%)	
Age(year)				0.0139				0.6223
< 49	3,658 (17.70%)	2,810 (17.69%)	848 (17.74%)		1,618 (17.86%)	835 (18.44%)	783 (17.29%)	
50–59	4,040 (19.55%)	3,114 (19.61%)	926 (19.38%)		1,788 (19.74%)	879 (19.41%)	909 (20.07%)	
60–69	6,348 (30.72%)	4,953 (31.18%)	1,395 (29.19%)		2,673 (29.51%)	1,341 (29.61%)	1,332 (29.41%)	
70–79	4,666 (22.58%)	3,554 (22.38%)	1,112 (23.27%)		2,096 (23.14%)	1,041 (22.99%)	1,055 (23.29%)	
≧ 80	1,950 (9.44%)	1,452 (9.14%)	498 (10.42%)		883 (9.75%)	433 (9.56%)	450 (9.94%)	
CCI score				< 0.05				0.5941
0	3,760 (18.20%)	2,780 (17.50%)	980 (20.51%)		1,788 (19.74%)	907 (20.03%)	881 (19.45%)	
1	7,218 (34.93%)	5,708 (35.94%)	1,510 (31.60%)		2,947 (32.53%)	1,483 (32.74%)	1,464 (32.33%)	
2	4,127 (19.97%)	3,125 (19.68%)	1,002 (20.97%)		1,883 (20.79%)	916 (20.23%)	967 (21.35%)	
≧ 3	5,557 (26.89%)	4,270 (26.88%)	1,287 (26.93%)		2,440 (26.94%)	1,223 (27.00%)	1,217 (26.87%)	
Disease categories				< 0.05				< 0.05
Endocrine and Metabolic	7,840 (37.94%)	6,362 (40.06%)	1,478 (30.93%)		2,954 (32.61%)	1,575 (34.78%)	1,379 (30.45%)	
Circulatory system	3,187 (15.42%)	2,368 (14.91%)	819 (17.14%)		1,481 (16.35%)	712 (15.72%)	769 (16.98%)	
Musculoskeletal	2,212 (10.71%)	1,622 (10.21%)	590 (12.35%)		1,087 (12.00%)	533 (11.77%)	554 (12.23%)	
Cancer	2,262 (10.95%)	1,559 (9.82%)	703 (14.71%)		1,204 (13.29%)	522 (11.53%)	682 (15.06%)	
Digestive system	960 (4.65%)	709 (4.46%)	251 (5.25%)		461 (5.09%)	221 (4.88%)	240 (5.30%)	
Other	4,201 (20.33%)	3,263 (20.54%)	938 (19.63%)		1,871 (20.66%)	966 (21.33%)	905 (19.98%)	

score of 3 or above showed the highest average number of outpatient visits and medical expenses, while those with a CCI score of 0 had the lowest average number of visits and medical expenses, as shown in Fig. 7. Across different pandemic periods, patients with endocrine and metabolic diseases had the highest average number of outpatient visits, while patients with other diseases, followed by cancer patients, had the highest average medical expenses. Patients with digestive system diseases had the lowest average number of visits and medical expenses during different pandemic periods, as depicted in Fig. 8.

Impact of regular and irregular chronic patients on Outpatient visit frequency

This study utilized Generalized Estimating Equations (GEE) to analyze the correlation between regular and irregular outpatient visits of patients with chronic diseases, along with their different patient characteristics and the frequency of outpatient visits, as presented in Table 3. During the post-pandemic period, compared to the pre-pandemic period, the average number of outpatient visits for irregularly attending patients was 5.85 times lower than that for regularly attending patients, showing statistically significant differences ($p<0.001$). There were no statistically significant differences in the

Table 2 Analysis of variance in healthcare utilization patterns among outpatient chronic patients during different pandemic periods

Subject	Variable	Pre-pandemic (2017–2018)		During the pandemic (2019–2020)		Post-pandemic (2022)		*p*-value
		Mean	Std	Mean	Std	Mean	Std	
Total								
	Average outpatient visits	13.8	10.1	10.8	8.5	11.3	9.2	< 0.001
	Average outpatient medical expenses	52739.7	102366.4	44800.7	93559.0	45001.3	99928.4	< 0.001
	Average Biochemical Test Abnormal Ratio	26.2%	18.4%	24.6%	17.7%	23.8%	17.5%	< 0.001
Regular Group								
	Average outpatient visits	12.4	9.4	12.6	9.5	12.7	10.1	0.1770
	Average outpatient medical expenses	52709.3	110417.6	55302.0	109276.3	55020.2	116034.4	0.4820
	Average Biochemical Test Abnormal Ratio	27.6%	18.9%	25.9%	17.8%	24.7%	17.4%	< 0.001
Irregular Group								
	Average outpatient visits	15.22	10.59	8.94	6.89	9.79	7.91	< 0.001
	Average outpatient medical expenses	52770.1	93655.8	34252.8	73013.5	34955.7	79364.7	< 0.001
	Average Biochemical Test Abnormal Ratio	24.7%	17.9%	23.3%	17.6%	22.8%	17.6%	< 0.001

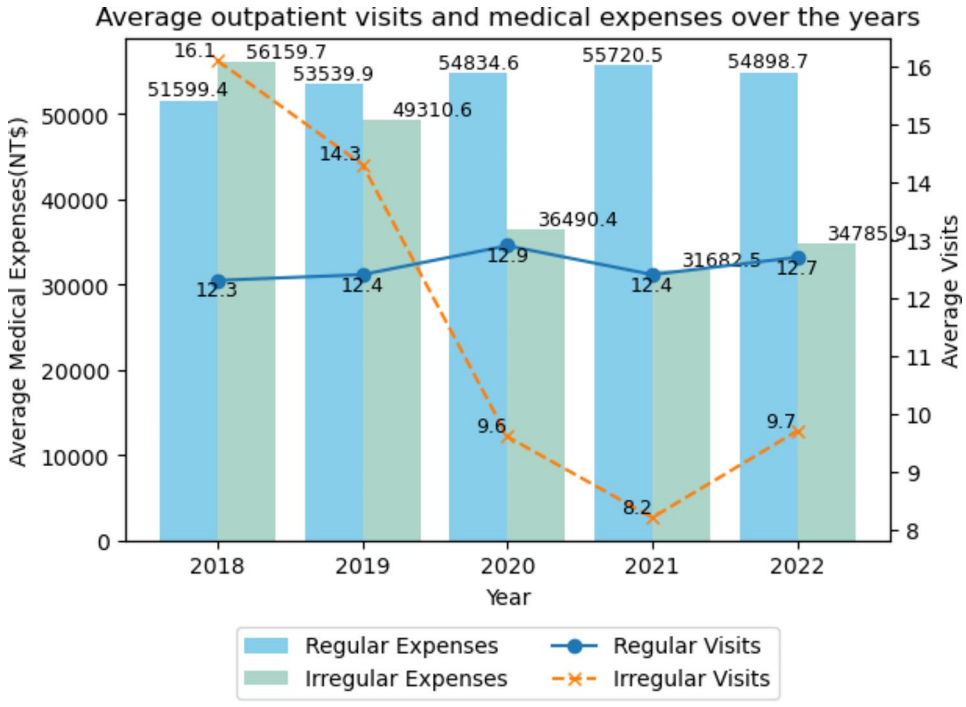

Fig. 3 Comparison of average outpatient visits and expenses between regular and irregular group

outpatient visit frequency between males and females. Within the age group of 70 to 79 years, the average number of outpatient visits was 0.9 times lower than the reference group, with statistically significant differences ($p<0.001$). For those aged 80 and above, the average number of outpatient visits was 1.35 times lower than the reference group, with statistically significant differences ($p<0.011$). Comparisons based on Charlson Comorbidity Index (CCI) scores showed that, compared to the CCI score of 0 group, those with a CCI score of 1 had 0.59 times fewer outpatient visits ($p<0.001$), a CCI score of 2 had 0.91 times fewer visits ($p<0.001$), and a CCI score of 3 or above had 1.88 times fewer visits ($p<0.001$). Regarding disease categories, patients with endocrine and metabolic diseases were the reference group, and patients with other chronic diseases had 0.87 times fewer outpatient visits ($p<0.001$), indicating statistically significant differences.

Impact of regular and irregular chronic patients on Outpatient Medical expenses

The study further utilized GEE to analyze the correlation between regular and irregular outpatient visits of patients with chronic diseases, different patient characteristics, and outpatient medical expenses, as presented in Table 4. During the post-pandemic period, compared to

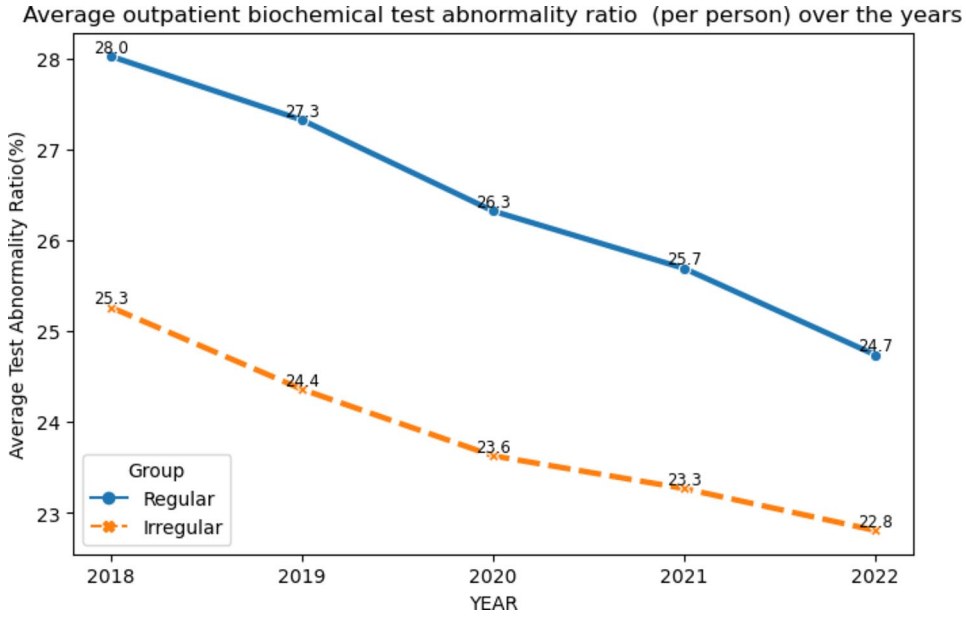

Fig. 4 Comparison of average biochemical test abnormal ratio between regular and irregular group

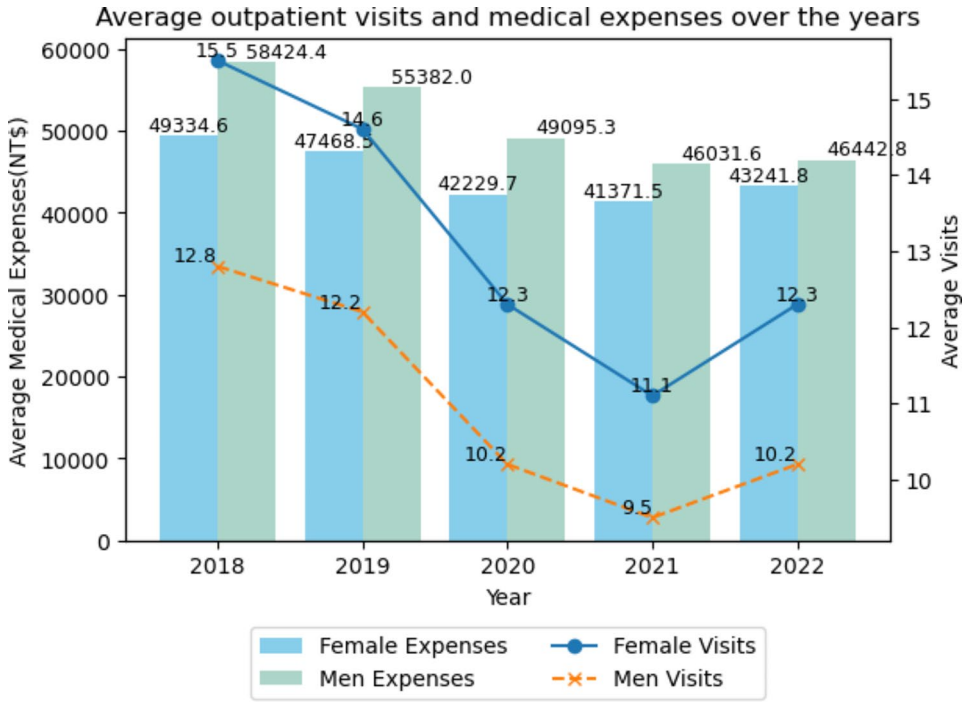

Fig. 5 Gender-based comparison of average outpatient visits and expenses

the pre-pandemic period, the average outpatient medical expenses for irregularly attending patients were 20,290.1 points less than that for regularly attending patients, indicating statistically significant differences ($p<0.001$). Males had average outpatient medical expenses 7,416.4 points less than females, with statistically significant differences ($p<0.001$). Stratified by age, compared to those aged 49 and below, those aged 50 to 59 had 5,903.3 points more in average outpatient medical expenses ($p=0.029$), those aged 60 to 69 had 13,390.3 points more ($p<0.001$), those aged 70 to 79 had 15,272.8 points more ($p<0.001$), and those aged 80 and above had 9,815.9 points more ($p=0.001$). Based on CCI scores, the reference group was CCI score of 0, and those with a CCI score of 2 had 6,231.5 points less in average outpatient medical expenses ($p=0.015$), while those with a CCI score of 3

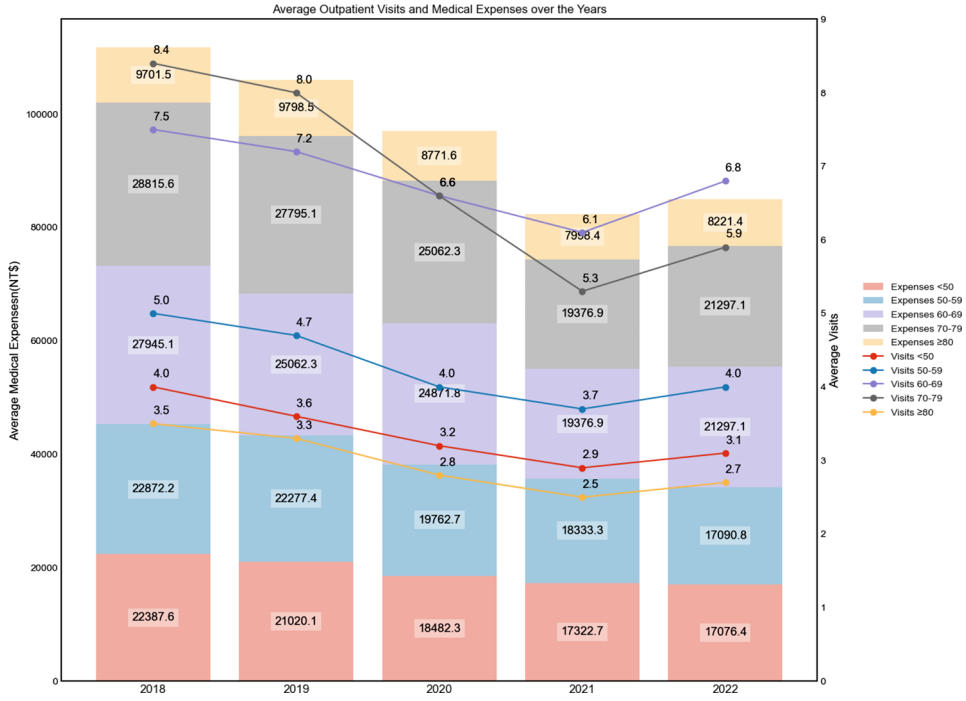

Fig. 6 Age-based comparison of average outpatient visits and expenses

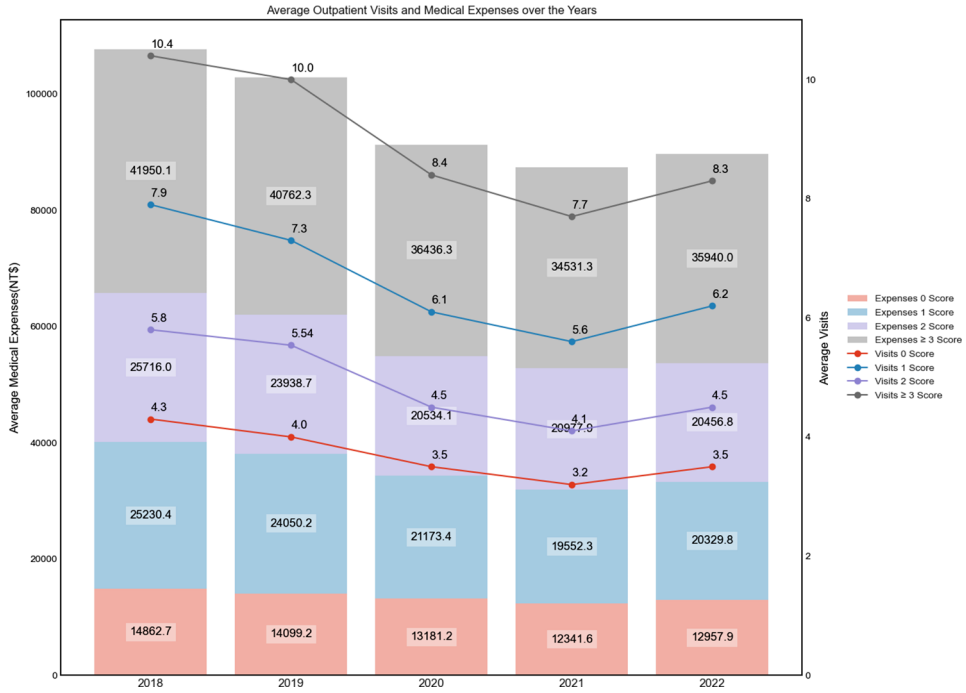

Fig. 7 CCI-based comparison of average outpatient visits and expenses

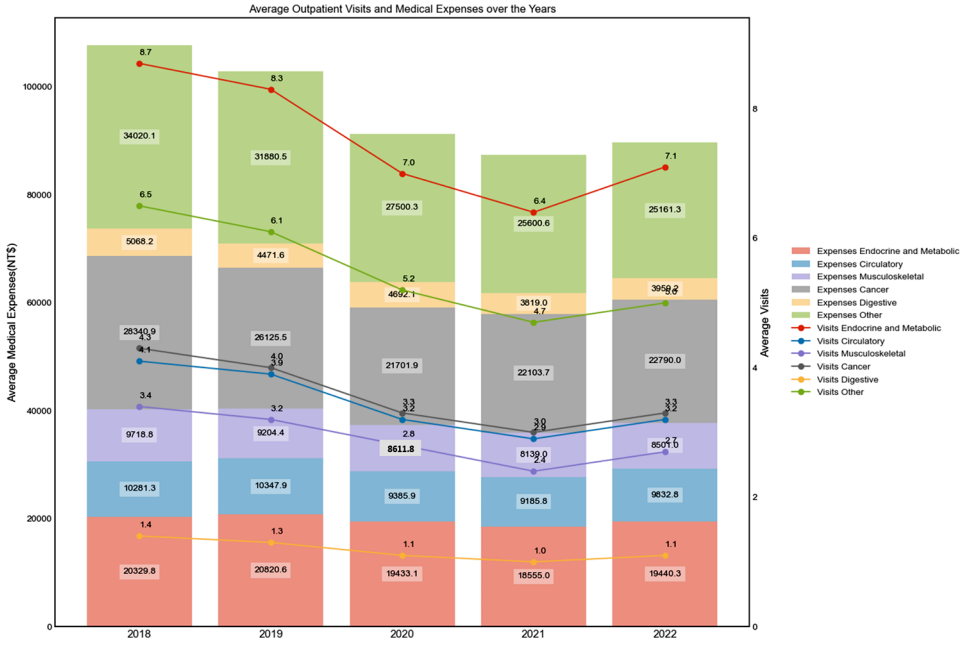

Fig. 8 Disease-specific comparison of average outpatient visits and expenses

Table 3 GEE analysis of average outpatient visits among outpatient chronic patients

Variable	Post-pandemic vs. Pre-pandemic				
	β	SE	95%CI		*p* value
Group					
Regular					
Irregular	-5.85	0.15	-6.15	-5.55	< 0.001
Sex					
Female					
Male	-0.11	0.15	-0.41	0.19	0.455
Age(year)					
< 49					
50–59	0.27	0.21	-0.13	0.68	0.893
60–69	-0.03	0.20	-0.42	0.37	0.185
70–79	-0.90	0.23	-1.35	-0.45	< 0.001
≧ 80	-1.35	0.32	-1.98	-0.73	< 0.001
CCI score					
0					
1	-0.59	0.18	-0.94	-0.24	< 0.001
2	-0.91	0.21	-1.32	-0.49	< 0.001
≧ 3	-1.88	0.23	-2.33	-1.43	< 0.001
Disease categories					
Endocrine and Metabolic					
Circulatory system	-0.02	0.22	-0.45	0.41	0.935
Musculoskeletal	-0.34	0.25	-0.83	0.14	0.168
Cancer	-0.32	0.27	-0.85	0.21	0.233
Digestive system	0.19	0.31	-0.41	0.80	0.531
Other	-0.87	0.22	-1.29	-0.45	< 0.001

or above had 6,061.5 points less ($p=0.03$). Regarding disease categories, using patients with endocrine and metabolic diseases as the reference group, cancer patients had 12,986.2 points less in average outpatient medical expenses ($p=0.014$), and patients with other chronic diseases had 16,803 points less ($p<0.001$), both showing statistically significant differences.

Impact of regular and irregular chronic patients on outpatient biochemical test results

This study utilized GEE to examine the correlation between regular and irregular outpatient visits of patients with chronic diseases, different patient characteristics, and the proportion of abnormal results in outpatient biochemical tests, as presented in Table 5. During the post-pandemic period, compared to the pre-pandemic period, the average proportion of abnormal results in outpatient biochemical tests for irregularly attending patients was 0.9% higher than that for regularly attending patients, showing statistically significant differences ($p<0.001$). There were no statistically significant differences in the proportion of abnormal results between males and females ($p=0.134$). No statistically significant differences were observed among different age groups in the proportion of abnormal results in outpatient biochemical tests. Stratified by CCI scores, the reference group was CCI score of 0, and those with a CCI score of 1 had 1.67% fewer abnormal results compared to the reference group ($p<0.001$). Based on disease categories, using patients with endocrine and metabolic diseases as the reference group, patients with circulatory system diseases had 2.42% more abnormal results ($p<0.001$),

Table 4 GEE analysis of average outpatient medical expenses among outpatient chronic patients

Variable	Post-pandemic vs. Pre-pandemic				
	β	SE	95%CI		*p* value
Group					
Regular					
Irregular	-20290.1	1764.9	-23749.2	-16831.0	< 0.001
Sex					
Female					
Male	-7416.4	1800.9	-10946.2	-3886.6	< 0.001
Age(year)					
< 49					
50–59	5903.3	2699.9	611.6	11195.1	0.029
60–69	13390.3	2689.1	8119.9	18660.8	< 0.001
70–79	15272.8	3022.0	9349.7	21195.9	< 0.001
≧80	9815.9	3018.7	3899.3	15732.5	0.001
CCI score					
0					
1	-2690.5	1599.0	-5824.4	443.5	0.092
2	-6231.5	2573.1	-11274.7	-1188.3	0.015
≧3	-6061.5	2799.1	-11547.8	-575.3	0.03
Disease categories					
Endocrine and Metabolic					
Circulatory system	1319.4	1375.8	-1377.2	4016.0	0.338
Musculoskeletal	-1390.7	1844.8	-5006.5	2225.0	0.451
Cancer	-12986.2	5283.9	-23342.6	-2629.9	0.014
Digestive system	-5135.8	2933.9	-10886.2	614.6	0.08
Other	-16803.0	1938.6	-20602.7	-13003.4	< 0.001

patients with musculoskeletal diseases had 4.46% more abnormal results ($p<0.001$), cancer patients had 3.87% more abnormal results ($p<0.001$), patients with digestive system diseases had 2.13% more abnormal results ($p=0.001$), and patients with other chronic diseases had 3.91% more abnormal results ($p<0.001$), all indicating statistically significant differences.

Discussion

This study analyzed the healthcare utilization patterns and health status of outpatient chronic patients in different pandemic periods to understand whether Covid-19 has altered routine healthcare-seeking behaviors in chronic patients and whether the irregular group has experienced adverse effects on their health conditions. The results revealed a significant difference in the average number of outpatient visits among chronic patients in the irregular group during different pandemic periods ($P<0.001$). However, there was no significant difference observed among patients in the regular group

Table 5 GEE analysis of average outpatient biochemical test abnormal ratio among outpatient chronic patients

Variable	Post-pandemic vs. Pre-pandemic				
	β	SE	95%CI		*p* value
Group					
Regular					
Irregular	0.90%	0.27%	0.40%	1.40%	< 0.001
Sex					
Female					
Male	0.40%	0.27%	-0.10%	0.90%	0.134
Age(year)					
< 49					
50–59	0.06%	0.45	-0.81%	0.93%	0.894
60–69	-0.44%	0.40	-1.22%	0.34%	0.265
70–79	-0.69%	0.41	-1.49%	0.12%	0.096
≧80	-0.20%	0.54	-1.26%	0.86%	0.715
CCI score					
0					
1	-1.67%	0.37	-2.40%	-0.95%	< 0.001
2	-0.65%	0.40	-1.43%	0.14%	0.107
≧3	-0.51%	0.37	-1.24%	0.22%	0.175
Disease categories					
Endocrine and Metabolic					
Circulatory system	2.42%	0.40%	1.64%	3.20%	< 0.001
Musculoskeletal	4.46%	0.40%	3.67%	5.24%	< 0.001
Cancer	3.87%	0.46%	2.97%	4.76%	< 0.001
Digestive system	2.13%	0.63%	0.90%	3.35%	0.001
Other	3.91%	0.38%	3.17%	4.64%	< 0.001

($P=0.1770$). Post-pandemic, compared to the pre-pandemic period, chronic patients in the irregular group had a significantly lower average number of outpatient visits, with a decrease of 5.85 visits ($p<0.001$) compared to those in the regular group. Research has indicated that the COVID-19 pandemic not only altered individuals' healthcare-seeking behaviors but also led to a more pronounced avoidance of medical utilization in regions severely affected by the pandemic and among populations with lower healthcare utilization [14]. Another study suggested that during the COVID-19 pandemic, approximately one in every five individuals in the general population exhibited avoidance behavior in seeking medical care. Notably, this avoidance behavior was particularly associated with females, those who self-assessed their health status as poor, and individuals experiencing heightened anxiety [15]. This study examines the outcomes of outpatient visit frequencies, and although there is no statistically significant difference by gender, it is observed that women have a higher average number of visits but incur lower medical expenses compared to men. This finding aligns with previous research investigating gender differences in healthcare utilization. Women tend to perceive their health status as poorer, which may partially explain the increased frequency of outpatient medical services. Conversely, men have a higher frequency

of hospitalizations and surgeries, possibly due to delaying medical treatment [16, 17]. Elderly chronic patients aged 70 to 79 and those aged 80 and above experienced a significantly greater reduction in outpatient visits compared to those aged below 50. Moreover, chronic patients with more severe comorbidities exhibited a significantly higher reduction in outpatient visits compared to those with lower comorbidity severity. Studies in the United States also indicated that over 20% of elderly individuals avoided seeking medical care during the pandemic due to concerns related to COVID-19. The likelihood of adopting avoidance behavior increased with age and poorer self-perceived health status among elderly individuals [18]. A Dutch generational study focused on the elderly population similarly reported that approximately one-third of the elderly population canceled primary care or hospital outpatient care appointments during the pandemic, particularly among those with multiple chronic conditions [19]. Facing an unfamiliar threat, humans may adopt extreme protective measures, such as avoiding public places. Taiwan's experience with the SARS epidemic in 2003, characterized by high infection rates in hospitals, may have reinforced the population's tendency to avoid medical utilization during the recent COVID-19 pandemic [20].

The pandemic-induced unemployment and income reduction have intensified the financial pressure on healthcare payments. Studies estimate that in 2020, approximately 3.5 million individuals in the United States lost insurance coverage due to COVID-19-related unemployment, leading to an increasing number of people facing economic hardship and potentially choosing to delay or forgo medical treatment due to cost issues [21]. During the COVID-19 pandemic, heightened concerns about infectious diseases have led to delays in the treatment of chronic illnesses. However, the overall healthcare costs associated with chronic diseases have been increasing annually, and the interruption of care for chronic patients may result in significant adverse health outcomes, leading to more substantial economic impacts [22]. The results of this study reveal a significant difference in the average outpatient medical expenses among the irregular group during different pandemic periods ($P<0.001$). In contrast, there were no significant differences observed among the regular group ($P=0.4820$). Furthermore, the irregular group had significantly lower outpatient medical expenses, with a decrease of \$20,290.1 compared to the regular group ($p<0.001$). Notably, within the irregular group, patients aged 60–69 and 70–79 had significantly higher outpatient healthcare costs compared to those below 50 years old. Research has consistently indicated a significant decrease in healthcare utilization among chronic patients during the pandemic period (IRR=0.65–0.77), with a more substantial impact observed in individuals aged 65 and above compared to middle-aged individuals [23]. A study in Singapore revealed a 46.5 SGD reduction in healthcare expenditure during the COVID-19 pandemic due to decreased hospitalizations and outpatient visits, accompanied by a 2.7% decline in new diagnoses of chronic diseases [24]. Another investigation focusing on the Medicare Shared Savings Program (MSSP) found a 14.6% reduction in hospitalizations and a 7.5% decrease in outpatient medical expenses among insured individuals during the pandemic, resulting in an 8.3% reduction in average non-COVID healthcare expenditure from \$11,496 to \$10,537 per person [25]. This study further observed a significant difference in the reduction of average outpatient medical expenses between chronic patients with cancer and those with endocrine disorders ($p=0.014$). Other studies also reported a substantial decrease of approximately −28% to -38% in the frequency of first-time visits to oncology outpatient clinics during the pandemic, along with significant reductions in pathological diagnoses, cancer surgeries, chemotherapy, and cancer screening tests [26]. Cancer screening, visits, treatments, and surgeries witnessed substantial declines, with hospital chemotherapy management service costs decreasing by -21% to -31%, and billing frequencies for tumor products also dropping by -26% to -31% [27]. Despite limitations in data sources that only allow estimation of outpatient health insurance claim costs, excluding expenses such as hospitalizations, out-of-pocket medical costs, and social care, the impact of the pandemic on healthcare utilization among chronic patients was still observed. While this study primarily focuses on examining the impact of the pandemic on chronic patients' healthcare-seeking behaviors through visit frequency and medical expenses, it is important to acknowledge that multiple factors may influence healthcare utilization patterns. The financial repercussions of the pandemic have negatively influenced healthcare utilization. Delaying necessary medical examinations and treatments due to economic reasons may lead to an increase in morbidity rates and future higher healthcare costs. Insufficient disease management could result in long-term physical and psychological disabilities [28]. Governments worldwide implemented measures such as home isolation, social distancing, and restricted healthcare service usage during the COVID-19 pandemic, significantly increasing healthcare expenditure and public health costs. However, these measures also simultaneously reduced the utilization of other healthcare services, contributing significantly to the trends in healthcare spending in 2020 and 2021 [29].

The consequences of delaying or forgoing medical care depend on factors such as the patient's health condition and the type of healthcare utilization being avoided. For many non-COVID-19 diseases, these consequences

may result in increased severity, incidence, and mortality rates. Studies indicate that regions with the highest COVID-19 death tolls also experienced a substantial increase in deaths due to other causes, such as diabetes and heart disease, suggesting that the consequences of avoiding healthcare utilization may already be evident [30]. This study observed a decreasing trend in the abnormal proportion of biochemical test results for both regular and irregular outpatient chronic patients who continued seeking care in hospitals, with significant differences across different pandemic periods ($p<0.001$). However, when exploring the impact of healthcare frequency on the health status of outpatient chronic patients, it was noted that irregularly seeking care outpatient chronic patients exhibited a 0.9% higher average proportion of abnormal biochemical test results ($p<0.001$) compared to the regularly seeking care group. This suggests a significant influence of regular healthcare utilization on the health status of chronic patients. The COVID-19 pandemic has altered people's healthcare-seeking behavior, resulting in reduced preventive care, delayed diagnoses of new illnesses, and interruptions in chronic disease management. These indirect effects on the health status of non-COVID-19 patients, especially those with chronic diseases requiring regular monitoring, may take several years to fully manifest. Therefore, continuous research on the impact of the COVID-19 pandemic on the health status of chronic patients is essential. Healthcare systems should also develop new practices, such as telemedicine and self-monitoring, to ensure the continuity of healthcare services, strengthen primary healthcare, and prevent interruptions in chronic disease management [31, 32].

Conclusions

The results of this study reveal that the impact of the pandemic on outpatient chronic patients with irregular healthcare-seeking patterns is significantly higher in terms of both outpatient visit frequency and medical expenses compared to patients with regular healthcare-seeking patterns. Additionally, the average abnormality ratio in biochemical test results is also significantly higher among outpatient chronic patients with irregular healthcare-seeking patterns. Understanding the changing trends in healthcare utilization and health conditions within the outpatient chronic disease population during the Covid-19 pandemic enables proactive measures in response to the new healthcare landscape in the post-pandemic era. Initiatives targeting specific populations, such as offering telemedicine outpatient services and implementing referral-based medical care, can provide a continuous and reassuring healthcare model for patients, while mitigating the operational impact of public health events on hospital services.

Supplementary Information

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Supplementary Material 1

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Author contributions

Conceptualization, W.-L.H., S.-L.L., H.-L.H., and W.-S.H.; methodology, W.-L.H., S.-L.L., H.-L.H., and W.-S.H.; software, P.-J.T.; validation, C.-Y.L.; formal analysis, W.-L.H., and W.-S.H.; data curation, H.-L.H.; writing—original draft preparation, W.-L.H., S.-L.L., H.-L.H., P.-J.T., H.-H.H., C.-Y.L., and W.-S.H.; writing—review and editing, W.-L.H., S.-L.L., H.-L.H., P.-J.T., H.-H.H., C.-Y.L., and W.-S.H.; visualization, W.-L.H.; supervision, W.-L.H., and W.-S.H.; project administration, W.-L.H., and W.-S.H.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval

The study obtained approval from the National Taiwan University Hospital (NTUH) Research Ethics Committee (REC) with the reference number 202207103RINC.

Competing interests

The authors declare no competing interests.

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