The Impact of Telemedicine on Healthcare Utilization and Health Outcomes

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The Impact of Telemedicine on Healthcare Utilization and Health Outcomes

A Dissertation

Submitted to the Department of Public Health

and the Graduate School of Yonsei University

in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy in Public Health

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December 2024

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Acknowledgments

I would like to express my heartfelt gratitude to everyone who supported and accompanied me throughout the entire journey of selecting, pursuing, and completing my doctoral studies. Thanks to these individuals, I found the courage to embrace new challenges even in difficult circumstances, and I have grown academically and personally through this process.

First of all, I extend my deepest thanks to my advisor, Professor Jaeyong Shin. His sharp insights and guidance in preventive medicine and public health, along with his profound academic inspiration as a leading authority in digital health, have been a solid foundation for my research. I am also deeply grateful for his warm encouragement and continuous interest, always approaching students with kindness and support.

I am deeply grateful to Professor Eun-Cheol Park, the head of our research lab, for his vision, expertise, and insightful guidance in preventive medicine and public health policy. His ability to clearly articulate complex ideas and provide constructive feedback has greatly enhanced my research and academic growth. I sincerely thank him for his thoughtful care and dedication to creating a supportive and stimulating academic environment. His commitment to mentoring students and inspiring them to reach their potential has been truly impactful, and I feel privileged to have learned under his leadership.

My gratitude also extends to Professor Chung Mo Nam, a distinguished authority in health statistics. His passionate and profound lectures greatly helped me tackle statistical challenges during my research. I am deeply thankful for the statistical insights and advice you provided during the preparation of my dissertation.

Above all, I am profoundly grateful to my mentor, Professor Sung-In Jang. His deep and professional insights into healthcare and policy significantly enhanced my academic capacity. You have provided countless opportunities for students and have guided us with

dedication and care. His support and mentorship were instrumental in completing my doctoral studies, and I am especially grateful for the academic growth and learning I gained through research projects and conferences under his guidance.

I would also like to express my heartfelt gratitude to Professor Suk-Yong Jang for his professional knowledge and warm advice. His insightful guidance and thoughtful suggestions were of immense help in advancing my research. I learned and grew in many areas that I could not have resolved on my own, thanks to his kind and clear counsel.

I am deeply appreciative of the guidance provided by Professor Shi Chul Lee, Dr. Chaewon Jeong, and Professor Wonho Lee, who contributed significantly to shaping my academic path. My sincere thanks also go to Professors Woojin Chung, Ganglip Kim, and Dong Hyun Lee, who provided invaluable support and inspiration during my doctoral studies.

I will never forget the time I shared with my colleagues during the doctoral program: Hyeon Ji Lee, Jun Hyun Kwon, Heenmoe Yoon, Do Woong Lee, Won Jeong Jeong, Jae Hong Joo, Seung Hoon Kim, Soo Hyun Kang, Sung Hoon Jeong, Hye Jin Joo, Kyung Deok Heo, Il Yoon, Hyun Gyu Kim, Su Young Kim, Yoo Shin Park, Bitna Jang, Fatima Nari, Minah Park, Gayoon Shim, Nataliya Nerobkova, Oyuntuya Shinetsetseg, Da Hye Hong, Soo Jin Kim, Jin Hyun Kim, Ye Seul Jang, Yunseo Jang, Min Jung Ju, Ji Soo Go, Jae Hyuk Lim, Danbi Kim, Chorong Kim, Ah Jung Go, Su Min Park, and Se Mi Park.

I would also like to extend my gratitude to Kwon Isul, Jeon Jiyeon, Choi Seoyoung, Park Junsu, Kim Yejin, and Kim Bomgyeol for being a source of strength.

Finally, I am deeply grateful to my family, who have always stood by my side with love and courage. To my beloved grandmother, grandfather, father, mother, brother, and dog, my family has been my greatest pillar of strength and the most precious presence in my life. Through every challenging moment, their unwavering support and love have been beyond words. I express my boundless gratitude and respect to them.

To everyone who has encouraged and supported me throughout this journey, thank you once again for helping me grow and succeed. I will continue striving to become a better person, both academically and personally, building on these unforgettable experiences.

December 2024

Yun Hwa Jung

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ABSTRACT

Impact of Telemedicine on Healthcare Utilization and Health Outcomes

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Background: With advancements in information and communication technology, telemedicine has emerged as an innovative approach to healthcare, enabling the remote provision of services such as consultations, treatment, and monitoring. In Korea, public interest in telemedicine increased significantly after the temporary approval of non-face-to-face consultations in 2020. However, telemedicine remains a contentious issue, with policy consensus yet to be reached and relevant legislation still pending. While telemedicine is anticipated to improve access to healthcare and support effective disease management, it also raises concerns regarding risks such as misdiagnosis, misuse due to technological limitations, legal liability, and healthcare disparities stemming from the digital divide. Furthermore, the existing body of research on telemedicine remains limited. This study seeks to examine the impact of telemedicine on healthcare utilization and health outcomes for chronic diseases where its application can be effectively implemented. Specifically, diabetes was chosen as a representative physical chronic disease and schizophrenia as a mental chronic disease, considering their need for continuous management, associated risks, and the potential benefits of telemedicine. Additionally, the study focused on telemedicine consultations, a policy challenge in Korea and concerning one of the most fundamental and direct methods within the traditional healthcare delivery system. By evaluating the impact of telemedicine consultations on healthcare utilization

and health outcomes for patients with chronic diabetes and schizophrenia, this research contributes to policy grounds for the safety and effectiveness of telemedicine.

Methods: We used a customized cohort from the Korea National Health Insurance Service. For the period of 2018–2022, we targeted patients aged 19 years or older with chronic diabetes or schizophrenia from January 1, 2019, to December 31, 2022. The telemedicine and in-person groups were matched in a 1:3 ratio using risk set, exact matching, and propensity score matching methods. Stratification and random sampling were performed. Autoregressive model of order one was reflected in the Tweedie, generalized Poisson, zero-inflated Poisson, and zero-inflated negative binomial distributions. Analyses were performed using comparative interrupted time series in the mixed-effects model of the generalized linear mixed model.

Results: Healthcare utilization and health outcomes differed depending on the type of disease and the frequency of telemedicine use. Among patients with chronic diabetes, medication adherence improved in the telemedicine group compared to the in-person group, while emergency room visits decreased among those who repeatedly received telemedicine. Conversely, patients with chronic schizophrenia had increased medication adherence and emergency room visits in the group that repeatedly used telemedicine compared to the in-person group. There was no significant difference between telemedicine and in-person groups in indicators such as outpatient visits, medication prescriptions, medication amounts, hospitalization days, diabetes complications, and depression as a comorbidity. Among patients who used telemedicine, 52.4% of patients with diabetes and 57.5% of patients with schizophrenia had repeated telemedicine consultations. The average monthly medication adherence of chronic diabetes patients who used telemedicine consultations decreased from 67.6% to 60.0% over time, showing a reduction of approximately 4.2% compared to in-person consultations (Exp(β)=0.958, 95% confidence interval [CI]: 0.927–0.991). Among chronic diabetes patients with repeated telemedicine consultations, the average monthly emergency room visits decreased from 0.99 to 0.91 days over time, representing a reduction of approximately 2.9% compared to in-person consultations (Exp(β)=0.971, 95%

CI: 0.956–0.986). For chronic schizophrenia patients, the average monthly medication adherence increased from 40.1% to 66.9% over time, with an improvement of approximately 7.4% compared to in-person consultations (Exp(β)=1.074, 95% CI: 1.028–1.121). However, the average monthly emergency room visits for chronic schizophrenia patients with repeated telemedicine consultations increased from 1.13 to 1.35 days over time, indicating an approximate 2.1% increase compared to in-person consultations (Exp(β)=1.021, 95% CI: 1.005–1.038).

Conclusions: Telemedicine may vary in its suitability depending on the nature of the disease. In cases such as chronic diabetes that require complex and frequent medication adjustments, telemedicine consultations may be less feasible than in-person consultations owing to limited information exchange and interaction between physicians and patients. Conversely, for patients with chronic schizophrenia who may face psychological resistance to face-to-face consultations owing to a lack of awareness of their condition or fear of social stigma, telemedicine may increase accessibility for patients and caregivers. It may also facilitate ongoing management such as improving medication adherence. Nevertheless, telemedicine has limitations, particularly in establishing rapport between doctors and patients or providing adequate psychological therapy. In diseases such as schizophrenia, where psychological treatment plays a critical role, telemedicine may increase the risk of health deterioration, leading to emergency room visits. Despite these challenges, for patients with chronic diabetes who are accustomed to telemedicine and experienced in self-management, telemedicine can serve as an effective tool for rapid response in emergencies. It may contribute to preventing negative health outcomes such as emergency room visits. Therefore, when telemedicine is appropriately utilized as a complementary tool, it can contribute to safe and effective healthcare delivery. This requires careful consideration of the characteristics of the disease and the patient's circumstances.

Keywords: Telemedicine, Consultations, Chronic diseases, Diabetes, Schizophrenia, Healthcare Utilization, Health Outcomes, Mixed-effects model, Comparative interrupted time series

I. Introduction

1. Study Background

With the development of information and communication technology (ICT), telemedicine is establishing itself as a new paradigm in healthcare. Telemedicine provides medical information and services from a distance using ICT.[1] It is divided between medical professionals or between medical professionals and patients, and the types of services include remote consultation, treatment, and monitoring.[2,3] Telemedicine has improved healthcare accessibility; however, its safety and effectiveness remain controversial.[4-6]

Telemedicine was initiated as a pilot project in South Korea in 1988.[7] Telemedicine between medical providers was permitted in 2002 and pilot projects for telemedicine between doctors and patients were implemented in 2014.[8] Since 2020, public awareness of telemedicine consultations has increased, with temporary permission for non-face-to-face consultations and the implementation of pilot projects.[9,10]

Telemedicine consultations were active among returning patients with chronic diseases, accounting for 24.6% of the total population in 2022.[4] The most frequently used physical diseases for telemedicine consultations were hypertension (18.6%), diabetes (9.9%), and dyslipidemia (3.7%), whereas dementia (2.5 %) and schizophrenia (1.3 %) were the most frequently used mental diseases.[9]

Despite increasing policy interest and timeliness in telemedicine, discussions on the direction of establishing telemedicine have not converged. Many medical professionals in Korea are concerned about the safety and responsibility of telemedicine, and the confusion of a conservative medical delivery system under the principle of in-person consultations.[11]

However, the public tends to positively anticipate the convenience and usability of telemedicine and improve medical accessibility.[4]

In telemedicine, non-face-to-face consultations are remote treatments that provide the most direct and traditional interactions between doctors and patients in medical practice. Therefore, it is suitable to confirm the safety and effectiveness of telemedicine. Particularly, research on non-face-to-face consultations for chronic diseases, which is expected to be the main field of telemedicine, is appropriate for confirming controversial safety and effectiveness.[12]

Therefore, we decided to focus on non-face-to-face consultations in telemedicine to study healthcare utilization and health outcomes of patients with chronic diseases. We selected diabetes as the chronic physical disease and schizophrenia as the chronic mental disease. Both diseases are frequently treated with telemedicine and represent significant chronic conditions, particularly due to the high risk of severe complications when not properly managed.[13,14] In addition, schizophrenia may make it difficult for patients to visit the hospital voluntarily because of psychological resistance or disease characteristics.[15] We focused on these diseases because they have a relatively large effect on patient health when remote treatment becomes possible.

This study investigated the impact of telemedicine on healthcare utilization and health outcomes in patients with chronic diabetes and schizophrenia. This objective and comprehensive study on the core areas of telemedicine aims to contribute to understanding patient safety and effectiveness and to provide evidence for appropriate policy development directions.

2. Study Objectives

This study aimed to evaluate the effect of telemedicine on healthcare utilization and health outcomes. We studied the impact of telemedicine on patients with chronic diabetes or schizophrenia, focusing specifically on in-person versus telemedicine consultations to understand the direct impact on healthcare.

The impact on healthcare utilization was assessed based on outpatient visits, medication prescriptions, and medication amounts. Health outcomes were evaluated on the basis of medication adherence, hospitalization, emergency room (ER) visits, and visits for diabetic complications or depression.

The specific objectives of the study are as follows:

First, we determined the trends in the healthcare utilization of patients who received telemedicine and in-person consultations before and after the index time.

Second, trends in the health outcomes of patients who received telemedicine and in-person consultations before and after the index time.

Third, we determined whether there are differences in healthcare service utilization after experiencing telemedicine compared with patients receiving in-person consultations.

Fourth, we determined whether there were differences in health outcomes after telemedicine treatment compared to patients receiving in-person consultations.

Fifth, the impact of telemedicine was determined based on the degree of telemedicine repetition.

Based on these objectives, this study aimed to verify the safety and effectiveness of telemedicine.

II. Literature Review

1. The Concept of Telemedicine

Telemedicine is a subset of telehealth and telehealth is a subset of digital health. Table 1 compares the content of digital health, telehealth, and telemedicine.[2,16] This study focused on telemedicine, which most directly affects patients' healthcare utilization and outcomes among digital health fields and is attracting attention as a new paradigm of health policy.

Telemedicine is a direct medical service that medical professionals provide remotely, including clinical interactions such as diagnosis, treatment, and prescription, regardless of time and space. For example, telemedicine is the non-face-to-face treatment of chronic patients by doctors. It can also be used for remote medical treatment, consultation, diagnosis, and prescription monitoring for patients with mental illnesses, homebound patients, and emergency patients.[2]

The main feature of telemedicine is that it is remote because it can provide medical services without being restricted by physical distancing.[17] It utilizes information and communications technology (ICT) such as smartphones, computers, tablets, and wearable devices. In addition, it is performed in a non-face-to-face manner, such as by phone, video, text, or voice. Interaction between medical professionals and patients can be achieved through mobile apps, internet platforms, and video programs.[3]

Telemedicine has different standards regarding legally permissible diseases, subjects, treatment methods, and privacy protection standards in each country. In addition, countries differ in the level of private and government initiatives as well as in the level of insurance and support.[18]

Table 1. Comparison of Digital Health, Telehealth, and Telemedicine

Category	Digital Health	Telehealth	Telemedicine
Definition	Digital technologies for health improvement and prevention, without remote services	Remote health management services focusing on non-medical activities	Remote medical services, including diagnosis, treatment, prescriptions
Examples	Smartwatch tracking, AI-based health programs, EHR analysis	Health education, chronic disease coaching, remote counseling	Teleconsultation, remote prescription, remote imaging analysis
Keywords	Wearable devices, AI, health data, disease prevention	Health education, monitoring, prevention, counseling	Diagnosis, treatment, prescription, teleconsultation

2. Policy Background

Regarding the policy background, we first examined the domestic and international situations of telemedicine. Subsequently, we review the expectations, concerns, and prior research related to telemedicine. Finally, we present a suitable theoretical model for this study.

2.1. Telemedicine in Korea

Telemedicine in Korea is presented in order of major milestones and current status. Table 2 presents major events related to telemedicine in Korea.

2.1.1. History of Telemedicine in Korea

In Korea, telemedicine was introduced in 1988 as a pilot project for remote imaging diagnosis between healthcare centers and university hospitals. The participating healthcare centers were located in the medically underserved Yeoncheon, Hwacheon, and Uljin areas, including Seoul National University Hospital, Chuncheon Hallym University Hospital, and Kyungpook National University Hospital. This pilot project was conducted as teleradiology using a publicly switched telephone network; however, it was not widely activated owing to limitations in ICT.[7]

The legal basis for telemedicine was established through a revision of the Medical Act in March 2002. However, Article 30-2 of the newly established Medical Act provides limited permission for local medical practitioners to provide medical knowledge or technology to remote medical practitioners who use ICT.[8] Although telemedicine among medical professionals was inactive, discussions on the introduction of telemedicine between doctors and patients began. After the law was amended, pilot projects for telemedicine between healthcare professionals were implemented in public health centers, community health centers, correctional facilities, and military bases located in remote and underserved areas.[6]

A pilot telemedicine project between medical staff and patients was implemented in 2014 under the supervision of the Ministry of Health and Welfare (MOHW) to verify its safety and effectiveness. Public health centers and medical institutions at the clinic level continuously observed, counseled, and educated returning patients with hypertension or diabetes through remote monitoring, and changed their prescriptions or had them visit medical institutions if they suspected any abnormal symptoms. Of the patients, 76.9% responded that they were generally satisfied with the remote monitoring. After participating in the project, the patients' medication compliance scores increased by 0.25 points to 4.88 points out of a total score of 6. The following items responded that remote monitoring is appropriate for chronic disease management: delivery system design and decision support, goal setting, problem-solving and contextual counseling, follow-up, and integration.[9]

In 2015, the following six government ministries jointly implemented the second telemedicine pilot project: the MOHW; the Ministry of National Defense; the Ministry of Oceans and Fisheries; the Ministry of Trade, Industry, and Energy; the Ministry of Justice; and the Ministry of Science, ICT, and Future Planning. Telemedicine pilot projects have diversified to include remote emergency consultations in rural and remote areas, deep-sea vessels, and telemedicine services for overseas patients.[9]

Concerning COVID-19, the MOHW temporarily permitted telephone consultations and proxy prescriptions between February 2020 and May 2023. If the doctor determines that safety can be ensured, patients can temporarily receive telephone consultations and prescriptions. Additionally, to minimize the exposure of vulnerable groups, such as those in self-quarantine, chronically ill patients, the elderly, and high-risk patients to infectious diseases, proxy prescriptions were temporarily permitted based on a doctor's clinical judgment.[10]

Since June 2023, the Ministry of Health and Welfare has promoted a non-face-to-face treatment pilot project. This is implemented within a limited scope until the temporarily permitted non-face-to-face treatment ends and is legally institutionalized. This is allowed, in principle, for video consultations, with a focus on returning patients who have experience

with face-to-face treatment at the medical clinic level and, as an exception, at the hospital level.[19]

Table 2. Major Milestones in Telemedicine Policy in Korea

Year	Major policy events	Name of policy events	Contents
1988	Introduction of telemedicine concept	Yeoncheon/Hwacheon/Uljin Health Centers - 3 University Hospitals Remote Diagnosis	The first implementation of remote imaging diagnosis between local health centers and university hospitals, marking the beginning of telemedicine.
2002	Limited legal basis provided	Amendment of the medical act (article 30-2 added)	Allowing remote medical support and cooperation between medical professionals.
2014	Telemedicine pilot project between medical staff and patients	1st telemedicine pilot project	Positive outcomes in satisfaction, adherence, and chronic disease management through remote monitoring for hypertension and diabetes.
2015	Diversification of telemedicine pilot projects	2nd telemedicine pilot project	Pilot projects for remote medical services for emergency remote consultations in rural areas, remote areas, oceangoing vessels, and overseas patients
2020	Temporary allowance of telemedicine due to COVID-19 Pandemic	Temporary permission for telephone consultations, prescriptions, and proxy prescriptions	Temporary permission for telephone consultations and prescriptions in cases where medical safety is determined to be ensured
2023	Policy expansion for telemedicine	Non-face-to-face medical treatment pilot project	Allowing limited non-face-to-face treatment until legal institutionalization
2024	Legislation amendment pending	Amendment to the medical act related to legislation of non-face-to-face medical treatment	Medical act amendment for telemedicine legislation pending in the health and welfare committee's legislative subcommittee

2.1.2. Current Status of Telemedicine in Korea

In Korea, telemedicine is permitted in a limited manner in the form of pilot projects.[19] As of 2024, revisions to the bill legislating telemedicine are pending. In Korea, telemedicine is used as an adjunct to the principle of in-person consultations. Telemedicine is mainly implemented for returning patients and clinic-level medical institutions, and institutions that only perform non-face-to-face medical consultations are prohibited.[11]

As of 2022, the number of telemedicine users is approximately 12.72 million, which is 24.6% of the total population.[4] 82.5% of the telemedicine patients used phone calls, whereas the rest used videos. The telemedicine consultation times were usually less than 5 minutes (45.8%) and 5–10 minutes (39.5%).[20] Most telemedicine users were in their 50s (11.3%) or 60s (11.3%). The areas with the highest number of telemedicine users relative to the population were Daegu Metropolitan City (4.0%) and Gyeongsangbuk-do (3.7%), which were at a high risk of COVID-19 confirmation, and Sejong Special Self-Governing City (2.2%).[9]

22,473 medical institutions participated in telemedicine through mobile apps such as ddocdoc, doctornow, my-doctor, and gooddoc.[4,21] The medical institutions that used telemedicine the most from February 2020 to one year were clinics (68.6%), general hospitals (13.6%), tertiary hospitals (10.3%), hospitals (6.1%), and long-term care hospitals (1.4%). In the second quarter of 2021, the internal medicine (61.0 %), psychiatry (5.2 %), and neurology (4.8 %) departments used telemedicine. The most common diseases treated in telemedicine were hypertension (18.6%), diabetes (9.9%), dyslipidemia (3.7%), acute bronchitis (3.2%), and dementia (2.5%). As of the second quarter of 2021, the departments in which telemedicine was used the most were internal medicine (61.0%), psychiatry (5.2%), and neurology (4.8%).[9] Of the telemedicine consultations, 81.5% were repeat visits, and 18.5% were first-time visits. Prescriptions after consultations accounted for 69.8% and 30.2% of the consultations were without prescriptions.[4]

Medical institutions received an additional management fee for the non-face-to-face treatment pilot project, which was 30% of the consultation fee. Outpatient consultation fees

at clinics were KRW 16,140 (USD 12.4) for the first visit and KRW 11,540 (USD 8.9.) for the follow-up visit, and telephone consultation management fees were KRW 3,460 (USD 2.7) for the first visit and KRW 4,840 (USD 3.7) for the follow-up visit in 2020. Medical expenses claimed by health insurance, including out-of-pocket expenses, amounted to KRW 1.4529 trillion (USD 1.1 billion.[22]

Medical professionals and the public have mixed opinions on telemedicine. According to a media survey in which 0.6% of all doctors participated, 65.2% opposed telemedicine and 34.8% supported it. The reasons for opposing telemedicine were as follows: the possibility of misdiagnosis due to a lack of safety and efficacy verification (29.1%), the collapse of the medical system due to violation of the principle of face-to-face treatment (23.7%), the collapse of the medical delivery system due to the concentration of large hospitals (23.1%), and unclear legal responsibility (23.8%). Even among those in favor of telemedicine, 72.5% thought that first visits should be banned, and only repeat visits should be allowed.[6]

Meanwhile, in a survey of 500 patients who used telemedicine conducted by the National Health Insurance Service (NHIS), 77.8% said they were satisfied with telemedicine and 87.8% said they would use it again.[4] In a survey conducted by the Federation of Korean Industries with 1,021 adults, 72.7% said they would use telemedicine, while 27.3% said they would not. The reasons for being positive about telemedicine were as follows: saving time and money for hospital visits (57.7%), eliminating blind spots with low medical accessibility (21.7%), reducing medical expenses compared to in-person consultations (10.8%), developing medical industry, and creating jobs (9.8%). The negative reasons for using telemedicine were as follows: the possibility of misdiagnosis (51.1%), concern about small- and medium-sized hospitals going bankrupt due to patients flocking to large hospitals (23.6%), difficulties in case of medical accidents (17.8%), and concerns about personal information leakage (7.5%).[5]

In Korea, discussions on the legislative and policy directions of telemedicine are underway. Opinions must be collected and consented to through sufficient interactions

among key stakeholders including medical experts, policymakers, and the public. If the development direction of telemedicine converges in Korea, rapid growth is expected based on ICT infrastructure.

2.2. Telemedicine in Major Countries

The use of telemedicine varies depending on the policy environment, technological infrastructure, and public acceptance. Therefore, we examined the characteristics of telemedicine in major countries to understand its impact on healthcare utilization and health outcomes.

The major countries selected are the United States, Japan, and Australia. Because the United States is an advanced and active country in telemedicine, it can provide advanced insights. Japan is one of the countries in which telemedicine is developing and has similar characteristics to Korea, where this study was conducted. Australia is a country that has specifically utilized telemedicine to address geographical accessibility issues in rural and indigenous areas. An overview of the characteristics of telemedicine in the major countries is presented in Table 3.

Table 3. Overview of Telemedicine Features in Major Countries

Country	Legalization	Main Target	Patient Scale	Cost Comparison
Korea	Act (2002) Guideline (2020)	Returning patients, Chronic diseases	24.6% of the population (2022)	30% additional
US	Act (1997) Regulation relaxation (2020)	Radiology, Psychiatry, Cardiology	37% of the adults (2021)	Equivalent to in-person (States with parity laws)
Japan	Notification (1997, 2015, 2018)	Chronic diseases at home	4.1% of total consultations (2021)	First visit: 87.2% of offline, Re-visit: same (2022)
Australia	Regulations (2011)	General practitioners treatment	18% of the population (2020)	50% of in-person consultations (recommended fee)

2.2.1. United States: Telemedicine Advancement

The United States introduced Medicare telehealth services under the Comprehensive Telehealth Act in 1997. In 2020, the COVID-19 pandemic eased insurance coverage and legal restrictions on telehealth services.[6]

The U.S. telehealth system is led by private platforms, including Teladoc Health and Amwell. The government has expanded the scope of medical insurance coverage for telehealth through the Centers for Medicare and Medicaid Services (CMS).[23]

In the US, telemedicine between doctors and patients was frequently utilized by radiologists (39.5%), psychiatrists (27.8%), and cardiologists (24.1%). Fields where telemedicine was commonly used among medical providers included ER (38.8%), pathology (30.4%), and radiology (25.5%).[24] As of 2021, approximately 37% of American adults used telemedicine.[25]

In 2022, the CMS announced that most items temporarily included in the telemedicine fee schedule during the COVID-19 period would remain applicable through 2023. Although telemedicine fee rates vary by state, states with parity laws tend to equate telemedicine consultation fees with in-person consultation fees.[6]

Policy-wise, some states restrict telemedicine-based medication-assisted treatment (telemedicine-based MAT), whereas others support telemedicine-based MAT for opioid use disorder (tele-MOUD) as a means of providing remote medical treatment for opioid use disorder.[26]

In addition, concerning information security in telehealth, the Health Insurance Portability and Accountability Act (HIPAA) has suspended the enforcement of regulations to ensure accessibility during COVID-19.[27] This has allowed for temporary provision of care through platforms such as Zoom and Skype. The Office for Research in Clinical Practice (OCR) of the U.S.[25] Department of Health and Human Services ended the HIPAA moratorium by August 2023, requiring all telehealth services to comply with HIPAA security regulations.[27]

2.2.2. Japan: Emerging Telemedicine

Japan officially permitted telemedicine in 1997 with a notification from the Ministry of Health, Labor, and Welfare. In 2015, the notifications were revised to permit telemedicine between doctors and patients.[28] Guidelines detailing the conditions and procedures for the implementation of telemedicine were established in 2018.[29]

In Japan, telemedicine has expanded to focus on chronic diseases at home. Specific diseases include diabetes, hypertension, asthma, bedsores, and cerebrovascular disorders.[28] As of 2021, telemedicine is estimated to account for approximately 4.1% (53.65 million cases) of the total number of medical consultations in Japan.[30] Regarding the telemedicine fee, the first medical examination was 251 points online and 288 points offline, and the number of re-examinations was the same at 73 points online and offline in 2022.[31]

In February 2016, approximately 1% of medical institutions in Japan participated in private commercial telemedicine service pocket doctors.[32] The demand for telemedicine in Japan is expected to continue to increase owing to an aging population. In addition, continued expansion is expected because of strengthened government support.[33]

2.2.3. Australia: Specialized Applications of Telemedicine

The National Health Information Management Advisory Council of Australia laid the foundation for telemedicine in 1999 with the publication Health Online: A Health Information Action Plan for Australia. The 2011 Health Insurance (General Medical Services Table) Regulations provided the legal basis.[29] In 2020, the Medicare Benefits Schedule was temporarily changed to subsidize primary care services provided by medical providers via telephone or video conferences.[34]

There were no restrictions on the types of care available; however, after COVID-19, essential specialist care became available. Before the COVID-19 pandemic, patients and healthcare providers were required to be at least 15 km away to access telemedicine, except for aboriginal health services and aged care facilities.[35] There were no distance restrictions

for the COVID-19 cases.[36] In 2007, the Australian government announced that it would build a National Broadband Network to provide access to 93% of the Australian population. As of 2020, 18% of Australians have used telemedicine services.[37]

The fee for telemedicine consultations in Australia is set at 50% of the fee for in-person consultations. However, as this is the recommended fee, patients may be required to pay an additional 10-20% out-of-pocket expense in practice.[6] Telehealth consultations accounted for 28% of federally funded consultations and were used heavily by GPs, specialists, and mental health professionals.[38] The provision of temporary subsidies by the government during COVID-19 has dramatically expanded access to telehealth.[39]

Australia has a low population density, and rural and indigenous communities are particularly vulnerable to access to healthcare.[40] The Australian Government's Department of Health and Aged Care supports policies to improve access to healthcare through telehealth.[36]

2.3. Expectations and Concerns about Telemedicine

2.3.1. Expectations and Concerns Regarding Healthcare Utilization

There were expectations and concerns regarding healthcare utilization:

The first is accessibility. Telemedicine provides an alternative to physical accessibility for residents of medically vulnerable areas, elderly people with limited mobility, and people with physical disabilities.[41] This can improve psychological accessibility for patients with mental illness who fear psychological rejection or social stigma. It can also enhance patients' economic accessibility by reducing non-medical costs such as transportation costs and lost productivity. Nevertheless, digital divides may occur because of the elderly, who have difficulty learning new things; low-income classes, who have difficulty securing equipment; and limitations in technological infrastructure.[42,43] In addition, concerns

regarding healthcare inequality have raised the possibility that the quality of telemedicine supported by vulnerable groups under welfare policies may be lower.

Secondly, it is fast and convenient. Telemedicine can provide rapid treatment by reducing waiting and transportation times. This can make it easier for patients with chronic diseases to receive follow-up care and prescriptions.[44] This is expected to alleviate the congestion in upper-level medical institutions. However, unnecessary or unimportant consultation requests can increase social costs. In addition, there are concerns about the misuse and abuse of medicines owing to the lack of a verification process.[11]

Third, there is an emergency response. Telemedicine has the potential to provide a preemptive response before a patient visits a hospital during an emergency.[45] However, the initial and maintenance costs may arise in terms of technology and money. There are limitations in responding to emergencies and the possibility of misdiagnoses.

2.3.2. Expectations and Concerns Regarding Healthcare Outcomes

Expectations and concerns regarding health outcomes included:

The first is continuity of care. Telemedicine can enhance the management of chronically ill patients and facilitate their monitoring. However, it is relatively difficult to form rapport due to the reduced interaction between doctors and patients.[41]

Second, there is the accuracy of diagnosis. Telemedicine can be used for data-based patient-centered treatment and behavioral therapy. However, there are significant limitations to the doctors' palpation, percussion, auscultation, measurement of patients' vital signs, functional tests, imaging tools, and specimen collection. This can lead to misdiagnoses and liability issues.[11]

Third, there are early detection and prevention. Telemedicine can be used to detect or prevent risk factors early through monitoring and data analysis.[46] Nevertheless, it can be

difficult to diagnose, which can worsen complications or multimorbidity and reduce the effectiveness of treatment.

The fourth is the quality of care. There is an expectation that telemedicine can provide care similar to in-person consultations.[47] However, treatment may be interrupted, or information may be distorted owing to technical issues. In addition, sensitive medical information can be leaked when it is transmitted remotely.[48]

3. Previous Studies on Telemedicine

3.1. Studies on the Impact of Telemedicine on Healthcare Utilization

The reviewed studies on telemedicine and healthcare utilization are listed in Table 4. The reviewed studies provided information on access to healthcare, usage intentions and patterns, and applicability to special situations of telemedicine.

Specifically, telemedicine contributed to patients' access to healthcare during COVID-19.[49,50] According to Zeltzer et al. (2024), increased access to telemedicine during the COVID-19 lockdown in Israel in 2020 increased primary care visits by 3.5% and lowered costs per episode by 5%.[49] Tourkmani et al. (2021) examined the impact of integrated care virtual clinics in high-risk patients with type 2 diabetes in Saudi Arabia in 2020, with a mean decrease in HbA1c of 1.66±1.29 points.[50]

Some patients were receptive to telemedicine.[51,52] Videoconferencing interventions were reported to be feasible for schizophrenia-spectrum disorders and clinical high-risk for psychosis individuals, and most patients reported high acceptance, in a scoping review conducted by Santesteban-Echarri et al. (2018).[51] Additionally, orthopedic outpatients who received videoconference examinations were similarly satisfied with the medical service and intended to use remote examinations again, although there were problems with examining patients remotely compared to in-office visits, Haukipuro et al.(2000).[52]

Frequent therapeutic interventions have been identified in patients treated with telemedicine.[53,54] In patients with hypertension, remote monitoring led to a 3.3% increase in medication prescriptions and a 7.2% increase in outpatient visits to primary care physicians, by Tang et al.(2023).[53] Even in rural areas, emergency physicians who referred critically ill children reported more frequent therapeutic interventions when consulting via telemedicine, and parents reported higher satisfaction with the children's care.[54]

In addition, telemedicine facilitates rapid responses to emergencies. In rural Mississippi, trauma patients who received telemedicine at a local community hospital (LCH) before transfer to a trauma center (TC) had a 1.5-hour shorter LCH stay, with no difference in TC mortality in a study by Duchesne et al. (2008).[55]

Table 4. Summary of Previous Studies on the Impact of Telemedicine on Healthcare Utilization

Authors	Research Title	Summary
Zeltzer et al.	The Impact of Increased Access to Telemedicine	Increased access to telehealth during COVID-19 led to a modest increase in primary care visits while reducing overall healthcare costs.
Tourkmani et al.	The impact of telemedicine on patients with uncontrolled type 2 diabetes mellitus during the COVID-19 pandemic in Saudi Arabia: Findings and implications	Glycated hemoglobin decreased in high-risk diabetic patients who visited a virtual integrated care clinic during COVID-19.
Haukipuro et al.	The feasibility of telemedicine for orthopaedic outpatient clinicsa randomized controlled trial	Orthopedic outpatients who had their examinations via video were more likely to choose video for their next visit.
Santesteban-Echarri et al.	Telehealth interventions for schizophrenia-spectrum disorders and clinical high-risk for psychosis individuals: A scoping review	Videoconferencing interventions appeared feasible and well accepted in individuals with schizophrenia-spectrum disorders and clinical high-risk for psychosis.
Tang et al.	Effects of Remote Patient Monitoring Use on Care Outcomes Among Medicare Patients With Hypertension	Patients with hypertension who were monitored remotely had increased medication use, frequency of healthcare visits, and spending.
Dharmar et al.	Impact of Critical Care Telemedicine Consultations on Children in Rural Emergency Departments	Critically ill children who received telemedicine in a rural emergency department had more treatment interventions and higher parental satisfaction.
Duchesne et al.	Impact of Telemedicine Upon Rural Trauma Care	Trauma patients who received telemedicine before transport to a TC in a rural area had a shorter length of stay at the local community hospital and no difference in TC mortality.

3.2. Studies on the Impact of Telemedicine on Health Outcomes

Table 5 summarizes the previous studies on telemedicine and healthcare utilization that were reviewed. Previous studies have identified continuity of care for patients, health outcomes, and patient and healthcare provider satisfaction and concerns.

Telemedicine can contribute to continuity of care for patients with chronic diseases such as diabetes.[56,57] In Davis et al.(2010), patients with diabetes who received remote comprehensive self-management education had a decrease in HbA1c from 9.4±0.3% at baseline to 8.2±0.4% at 12 months and a decrease in LDL cholesterol from 103.0±6.5 mg/dl at baseline to 89.7±6.9 mg/dl at 12 months.[56] By Faruque et al. (2017), telemedicine improved HbA1c in patients with diabetes (mean difference at 3 months: -0.57%). However, there was no significant effect on quality of life, mortality, or hypoglycemia.[57]

Telemedicine through monitoring and consultation has improved health outcomes.[58,59] Patients with diabetes, chronic obstructive pulmonary disease, or heart failure who used home-based telehealth had an odds ratio (OR) of 0.82 lower risk of emergency hospitalization, and an OR of 0.54 lower risk of mortality by Steventon et al.(2012).[58] For patients with cardiovascular disease, receiving both remote monitoring and counseling resulted in a reduction in short-term cardiovascular-related hospitalizations by a risk ratio (RR) of 0.72 and a decrease in mortality risk by an RR of 0.83, Kuan et al.(2022).[59]

On the other hand, remote monitoring of patients in the intensive care unit was not associated with improved hospitals (pre- vs. post-intervention reduction: 2.1%, 95% CI: 0.2–4.1) or intensive care unit (ICU) mortality (pre- vs. post-intervention reduction: 1.4%, 95% CI: -0.3–3.2), according to Thomas et al.(2009).[60]

Telemedicine has also been used to improve medication adherence and screen for complications.[61,62] Schulze et al. (2019) evaluated a telemedicine intervention including phone calls and text messages in patients with schizophrenia or bipolar disorder, and found that patients had an OR of 4.11 (95% CI: 1.47–11.45)for continued medication 6 months after discharge.[61] Additionally, telemedicine was effective in screening diabetic retinopathy in patients with diabetes according to Galiero et al. (2020).[62]

Although patients and providers tend to be generally satisfied with telehealth and services in the mental health field, providers express many concerns about the potential negative impacts of telehealth, according to Hubley et al.(2016).[63]

Table 5. Summary of Previous Studies on the Impact of Telemedicine on Health Outcomes

Authors	Research Title	Summary
Davis et al.	TeleHealth Improves Diabetes Self-Management in an Underserved Community: Diabetes TeleCare	Patients who received remote comprehensive diabetes self-management education had reduced HbA1c and LDL cholesterol.
Faruque et al.	Effect of telemedicine on glycated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials	Telemedicine improved HbA1c in patients with diabetes but not quality of life, mortality, or hypoglycemia.
Steventon et al.	Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial	Patients with diabetes, chronic obstructive pulmonary disease, or heart failure who received home-based telehealth had reduced mortality and emergency hospitalization rates.
Kuan et al.	Efficacy of telemedicine for the management of cardiovascular disease: a systematic review and meta-analysis	Patients with heart failure who receive both remote disease monitoring and counseling may reduce their risk of short-term cardiovascular hospitalizations and death.
Thomas et al.	Association of Telemedicine for Remote Monitoring of Intensive Care Patients With Mortality, Complications, and Length of Stay	Remote monitoring of intensive care unit patients was not associated with improvements in hospital or ICU mortality.
Schulze et al.	Improving Medication Adherence With Telemedicine for Adults With Severe Mental Illness	Patients with schizophrenia or bipolar disorder demonstrated good medication adherence after discharge through telemedicine, including phone calls and text messages.
Galiero et al.	The Importance of Telemedicine during COVID-19 Pandemic: A Focus on Diabetic Retinopathy	Telemedicine was effective in screening for diabetic retinopathy.
Hubley et al.	Review of key telepsychiatry outcomes	Although patients and providers were generally satisfied with telepsychiatry services, providers expressed concerns about the negative impacts of teletherapy.

4. Theoretical Model

The Behavioral Model of Health Services Use by Andersen and Davidson (2007) provides a comprehensive framework for analyzing the factors influencing healthcare utilization and outcomes.[64] This model was developed based on the Andersen Healthcare Utilization Model (1968), a representative model for medical services.[65-67] However, Andersen and Davidson's (2007) model considers environmental factors and health systems together, unlike Andersen's (1968) model.[64]

As shown in Figure 1, the Andersen and Davidson (2007) model categorizes determinants into contextual and individual characteristics, highlighting the interplay between predisposing, enabling, and need factors. These contextual and individual characteristics are in a circular and complex relationship that influences health behaviors and outcomes.[64]

We focused on this model because the core of the study, telemedicine, corresponds to the contextual factors of health infrastructure. This is because contextual characteristics include social, policy-related, and environmental factors. Contexts, such as telemedicine or in-person consultations, affect individuals' predisposing, enabling, and needing factors.[68]

In terms of individual characteristics, the predisposing factors include demographic, social, and belief-based attributes that affect the likelihood of an individual using health services.[69] Enabling factors are external factors that enable an individual to use health services, such as financing, organizational resources, and health policies.[70] Needs factors refer to the degree to which an individual needs health services, corresponding to objective and subjective health statuses.[64] Based on individual factors, this study was designed to reflect those that could potentially confound the study topic.

Health behaviors and outcomes are affected by these factors. Health behaviors refer to behaviors that individuals perform to maintain or improve health, and health service behaviors are aimed at prevention, diagnosis, treatment, and rehabilitation. For health

behavior indicators, this study identified patients' access to healthcare and their patterns of use. Health outcomes are subjective or evaluated health statuses or patient satisfaction resulting from health behaviors.[64] Regarding health outcome indicators, this study identified patients' adverse health outcomes and the continuum of care.

By applying Andersen and Davidson (2007), we systematically identified the impact of telemedicine on healthcare utilization and outcomes, considering contextual and individual characteristics.

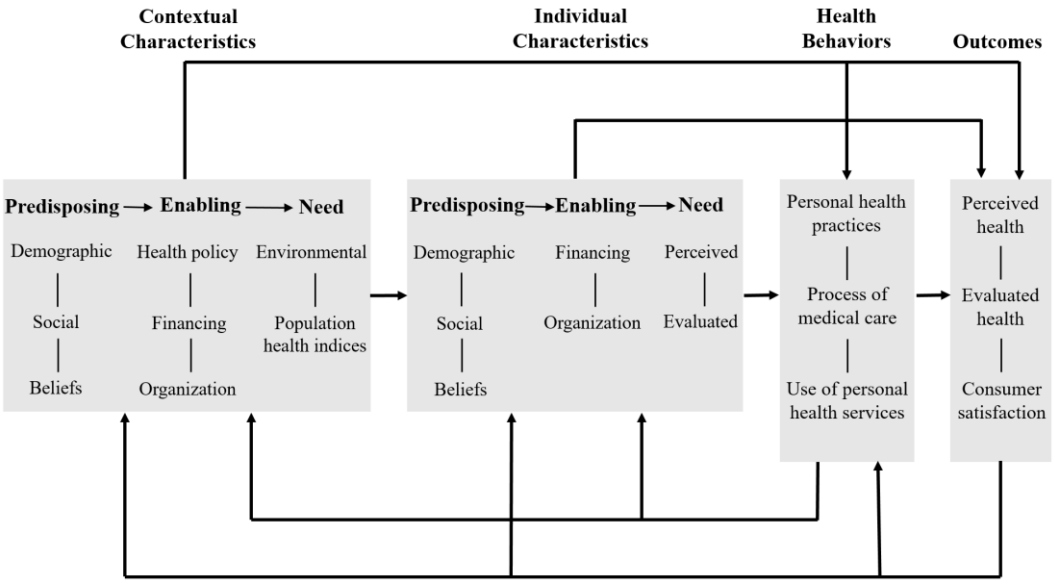


Figure 1. Behavioral Model of Health Services Use (Andersen and Davidson, 2007)

III. Material and Methods

1. Conceptual Framework

The theoretical framework of this study was based on the behavioral model of health service use. This model, developed by Andersen and Davidson in 2007, is widely recognized for its applicability in understanding individual health behaviors and outcomes. It was deemed suitable for analyzing the impact of the telemedicine consultation pilot project policy on patients' health service utilization and the corresponding health outcomes.

The conceptual framework of the study is shown in Figure 2, according to the theoretical model. Predisposing factors include basic characteristics that influence an individual's tendency to utilize medical services. Demographic variables included sex, age, and region, whereas social variables included employment and income levels. Enabling factors include resources and environmental variables that affect accessibility to medical services. Financing variables included health insurance type; organizational resources included the study participation period; and health policy included the year. Need factors included health status variables that motivated medical care use. The evaluated health variables included disability, Charlson Comorbidity Index (CCI) scores, and prevalence period.

Health behaviors influenced by predisposing, enabling, and need factors were analyzed for telemedicine and in-person consultations. Health behaviors included outpatient visits, medication prescriptions, and medication amounts as variables, indicating that patients with chronic diseases used healthcare and medical services. Health outcomes influenced by health behaviors include medication adherence, hospitalization, ER visits, and visits for diabetes-related complications or depression.

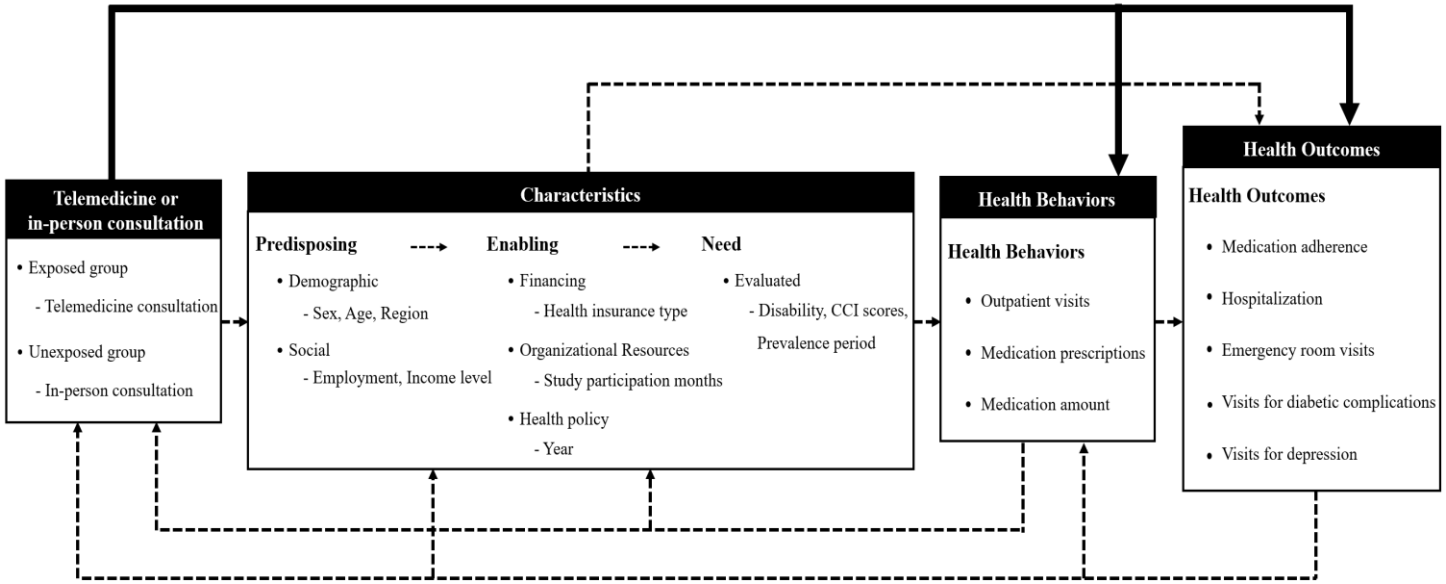


Figure 2. Conceptual Framework of the Study

2. Data Sources and Study Population

2.1. Data Sources

We obtained a customized cohort from the Korea NHIS to test our hypotheses. Since the implementation of universal health coverage in 1989, all Korean citizens have been required to enroll in the NHIS, resulting in coverage of approximately 98% of the population. The NHIS database integrates various types of data, including health examination records, medical claims, sociodemographic information, and mortality statistics, for the entire Korean population. Among these, medical claims data are the most comprehensive, offering detailed information on healthcare utilization and related activities.[71]

The customized cohort was constructed by randomly sampling 50% of Korean patients aged 19 years or older who were diagnosed with diabetes or schizophrenia. This dataset spans from January 2018 to December 2022 and includes medical information derived from healthcare claims statements coded according to the International Classification of Diseases, 10th revision (ICD-10). All patient information, including demographic, socioeconomic, and health-related variables, was anonymized. Information regarding telemedicine services was extracted from healthcare claims statements using specific billing codes.[72]

2.2. Study Population

We focused on patients with chronic diseases, who were the main users of telemedicine. We targeted diabetes as the chronic physical disease and schizophrenia as the chronic mental disease. The ICD-10 codes for diabetes and schizophrenia are presented in Table 6. A total of 3,799,568 patients with diabetes and 260,424 patients with schizophrenia were included among adults aged 19 years or older from January 1, 2019, to December 31, 2022, in the acquired customized cohort.

Table 6. Targeted Study Diseases by Type

Type	Diseases	ICD-10 code
Physical side	Diabetes	E10, E11, E12, E13, E14
Psychiatric side	Schizophrenia	F20, F21, F22, F23, F24, F25, F26, F27, F28, F29

Based on the Centers for Disease Control and Prevention (CDC) criteria, 1,366,319 patients with diabetes and 109,133 patients with schizophrenia for less than 1 year were excluded. Outliers of outpatient visits, hospitalizations, and ER visits were eliminated to increase the reliability and robustness of the data. Patients above the 99.5th percentile were considered outliers, and 16,059 patients with diabetes and 582 patients with schizophrenia were excluded.[73,74]

The telemedicine and in-person groups by disease were matched 1:3 using risk set matching, exact matching for sex and age, and Propensity score (PS) matching for CCI scores and prevalence period to control for confounding factors, including time-dependent variables. After matching and exclusion, there were 130,936 patients with diabetes: 32,734 in the telemedicine group and 98,202 in the in-person group. There were 6,644 patients with schizophrenia: 1,661 in the telemedicine group and 4,983 in the in-person group.

We performed sampling for analysis within the allowed computer memory according to the NHIS policy that provided the data. Stratified sampling was performed for sex and age. Random sampling was used to extract 2% of patients with diabetes and 20% of patients with schizophrenia. The characteristics of the participants after matching and sampling were confirmed using the Standardized Mean Difference (SMD). Finally, 2,620 patients with diabetes were included: 655 in the telemedicine group and 1,965 in the in-person consultation group (Figure 3). The total number of patients with schizophrenia was 1,328, with 332 in the telemedicine group and 996 in the in-person consultation group (Figure 4). Additionally, the group of telemedicine twice or more, and the in-person group were extracted for sub-analysis. The selection flow was consistent, whereas 3% of patients with diabetes and 30% of patients with schizophrenia were sampled for sample size.

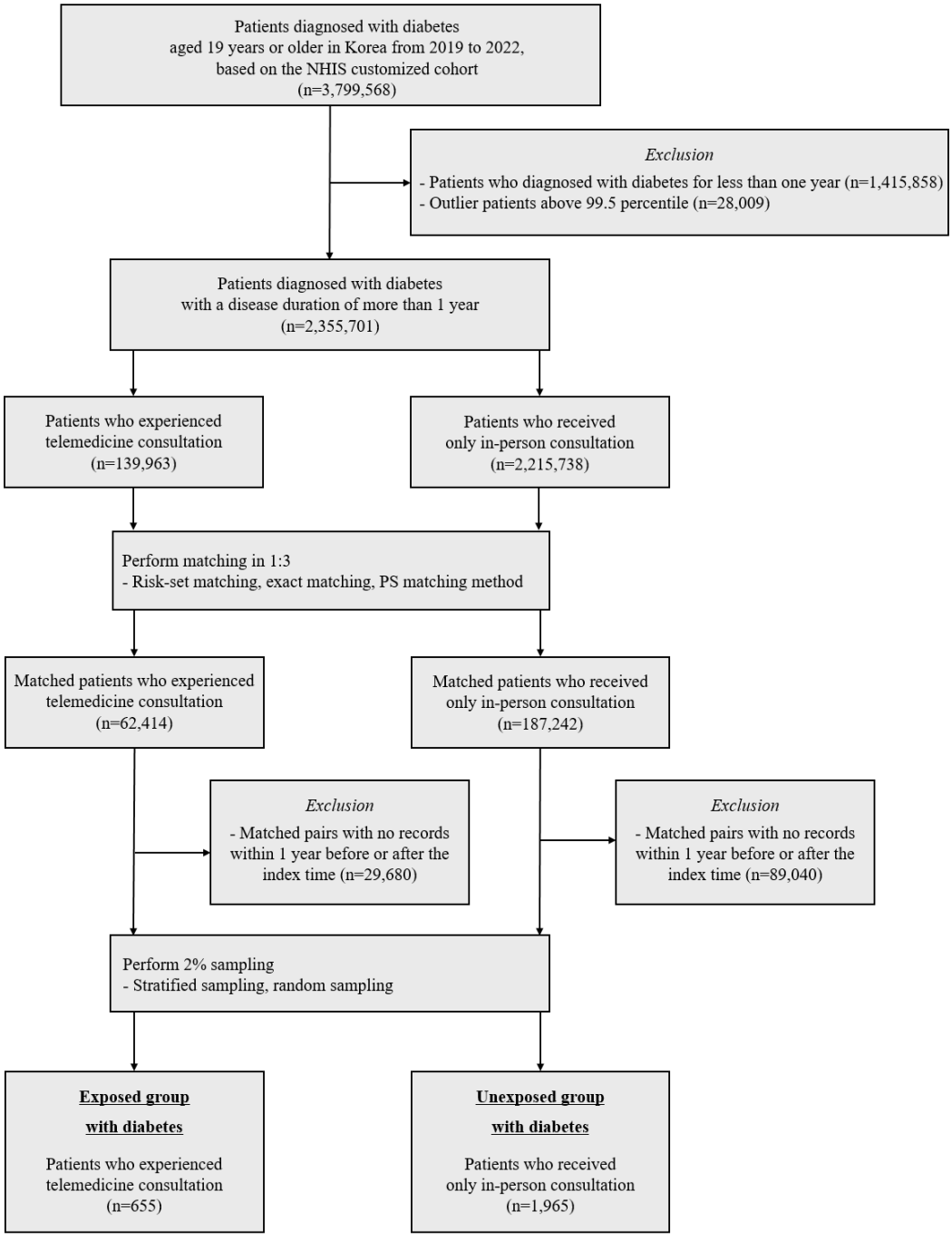


Figure 3. Flowchart of Study Patients Selection: Patients with Diabetes

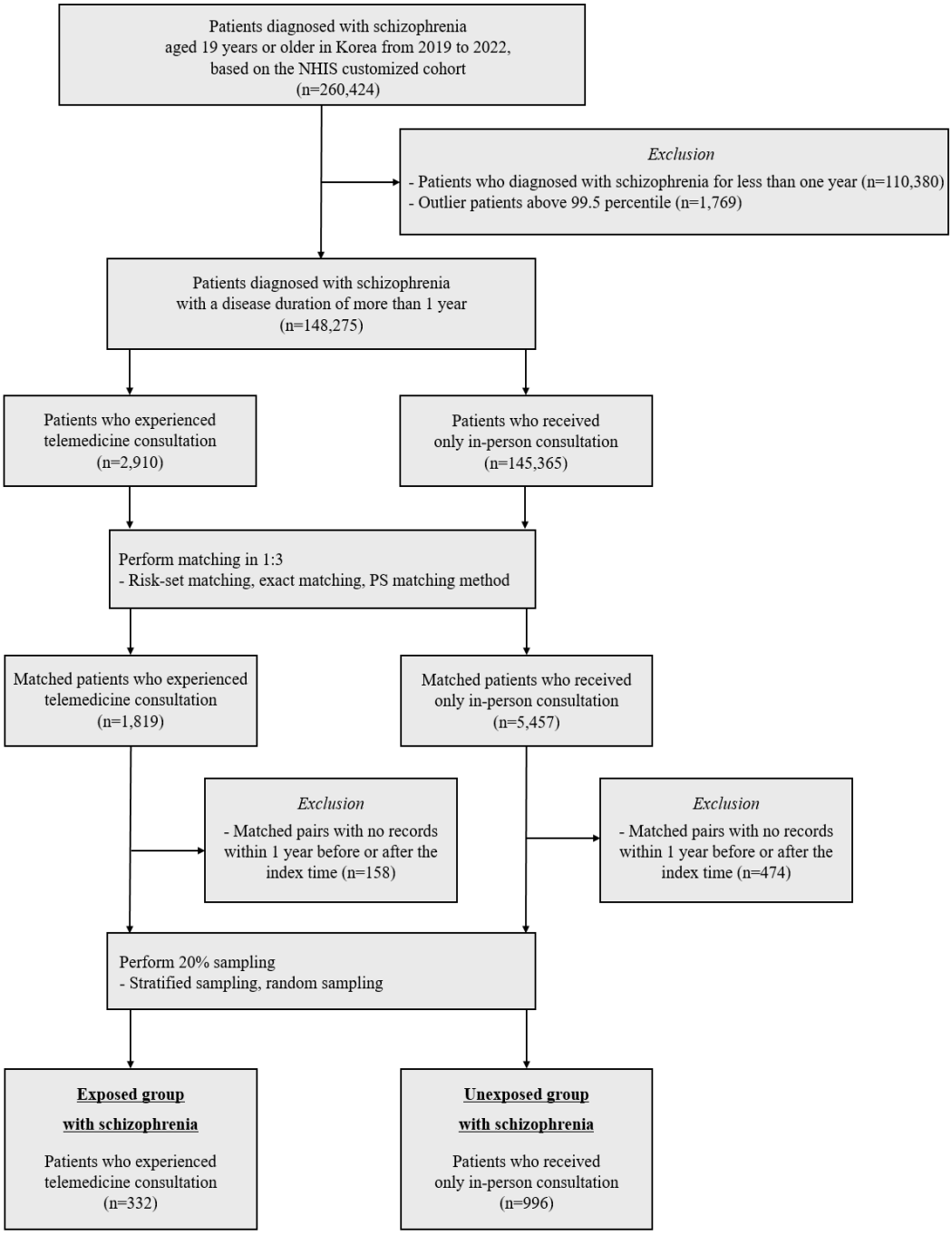


Figure 4. Flowchart of Study Patients Selection: Patients with Schizophrenia

3. Variables

3.1. Outcome Variables

The outcome variables were classified as healthcare utilization and health outcome indicators. Among the eight variables, three were healthcare utilization indicators, and five were health outcome indicators. The indicator classifications and distribution models of the outcome variables are presented in Table 7.

3.1.1. Healthcare Utilization Indicators

Healthcare utilization indicators included the number of days of outpatient visits, the number of medication prescriptions, and the amount of prescribed medication.

Outpatient visits were calculated as the number of days patients with diabetes or schizophrenia visited medical and health institutions for each disease by month. For patients with schizophrenia, the number of days they visited psychiatric outpatient clinics was also included. Outpatient visits, treated as a count variable, exhibited equidispersion and were modeled using a generalized Poisson distribution.[75]

Medication prescriptions were calculated as the number of days of all medications prescribed for diabetes or schizophrenia per month. Medication prescriptions, treated as count variables, exhibited equidispersion and were modeled using a generalized Poisson distribution.[75]

The prescribed medication amount was calculated as the average daily dose of medications prescribed for diabetes or schizophrenia and expressed in grams. The doses were calculated for the 50 most frequently prescribed drugs. The 50 most frequently used drugs are presented in Appendix 3 and 4. The medication amount, treated as continuous, exhibited underdispersion and was modeled using a Tweedie distribution.[76]

3.1.2. Health Outcome Indicators

Health outcome indicators included medication adherence, days of hospitalization, days of ER visits, doctor visits for diabetic complications, and doctor visits for depression.

Medication adherence was calculated as the monthly proportion of days covered (PDC). We chose the PDC method to account for the multidrug regimen of patients with polypharmacy. Medication adherence included all the medications prescribed for diabetes and schizophrenia. The PDC is calculated as follows:[77]

$$\mathrm{PDC} = \frac{\text{Covered Days (Non-overlapping days of medication use)}}{\text{Observation Period Days}}$$

Medication adherence, treated as a continuous variable, was under-dispersed and modeled using the Tweedie distribution.[76]

Hospitalization was calculated as the number of days of hospitalization in medical and healthcare facilities for each type of diabetes and schizophrenia per month. The duration of psychiatric hospitalization was also included in the study. This count variable exhibited equidispersion with a zero proportion exceeding 90% and was modeled using a Zero-Inflated Poisson (ZIP) distribution with a complementary log-log (cloglog) link function.[78-80]

ER visits were calculated as the monthly number of days in which patients with diabetes or schizophrenia were treated as emergencies or referrals for healthcare claims statements. ER visits, calculated as count variables, were equidispersion and assumed a generalized Poisson distribution.[75]

Visits for diabetes-related complications were calculated as the monthly number of days that patients with diabetes had healthcare claims statements for diabetes-related complications. Complications associated with diabetes are detailed in Appendix 5. Visits for diabetes complications, treated as continuous, exhibited underdispersion, with a zero

proportion exceeding 60%, and were modeled using a Zero-Inflated Negative Binomial (ZINB) distribution with a logit link function.[81]

Visits for depression were calculated as the monthly number of days that patients with diabetes or schizophrenia received healthcare claims statements for depression. ICD-10 codes for depression are presented in Appendix 5. Visits for depression, treated as a count variable, exhibited underdispersion, with a zero proportion exceeding 85%, and were modeled using a ZINB distribution with a cloglog link function.[81]

Table 7. Classification and Distribution Models of Outcome Variables

Indicator Classification	Outcome Variables	Distribution Model
Healthcare Utilization	Days of outpatient visits (per month)	Generalized Poisson
	Number of medication prescriptions (per month)	Generalized Poisson
	Prescribed medication amount (daily average, grams)	Tweedie
Health Outcomes	Medication adherence (per month, %)	Tweedie
	Days of hospitalization (per month)	ZIP
	Days of ER visits (per month)	Generalized Poisson
	Doctor visits for diabetes complications (per month)[a]	ZINB
	Doctor visits for depression (per month)	ZINB

[a] Restricted to patients diagnosed with diabetes.

3.2. Variable of Interest

The variable of interest in this study was telemedicine exposure. The study design for telemedicine exposure using a comparative interrupted time series (CITS) is outlined in Figure 5.

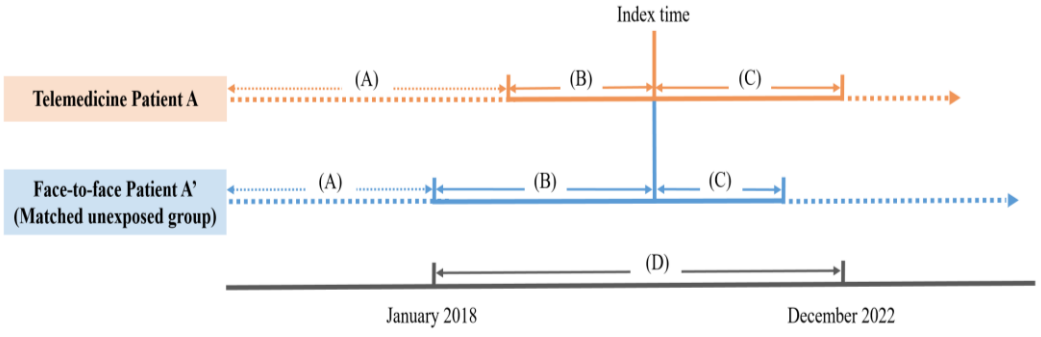


Figure 5. Study Design of Dynamic Cohort for CITS

Based on the CDC's chronic disease criteria, the period (A) when diabetes or schizophrenia lasted less than 1 year was excluded to ensure the stability of the cohort. Telemedicine is distinguished by the type of medical practice and specific details of the healthcare claim statements, as shown in Table 8.

Table 8. Telemedicine Identification Based on Prescription Records

Prescription Records	Identification
Type of medical practice	Telephone consultation, Remote consultation, Remote collaborative treatment
Specific details	Telephone, Telemedicine, Telehealth, Non-face-to-face

The telemedicine group comprised patients who were exposed to telemedicine consultation at least once, whereas the in-person group comprised patients who received only in-person consultations. As the experience and timing of telemedicine use in patients varied, risk set matching was used to adjust for time-dependent confounding variables. The first telemedicine consultation date for each patient who received telemedicine was designated as the index time. In addition, exact matching and PS matching were performed to enhance the comparability between the exposed patient A and unexposed patient A'.[82]

Each patient's observation period was within one year before (B) and after (C) the index time. The observation period, from the start date of period (B) to the last day of period (C), ranged from January 2019 to December 31, 2022 (D). As the study followed a dynamic cohort design, the basic time unit was elapsed time.

3.3. Independent Variables

The independent variables were grouped into four categories: demographic, socioeconomic, health-related, and study context factors for a total of 11 variables.

Demographic factors included sex, age, and region; socioeconomic factors included employment, income level, and health insurance type; health-related factors included disability, CCI scores, and prevalence period; and study context factors included year and study participation months. CCI scores were calculated for the year prior to the date of treatment. The subcategories of each variable are detailed in Table 9.

Table 9. Definition and Categories of Independent Variables

Variable Categories	Independent Variables	Definition
Demographic factors	Sex	Male, Female
	Age (years)	19 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 or more
	Region	Metropolis, Small cities and rural
Socioeconomic factors	Employment	White collar, Service industry, Blue collar, Unemployed
	Income level	Low (20th percentile, 0 to 6), Medium (7 to 13), High (14 to 20)
	Health insurance type	Employment-insured, Community-insured, Medical aid
Health-related factors	Disability	No, Yes
	CCI scores [a]	0, 1, 2, 3 or more
	Prevalence period	New onset, 1 year, 2 years, 3 years or more
Study Context Factors	Year	2019, 2020, 2021, 2022
	Study participation months	1 to 24 months

[a] CCI scores were calculated by Quan's method with weights assigned for the period one year prior to the time of analysis (Appendix 6).[83,84]

4. Statistical Methods

4.1. Study Design

We obtained a customized retrospective cohort from the NHIS, tailored our research objectives, and conducted a quasi-experimental study using the data. We created a dynamic cohort using the first telemedicine consultation day of the telemedicine group as the index time, and matched the risk set with the in-person consultation day of the in-person group without replacement.

To evaluate the longitudinal impact of the telemedicine, the pre-policy period was defined as the time before the index date and the post-policy period as the time after. A CITS design was adopted, with the telemedicine group serving as the policy-exposed group and the in-person group serving as the non-exposed group. The CITS equation used in this study is the generalized linear mixed model (GLMM) method, which is as follows:[85-87]

$$g(E[Y_{it}]) = \beta_0 + \beta_1 \cdot Time_t + \beta_2 \cdot Intervention_t + \beta_3 \cdot (Time_t \cdot Intervention_t)$$
$$+\beta_4 \cdot Group_i + \beta_5 \cdot (Group_i \cdot Time_t) + \beta_6 \cdot (Group_i \cdot Intervention_t)$$
$$+\beta_7 \cdot (Group_i \cdot Time_t \cdot Intervention_t) + \beta_x \cdot X_{it} + u_i + e_{it}$$

g: Link function

E: Expectation

Y: Dependent variables

t: Time period

i: Individual

Time: Time variable

Intervention: Dummy variable that assigns 1 after the index time calculated by risk matching with the first telemedicine consultation (Intervention=1: after the index time; intervention=0: before the index time)

Group: Dummy variable which assigns 1 if the patients experienced telemedicine consultations (Group=1: telemedicine group; Group=0: in-person group)

X_{it}: Covariates

u_i: Random effects for individuals

e_{it}: Error term

4.2. Model Specification and Distribution

This study was conducted using a mixed-effects model, specifically the GLMM. The exposure variable, which represented the primary focus of the study, and other independent variables were modeled as fixed effects to evaluate their population-wide influence on healthcare utilization and health outcomes. Random effects were included to account for individual-level variability and model correlations arising from repeated measurements among individuals. This approach allowed us to examine the impact of telemedicine policies while adjusting for heterogeneity across individuals.

We conducted nonlinear mixed-effects model analyses, accounting for the distribution type by outcome. The regression models incorporated distributions such as Tweedie, generalized Poisson, ZIP, and ZINB, which were chosen based on the characteristics of the dependent variable. To address autocorrelation in the data, a log-likelihood function was formulated using an autoregressive model of order one [AR(1)].

The variables for the zero-inflation component were selected using a stepwise logistic regression method. Among the outcomes, hospitalization and depression demonstrated excess zero inflation; as a result, a cloglog link function was employed. A logit link function was used to model the outcomes of diabetic complications.

4.3. Statistical Assumptions

The main assumptions of CITS were identified as follows:

First, stationarity was evaluated using the augmented Dickey-Fuller (ADF) test. For all diseases and outcomes analyzed, the p-value for the ADF test statistic under the trend hypothesis was less than 0.0001. Consequently, the null hypothesis (H0) of the unit root is rejected, indicating that the data are stationary.[88]

Second, independence and autocorrelation were evaluated using the Durbin-Watson (DW) test.[89] For all diseases and outcomes analyzed, the DW statistic was less than two and the p-value was below 0.0001, indicating the presence of positive autocorrelation. In patients with diabetes, the DW statistic was highest for the prescribed medication amount (1.5148) and lowest for doctor visits for depression (0.9102). In patients with schizophrenia, the DW statistic was highest for the number of medication prescriptions (1.101) and lowest for doctor visits for depression (0.4755). Further evaluation of the residual autocorrelation using a time-series plot of Pearson residuals revealed heteroscedasticity, characterized by increased residual volatility at the index time when the policy was implemented. The autocorrelation function (ACF) and partial autocorrelation function exhibit gradual decay with a high autocorrelation coefficient at lag one.[90] Therefore, the AR(1) structure is incorporated into the log-likelihood function.

Third, the homoscedasticity was evaluated using a residual-versus-predicted value plot.[91] For zero-inflated outcomes, the variance in Pearson residuals was larger at smaller predicted values and gradually decreased as the predicted values increased. However, this tendency was less pronounced for nonzero-inflated outcomes. To address these issues, an AR(1) structure was incorporated into the model to account for temporal autocorrelation, and random effects were included to adjust for individual heterogeneity. Appropriate distributions were applied to each outcome to address heteroscedasticity, overdispersion, underdispersion, and residual non-normality.

Fourth, the linearity was assessed using plots of residuals over time and regression lines. While the variance of the Pearson residuals increased slightly at the index time, when exposure to the policy began, the regression line of the residuals over time remained horizontal, indicating no systematic temporal trend. Thus, the linearity assumption is generally supported but was further reinforced in the model by including interaction terms between time and policy interventions, as well as individual random effects.[92]

Finally, residual normality was assessed both statistically and visually. Pearson residuals were evaluated using the Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling tests, as well as histograms, quantile-quantile (Q-Q) plots, and probability-probability (P-P) plots. For all diseases and outcomes, the p-values for the Kolmogorov-Smirnov test were less than 0.01, and the Cramer-von Mises and Anderson-Darling tests had statistics less than 0.005. The histograms of the residuals exhibit negative skewness. In the Q-Q plot, the observed quantiles deviate from the theoretical quantiles, particularly for larger values. In the P-P plot, the empirical cumulative distribution function does not align with the theoretical cumulative distribution function at larger values. Therefore, the normality assumption was not satisfied and a suitable log-likelihood distribution was applied to each outcome.[93-96]

Multicollinearity was assessed using variance inflation factors (VIF). The VIF values for all variables were less than 10, indicating that it was not a significant issue.[97]

4.4. Main and Sub-analyses

This study was conducted using a matched-pair design of telemedicine and in-person consultations. Outcomes for healthcare utilization and health outcomes in patients with diabetes and schizophrenia were analyzed using a mixed-effects model implemented with the PROC NLMIXED and PROC SGPLOT procedures.[98,99]

Exposure and independent variables were modeled as fixed effects, and individuals were treated as random effects. Based on the characteristics of the outcome variables, the

log-likelihoods reflecting AR(1) were estimated using Tweedie, generalized Poisson, ZIP, and ZINB distributions.

Zero-inflated component variables were modeled using stepwise logistic regression. The zero-inflated link function uses cloglog and logit, depending on the proportion of zeros. For zero-inflated outcomes, the predicted values presented in the results reflect the probability of non-zero outcomes.

The main analysis presented the overall policy effect and the differences before and after policy implementation for both the telemedicine and in-person groups, categorized by disease and outcome. These effects were reported as exponentiated parameter estimates [Exp(β)] with 95% confidence intervals (CIs). Statistical graphics for the predicted values were provided, showing the elapsed time before and after the index time.

The sub-analyses included analyses stratified by the number of telemedicine consultations. Additionally, outcomes for the entire group and details analyses by independent variables, by outcome tertile, and by calendar time are presented as Appendix.

The telemedicine and in-person groups were matched by the exact, PS, and risk-set methods were evaluated for adequacy of matching by SMD. The adequacy of the matching and sampling processes for the telemedicine and in-person consultation groups, which were finally produced by stratification and random sampling after matching, was also evaluated by SMD. The general characteristics of the participants are presented as frequencies and percentages using descriptive statistical analysis. Additionally, the mean and standard deviation (SD) of the outcomes by group and before and after policy implementation were reported.

Statistical analyses were performed using Statistical Analysis System (SAS) version 9.4 software (SAS Institute Inc., Cary, NC, USA). Statistical significance was set at $p < 0.05$.

5. Ethics Statement

The study protocol was reviewed and approved by the Institutional Review Board of Yonsei University Health System in accordance with the principles of the Declaration of Helsinki (IRB Number: 4-2023-0902). The requirement for informed consent was waived because the NHIS database obtained (NHIS-2024-1-112) does not contain any personally identifiable information.

IV. Results

1. Characteristics of Study Participants

1.1. General characteristics at index time

The general characteristics of participants with diabetes or schizophrenia are presented in Tables 10 and 11, respectively. These tables present the variables corresponding to the demographic, socioeconomic, health-related, and study context factors of the participants at the index time. The study included patients aged 19 years or older with a disease duration of more than one year.

1.1.1. General characteristics at index time in patients with diabetes

A total of 2,620 participants with diabetes were analyzed, with 655 (25%) in the telemedicine consultation group and 1,965 (75%) in the in-person consultation group. The participants had a similar sex distribution, with 51.6% male and 48.4% female, and the mean age was 62.3 years (SD: 15.6 years). Among them, 44.3% lived in metropolitan areas and 55.7% lived in small cities or rural areas.

Regarding socioeconomic factors, 39.5% of the participants with diabetes were unemployed, and blue-collar workers were the most common (28.1%). Income levels were reported as high (42.8%), medium (27.8%), and low (29.5%).

Regarding health-related factors, 12.1% of participants with diabetes had disabilities, and the most common CCI score was 1 (47.5 %). The diabetes duration was reported as 2 years for 42.1% of participants and 3 years or more for 43.3%.

Regarding the study context factors, the index time for participants with diabetes was generally distributed across 2020 (37.3%), 2021 (28.6%), and 2022 (34.1%). The average study observation period was 15.5 months (SD: 5.4 months) for the telemedicine group and 9.2 months (SD: 5.5 months) for the in-person group.

Table 10. Characteristics of Study Population with Diabetes at Index

Variables	Patients with diabetes						*SMD*
	Total		Telemedicine group		In-person group		
	n	%	n	%	n	%	
Sex							*0.000*
Male	1,352	51.60	338	51.60	1,014	51.60	
Female	1,268	48.40	317	48.40	951	48.40	
Age (Mean: 62.3, SD: 15.6)							*0.000*
19 to 29	32	1.22	8	1.22	24	1.22	
30 to 39	184	7.02	46	7.02	138	7.02	
40 to 49	372	14.20	93	14.20	279	14.20	
50 to 59	564	21.53	141	21.53	423	21.53	
60 to 69	536	20.46	134	20.46	402	20.46	
70 or more	932	35.57	233	35.57	699	35.57	
Region							*0.111*
Metropolis	1,160	44.27	317	48.40	843	42.90	
Small cities and rural	1,460	55.73	338	51.60	1,122	57.10	
Employment							*0.035*
White collar	386	14.73	81	12.37	305	15.52	
Service industry	461	17.60	115	17.56	346	17.61	
Blue collar	737	28.13	191	29.16	546	27.79	
Unemployed	1,036	39.54	268	40.92	768	39.08	
Income level							*0.039*
High	1,121	42.79	270	41.22	851	43.31	
Medium	727	27.75	186	28.40	541	27.53	
Low	772	29.47	199	30.38	573	29.16	
Health insurance							*0.039*
Workplace-insured	1,649	62.94	405	61.83	1,244	63.31	
Regionally-insured	786	30.00	199	30.38	587	29.87	
Medical aids	185	7.06	51	7.79	134	6.82	
Disability							*0.037*
No	2,304	87.94	582	88.85	1,722	87.63	
Yes	316	12.06	73	11.15	243	12.37	

Table 10. (Continued)

Variables	Patients with diabetes						*SMD*
	Total		**Telemedicine group**		**In-person group**		
	n	**%**	**n**	**%**	**n**	**%**	
CCI scores (Mean: 2.0, SD: 1.5)							*0.007*
1	1,244	47.48	311	47.48	933	47.48	
2	637	24.31	162	24.73	475	24.17	
3 or more	739	28.21	182	27.79	557	28.35	
Prevalence period years (Mean: 2.5, SD: 0.9)							*0.029*
1 year	382	14.58	93	14.20	289	14.71	
2 year	1,104	42.14	271	41.37	833	42.39	
3 years or more	1,134	43.28	291	44.43	843	42.90	
Year (Mean: 2021.0, SD: 0.8)							*0.000*
2019	4	0.15	1	0.15	3	0.15	
2020	976	37.25	244	37.25	732	37.25	
2021	748	28.55	187	28.55	561	28.55	
2022	892	34.05	223	34.05	669	34.05	
Study participation months (Mean: 10.8, SD: 6.1)							*1.146*
Telemedicine group: Mean 15.539, SD: 5.398							
In- In-person group: Mean: 9.241, SD: 5.528							
Total	**2,620**	**100.00**	**655**	**25.00**	**1,965**	**75.00**	

1.1.2. General characteristics at index time in patients with schizophrenia

Among the 1,328 participants with schizophrenia, the ratio of the telemedicine consultation group (n=332, 25%) to the in-person consultation group (n=996, 75%) was 1:3. The gender distribution was fairly balanced (male: 48.5%, female: 51.5%), and the age had a mean of 58.3 years (SD: 15.1 years). Participants living in small cities and rural areas accounted for 62.0%, which was higher than that of those living in metropolitan areas.

Regarding the socioeconomic factors of patients with schizophrenia, 67.1% of the participants were unemployed and 15.4% of those employed worked in blue-collar jobs. 59.9% of them had low income, while 22.4% had high income.

In terms of health-related factors, 51.5% of participants with schizophrenia reported disabilities. The participants' CCI scores were 0 (68.4 %) and 1 (19.5 %). The most commonly reported duration of schizophrenia was two years (75.8%).

Regarding study context factors, the index time for patients with schizophrenia was 78.0% in 2020 and 12.3% in 2022. The average study observation period was 19.4 months (SD: 4.9 months) for the telemedicine group and 17.9 months (SD: 6.1 months) for the in-person group.

Table 11. Characteristics of Study Population with Schizophrenia at Index Time

Variables	Patients with schizophrenia						*SMD*
	Total		Telemedicine group		In-person group		
	n	%	n	%	n	%	
Sex							0.*000*
Male	644	48.49	161	48.49	483	48.49	
Female	684	51.51	171	51.51	513	51.51	
Age (Mean: 53.8, SD: 15.1)							*0.000*
19 to 29	80	6.02	20	6.02	60	6.02	
30 to 39	152	11.45	38	11.45	114	11.45	
40 to 49	256	19.28	64	19.28	192	19.28	
50 to 59	364	27.41	91	27.41	273	27.41	
60 to 69	276	20.78	69	20.78	207	20.78	
70 or more	200	15.06	50	15.06	150	15.06	
Region							*0.213*
Metropolis	505	38.03	101	30.42	404	40.56	
Small cities and rural	823	61.97	231	69.58	592	59.44	
Employment							*0.176*
White collar	106	7.98	25	7.53	81	8.13	
Service industry	127	9.56	29	8.73	98	9.84	
Blue collar	204	15.36	35	10.54	169	16.97	
Unemployed	891	67.09	243	73.19	648	65.06	
Income level							*0.164*
High	297	22.36	66	19.88	231	23.19	
Medium	236	17.77	42	12.65	194	19.48	
Low	795	59.86	224	67.47	571	57.33	
Health insurance							*0.276*
Workplace-insured	451	33.96	94	28.31	357	35.84	
Regionally-insured	331	24.92	61	18.37	270	27.11	
Medical aids	546	41.11	177	53.31	369	37.05	
Disability							*0.294*
No	644	48.49	125	37.65	519	52.11	
Yes	684	51.51	207	62.35	477	47.89	

Table 11. (Continued)

Variables	Patients with schizophrenia						*SMD*
	Total		Telemedicine group		In-person group		
	n	%	n	%	n	%	
CCI scores (Mean: 0.5, SD: 1.1)							*0.007*
0	908	68.37	227	68.37	681	68.37	
1	259	19.50	63	18.98	196	19.68	
2	80	6.02	22	6.63	58	5.82	
3 or more	81	6.10	20	6.02	61	6.12	
Prevalence period years (Mean: 2.2, SD: 0.7)							*0.004*
1 year	108	8.13	27	8.13	81	8.13	
2 year	1,006	75.75	252	75.90	754	75.70	
3 years or more	214	16.11	53	15.96	161	16.16	
Year (Mean: 2020.3, SD: 0.7)							*0.000*
2019	4	0.30	1	0.30	3	0.30	
2020	1,036	78.01	259	78.01	777	78.01	
2021	124	9.34	31	9.34	93	9.34	
2022	164	12.35	41	12.35	123	12.35	
Study participation months (Mean: 18.3, SD: 5.9)							*0.287*
Telemedicine group: Mean 19.437, SD: 4.852							
In- In-person group: Mean: 17.855, SD: 6.106							
Total	**1,328**	**100.00**	**332**	**25.00**	**996**	**75.00**	

1.2. Telemedicine Utilization Rate

Figure 6 shows the cumulative frequency of telemedicine use during the 12 months following the index. Among patients with diabetes, 655 used telemedicine. Among patients with diabetes who experienced telemedicine, 343 (52.4%) experienced telemedicine once, and 312 (47.6%) experienced telemedicine twice or more. Among patients with schizophrenia, 332 experienced telemedicine. Among the patients with schizophrenia who experienced telemedicine, 141 (42.5%) experienced telemedicine once and 191 (57.5%) experienced telemedicine twice or more. Telemedicine for patients with diabetes and schizophrenia had similar cumulative frequency patterns. The cumulative number of patients with an increase in telemedicine experience was lower.

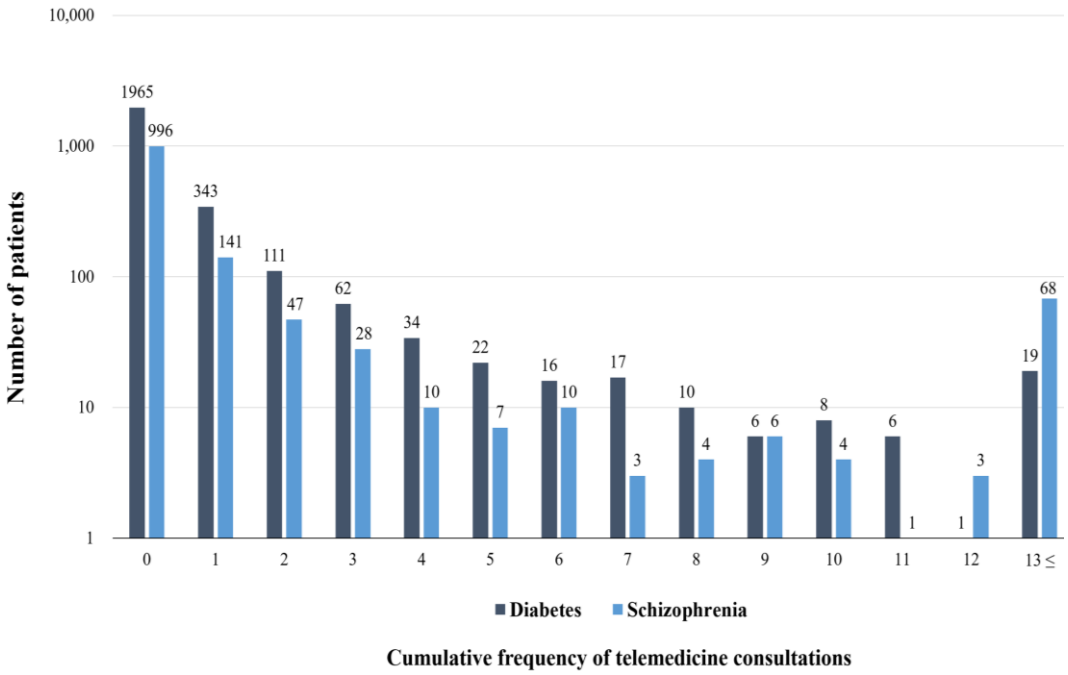


Figure 6. Cumulative Frequency of Telemedicine Consultations per Patient by Disease within 12 Months Post-Index Time

2. Comparison of Outcomes Before and After Index Time

Outcomes before and after the index period are presented in Table 12 for patients with diabetes and Table 13 for patients with schizophrenia.

2.1. Comparison of Outcomes Before and After Index Time in Patients with Diabetes

The telemedicine group had the lowest difference in the mean value of the pre- and post-exposure periods in the number of medication prescriptions per month (0.005). In contrast, monthly medication adherence was 66.2% in the pre-exposure period but decreased by approximately 5.0% to 61.2% in the post-exposure period. The daily average prescribed medication amount increased by 0.5 grams from 6.6 grams before the index time.

In the in-person group, the monthly days of hospitalization showed the smallest difference (0.003) before and after the index time. In the in-person group, the outcomes with the largest increases and decreases in the difference before and after the index time were the same as those in the telemedicine group. Medication adherence decreased by 9.9% from 74.9% before the index time, and the prescribed medication amount increased by 1.91 grams from 11.2 grams.

2.2. Comparison of Outcomes Before and After Index Time in Patients with Schizophrenia

In patients with schizophrenia, the outcome with the smallest difference before and after the index time was the number of days of hospitalization per month, with a difference of 0.006 in the telemedicine group and -0.004 in the in-person group.

In patients with schizophrenia, the greatest increase from the pre- to post-index time was in medication adherence, which was the opposite pattern to that observed in patients with diabetes. In the telemedicine group, medication adherence increased by 11.4% from 50.8% before the index time, and by 12.0% from 48.5% in the in-person group.

Table 12. Healthcare Utilization and Health Outcomes in Patients with Diabetes Before and After Index Time

Outcomes	Patients with diabetes							
	Telemedicine group				In-person group			
	Before		After	Diff.[a]	Before		After	Diff.[a]
	Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD	
Healthcare utilization								
Days of outpatient visits (per month, days)	1.264 ± 0.726		1.398 ± 0.848	0.134	1.180 ± 0.577		1.257 ± 0.782	0.077
Number of medication prescriptions (per month, days)	1.053 ± 0.451		1.058 ± 0.603	0.005	0.966 ± 0.491		0.975 ± 0.586	0.009
Prescribed medication amount (average daily, grams)	6.617 ± 14.035		7.078 ± 16.708	0.461	11.232 ± 25.890		13.138 ± 31.492	1.906
Health outcomes								
Medication adherence (per month, %)	66.226 ± 32.527		61.196 ± 32.039	-5.030	74.856 ± 33.135		64.987 ± 33.232	-9.869
Days of hospitalization (per month, days)	0.006 ± 0.078		0.020 ± 0.157	0.014	0.020 ± 0.160		0.023 ± 0.177	0.003
Days of emergency room visits (per month, days)	0.935 ± 0.618		1.002 ± 0.718	0.067	0.844 ± 0.620		0.899 ± 0.785	0.055
Number of visits to the doctor for diabetes complications (per month, days)	0.512 ± 0.751		0.563 ± 0.861	0.051	0.458 ± 0.666		0.498 ± 0.862	0.040
Number of visits to the doctor for depression (per month, days)	0.035 ± 0.253		0.036 ± 0.239	0.002	0.033 ± 0.239		0.050 ± 0.336	0.017

[a] The difference between the mean of After and the mean of Before

Table 13. Healthcare Utilization and Health Outcomes in Patients with Schizophrenia Before and After Index Time

Outcomes	Patients with schizophrenia					
	Telemedicine group			In-person group		
	Before	After	Diff.[a]	Before	After	Diff.[a]
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Healthcare utilization						
Days of outpatient visits (per month, days)	1.262 ± 0.737	1.395 ± 0.886	0.133	1.292 ± 0.799	1.379 ± 0.943	0.086
Number of medication prescriptions (per month, days)	1.246 ± 0.633	1.380 ± 0.784	0.134	1.335 ± 0.692	1.413 ± 0.881	0.078
Prescribed medication amount (average daily, grams)	0.393 ± 1.329	0.544 ± 2.578	0.151	0.339 ± 1.806	0.361 ± 1.777	0.022
Health outcomes						
Medication adherence (per month, %)	50.787 ± 31.221	62.190 ± 28.731	11.404	48.471 ± 33.049	60.508 ± 29.849	12.037
Days of hospitalization (per month, days)	0.054 ± 0.257	0.060 ± 0.288	0.006	0.086 ± 0.330	0.082 ± 0.325	-0.004
Days of emergency room visits (per month, days)	1.104 ± 0.663	1.230 ± 0.813	0.127	1.224 ± 0.775	1.307 ± 0.949	0.083
Number of visits to the doctor for depression (per month, days)	0.158 ± 0.462	0.220 ± 0.602	0.062	0.163 ± 0.489	0.196 ± 0.582	0.033

[a] The difference between the mean of After and the mean of Before

3. Predicted Outcomes Before and After the Index Time

The predicted outcomes before and after the index time are presented in the order of patients with diabetes and schizophrenia.

The predicted values for each unit of each outcome. The predicted values were summed on a monthly basis; however, the medication amount was calculated as the daily average.

The predicted trends are presented in the graphs. The basic unit of study time on the x-axis of each graph is the elapsed time of the study. The records observed at the study elapsed time include records of diabetes and schizophrenia duration of one year or more in the study participants according to the study inclusion. Even if they were study participants, the records of diagnosis at the time when the duration of the disease was less than one year were excluded according to the exclusion condition.

3.1. Predicted Values and Trends in Patients with Diabetes

The predicted outcomes for patients with diabetes are presented in Table 14 and Figure 7.

A. Outpatient Visits

In patients with diabetes, the slopes of the monthly number of days of outpatient visits were similar between the telemedicine and in-person groups. Outpatient visits were slightly higher in the telemedicine group than in the in-person group during all the study periods. The average days of monthly outpatient visits were 1.28 days (95% CI: 1.27–1.29) before exposure and 1.35 days (95% CI: 1.35–1.36) after exposure in the telemedicine group, and 1.18 days (95% CI: 1.18–1.19) before exposure and 1.23 days (95% CI: 1.22–1.23) after exposure in the in-person group.

B. Medication Prescription

The monthly number of days of medication prescription was also slightly higher in the telemedicine group than that in the in-person group. The gap between the two groups tended

to increase after the exposure. Before exposure, the monthly average of medication prescriptions was 1.06 days (95% CI: 1.05–1.06) in the telemedicine group and 0.98 days (95% CI: 0.98–0.99) in the in-person group. After exposure, the average of medication prescriptions was 1.05 days (95% CI: 1.04–1.05) in the telemedicine group and 0.96 days (95% CI: 0.95–0.96) in the in-person group.

C. Medication Amount

The telemedicine group had lower medication amounts and relatively smaller fluctuations than the in-person group. Both groups tended to have lower mediation amounts before the index time, and this trend was alleviated after the index time. The mean daily dose of prescribed diabetes medications in the telemedicine group was 7.30 grams (95% CI: 7.02–7.58) before exposure and 6.69 grams (95% CI: 10.79–11.80) after exposure, regardless of the drug formulation. On the other hand, the in-person group had a mean daily dose of 11.29 grams (95% CI: 10.79–11.80) before exposure and 14.24 grams (95% CI: 13.66–14.82) after exposure.

D. Medication Adherence

In patients with diabetes, medication adherence increased in the telemedicine group and decreased in the in-person group before the index time. After the index period, both groups showed a decreasing trend, although the slope was more gradual in the telemedicine group. Monthly average medication adherence was 67.55% (95% CI: 66.96–68.14) before exposure and 59.97% (95% CI: 59.49–60.44) after exposure in the telemedicine group. In the in-person group, it was 73.25% (95% CI: 72.78–73.72) before exposure and 65.95% (95% CI: 65.53–66.36) after exposure.

E. Hospitalization

The predicted Monthly average hospitalizations were consistent with the predicted values during the study period. The telemedicine group had fewer average monthly

hospitalization days than the in-person group. The monthly average hospitalization days were 0.01 days (95% CI: 0.01–0.01) before exposure and 0.02 days (95% CI: 0.02–0.02) after exposure in the telemedicine group. On the other hand, the in-person group had 0.02 days (95% CI: 0.02–0.03) before exposure and 0.03 days (95% CI: 0.03–0.03) after exposure.

F. ER Visits

The number of days of ER visits days was slightly higher in the telemedicine group than in the in-person group throughout the study period. Compared to before exposure, the monthly ER visits days increased by 0.04 days in the telemedicine group, while it increased by 0.01 days in the in-person group. The monthly average ER visits days were 0.94 days (95% CI: 0.93–0.95) before exposure and 0.98 days (95% CI: 0.98–0.99) after exposure in the telemedicine group. In the in-person group, they were 0.87 days (95% CI: 0.86–0.88) before exposure and 0.88 days (95% CI: 0.87–0.88) after exposure.

G. Visits for Diabetes Complications

Regardless of the exposed or non-exposed group, the number of doctor visits for diabetes complications decreased by 0.03 days after the index time compared with before. The average number of monthly diabetes complication visits decreased from 0.55 days (95% CI: 0.55–0.56) to 0.52 days (95% CI: 0.51–0.52) in the telemedicine group and from 0.49 days (95% CI: 0.49–0.50) to 0.46 days (95% CI: 0.46–0.46) in the in-person group.

H. Visits for Depression

The predicted average number of monthly physician visits for depression among patients with diabetes showed a slightly increasing trend in the telemedicine and in-person groups. In both groups, the number increased from 0.03 days before the index time to 0.04 days after.

Table 14. Predicted Values Before and After Index Time in Patients with Diabetes [a]

Outcomes	Patients with diabetes							
	Predicted values							
	Before the index time				After the index time			
	Mean	95% CI		SD	Mean	95% CI		SD
Health utilization								
Outpatient visits (days)								
Telemedicine, twice or more	1.28	(1.27	– 1.29)	0.31	1.35	(1.35	– 1.36)	0.32
In-person consultations	1.18	(1.18	– 1.19)	0.35	1.23	(1.22	– 1.23)	0.38
Medication prescription (days)								
Telemedicine, twice or more	1.06	(1.05	– 1.06)	0.2	1.05	(1.04	– 1.05)	0.19
In-person consultations	0.98	(0.98	– 0.99)	0.23	0.96	(0.95	– 0.96)	0.23
Medication amount (grams)								
Telemedicine, twice or more	7.3	(7.02	– 7.58)	9.64	6.69	(6.43	– 6.95)	8.57
In-person consultations	11.29	(10.79	– 11.80)	21.91	14.24	(13.66	– 14.82)	25.28
Health outcomes								
Medication adherence (%)								
Telemedicine, twice or more	67.55	(66.96	– 68.14)	21.16	59.97	(59.49	– 60.44)	16.07
In-person consultations	73.25	(72.78	– 73.72)	21.28	65.95	(65.53	– 66.36)	18.97
Hospitalization (days)								
Telemedicine, twice or more	0.01	(0.01	– 0.01)	0.02	0.02	(0.02	– 0.02)	0.02
In-person consultations	0.02	(0.02	– 0.03)	0.03	0.03	(0.03	– 0.03)	0.03
Emergency room visits (days)								
Telemedicine, twice or more	0.94	(0.93	– 0.95)	0.23	0.98	(0.98	– 0.99)	0.24
In-person consultations	0.87	(0.86	– 0.88)	0.35	0.88	(0.87	– 0.88)	0.38
Visits for diabetes complications (days)								
Telemedicine, twice or more	0.55	(0.55	– 0.56)	0.21	0.52	(0.51	– 0.52)	0.22
In-person consultations	0.49	(0.49	– 0.50)	0.2	0.46	(0.46	– 0.46)	0.21
Visits for depression (days)								
Telemedicine, twice or more	0.03	(0.03	– 0.04)	0.02	0.04	(0.04	– 0.04)	0.02
In-person consultations	0.03	(0.03	– 0.03)	0.02	0.04	(0.04	– 0.05)	0.03

[a] The period of the predicted values is monthly, except for the medication amount, which is daily.

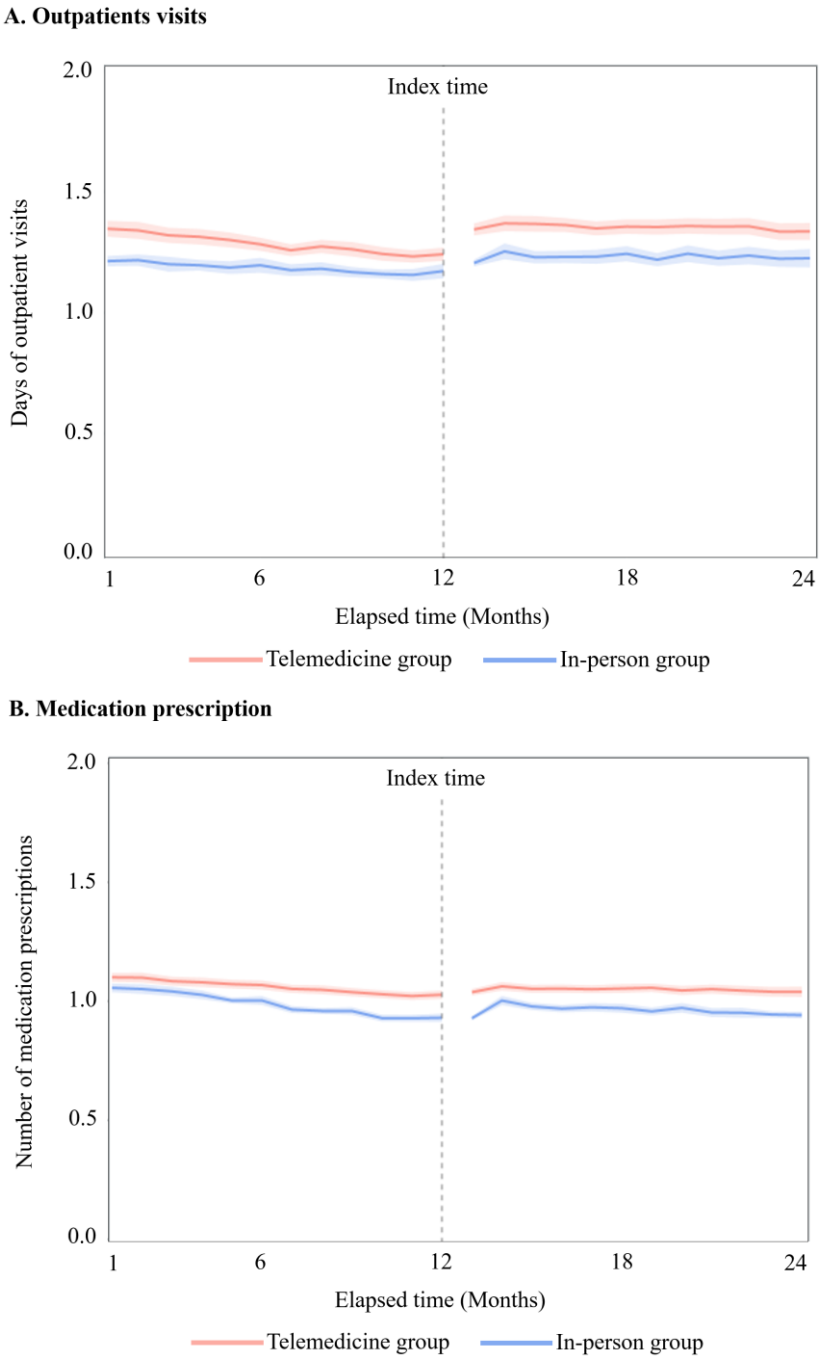
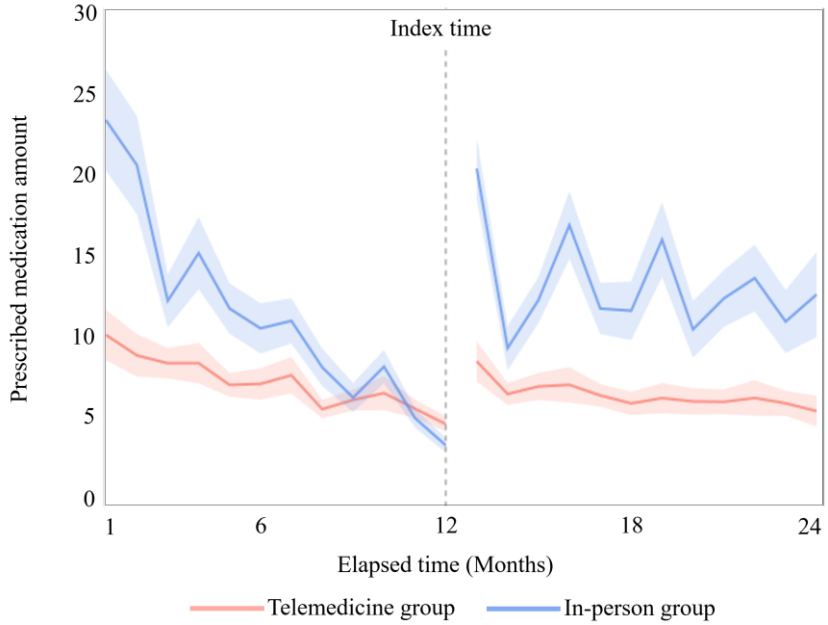


Figure 7. Visualization of Predicted Values Before and After Index Time in Patients with Diabetes

C. Medication amount



D. Medication adherence

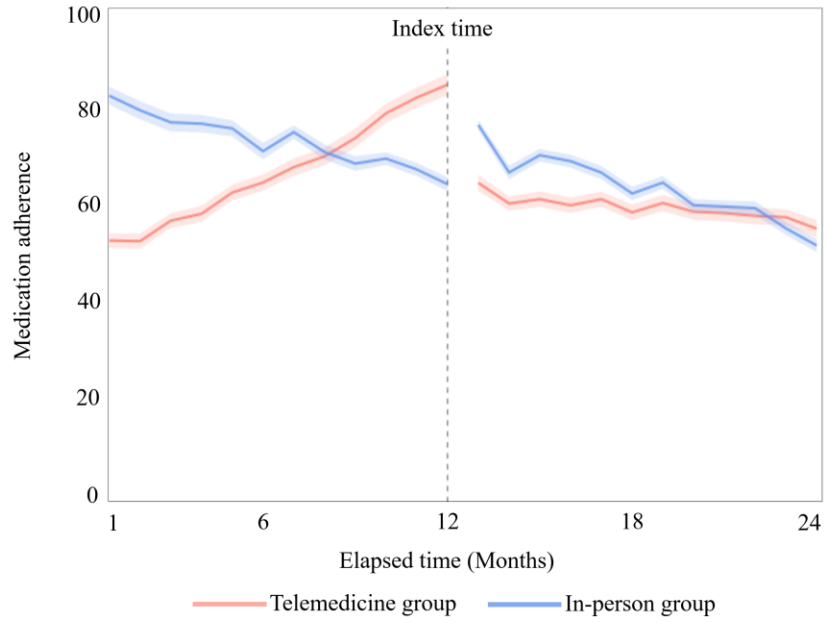
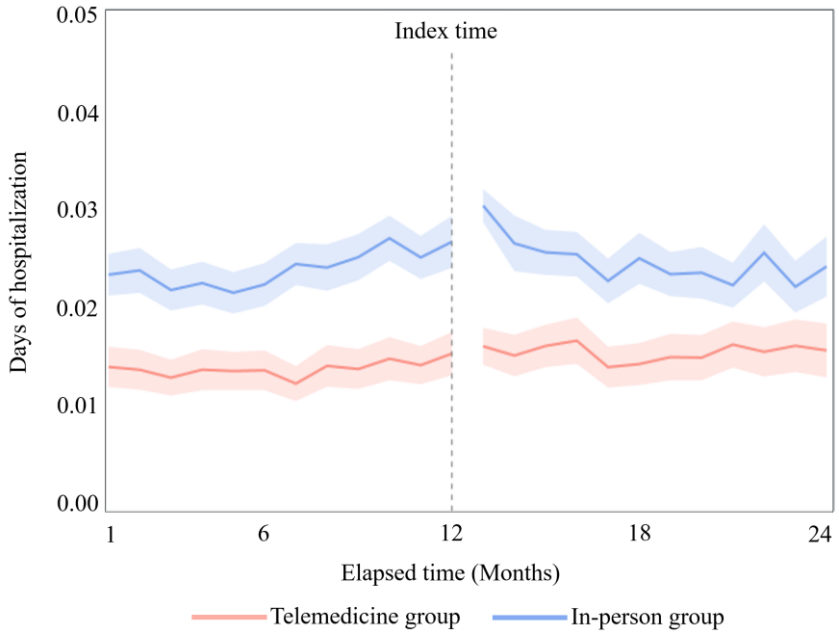


Figure 7. (Continued)

E. Hospitalization



F. Emergency room visits

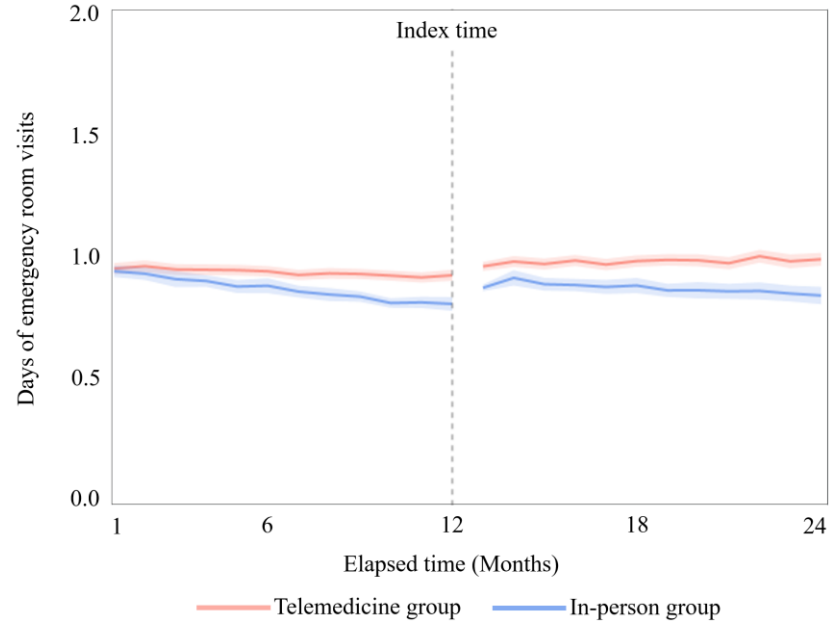
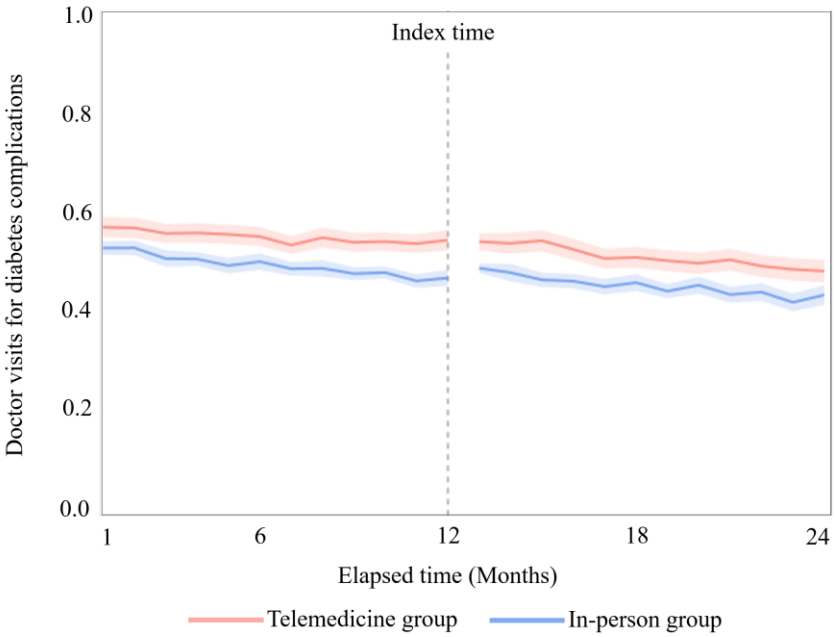


Figure 7. (Continued)

G. Visits for diabetes complications



H. Visits for depression

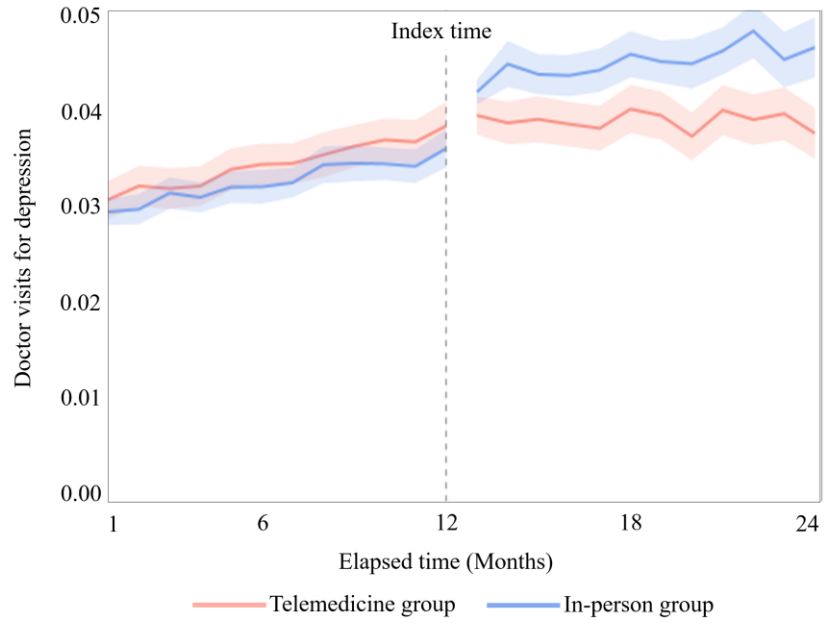


Figure 7. (Continued)

3.2. Predicted Values and Trends in Patients with Schizophrenia

The predicted values before and after the index time for patients with schizophrenia are presented in Table 15, and the predicted trends are presented in Figure 8.

A. Outpatient Visits

The monthly days of outpatient visits for patients with schizophrenia overlapped more between the 95% CIs of the telemedicine and in-person groups after the index time than before the index time. The number of monthly outpatient visits days before exposure was 1.28 days (95% CI: 1.26–1.29) in the telemedicine group and 1.31 days (95% CI: 1.30–1.32) in the in-person group. After exposure, the difference in days decreased from before exposure to 1.37 days (95% CI: 1.36–1.39) in the telemedicine group and 1.35 days (95% CI: 1.34–1.36) in the in-person group.

B. Medication Prescription

The predicted values and patterns of medication prescription days in patients with schizophrenia were similar to those observed during outpatient visits. In the in-person group, the average monthly medication prescriptions were 1.35 days (95% CI: 1.34–1.36) before exposure and 1.38 days (95% CI: 1.37–1.39) after exposure.

C. Medication Amount

Over the study period, the telemedicine group showed an increasing trend in the amount of medication administered, whereas the in-person group showed little change. The gap in the amount of medication between the two groups gradually widened and did not overlap after the 8th month of elapsed time. At the 8th month of elapsed time, the average daily medication amount in the telemedicine group was 0.28 grams (95% CI: 0.26–0.30), and in-person group was 0.23 grams (95% CI: 0.22–0.24). At the last observation at 24 months, it was 0.44 grams (95% CI: 0.40–0.48) in the telemedicine group and 0.25 grams (95% CI: 0.22–0.29) in the in-person group.

D. Medication Adherence

In patients with schizophrenia, the monthly average medication adherence before the index time was 51.97% (95% CI: 51.56–52.39) in the telemedicine group, which was higher than 48.01% (95% CI: 47.71–48.30) in the in-person group. After the index time, medication adherence in the two groups overlapped by approximately 60%.

E. Hospitalization

The monthly average hospitalization trends in the telemedicine and in-person groups were similar, with only an intercept difference. The y-axis intercept value of the telemedicine group was 0.02 days lower than that of the in-person group: The monthly mean hospitalization days were 0.06 days in the telemedicine group and 0.08 days in the in-person group.

F. ER Visits

The number of ER visits days tended to be fewer in the telemedicine group than in the in-person group, and the patterns were similar between the two groups. In the telemedicine group, the average number of ER visits days per month increased from 1.13 days (95% CI: 1.12–1.14) before exposure to 1.20 days (95% CI: 1.19–1.22) after exposure. In the in-person group, the number of days before and after exposure increased from 1.24 days (95% CI: 1.23–1.25) to 1.27 days (95% CI: 1.26–1.29).

G. Visits for Depression

The number of days for which patients with schizophrenia visited a physician for depression decreased slightly after the index time. However, the y-axis intercept increased in both telemedicine and in-person groups at the index time. The average number of monthly visits to a physician for depression was slightly higher in the telemedicine group (before exposure: 0.17 days, after exposure: 0.21 days) than in the in-person group (before exposure: 0.15 days, after exposure: 0.19 days).

Table 15. Predicted Values Before and After Index Time in Patients with Schizophrenia [a]

Outcomes	Patients with diabetes					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Health utilization						
Outpatient visits (days)						
Telemedicine, twice or more	1.28	(1.26 – 1.29)	0.42	1.37	(1.36 – 1.39)	0.46
In-person consultations	1.31	(1.30 – 1.32)	0.52	1.35	(1.34 – 1.36)	0.56
Medication prescription (days)						
Telemedicine, twice or more	1.28	(1.27 – 1.29)	0.38	1.34	(1.33 – 1.36)	0.39
In-person consultations	1.35	(1.34 – 1.36)	0.46	1.38	(1.37 – 1.39)	0.48
Medication amount (grams)						
Telemedicine, twice or more	0.28	(0.27 – 0.28)	0.18	0.39	(0.38 – 0.40)	0.25
In-person consultations	0.24	(0.23 – 0.24)	0.32	0.25	(0.24 – 0.26)	0.32
Health outcomes						
Medication adherence (%)						
Telemedicine, twice or more	51.97	(51.56 – 52.39)	12.03	60.14	(59.68 – 60.61)	13.44
In-person consultations	48.01	(47.71 – 48.30)	14.18	60.19	(59.83 – 60.56)	17.22
Hospitalization (days)						
Telemedicine, twice or more	0.06	(0.06 – 0.07)	0.04	0.06	(0.06 – 0.06)	0.04
In-person consultations	0.08	(0.08 – 0.09)	0.05	0.08	(0.08 – 0.08)	0.05
Emergency room visits (days)						
Telemedicine, twice or more	1.13	(1.12 – 1.14)	0.39	1.20	(1.19 – 1.22)	0.41
In-person consultations	1.24	(1.23 – 1.25)	0.52	1.27	(1.26 – 1.29)	0.55
Visits for depression (days)						
Telemedicine, twice or more	0.17	(0.17 – 0.17)	0.06	0.21	(0.20 – 0.21)	0.08
In-person consultations	0.15	(0.15 – 0.15)	0.05	0.19	(0.19 – 0.19)	0.07

[a] The period of the predicted values is monthly except for the medication amount, which is daily.

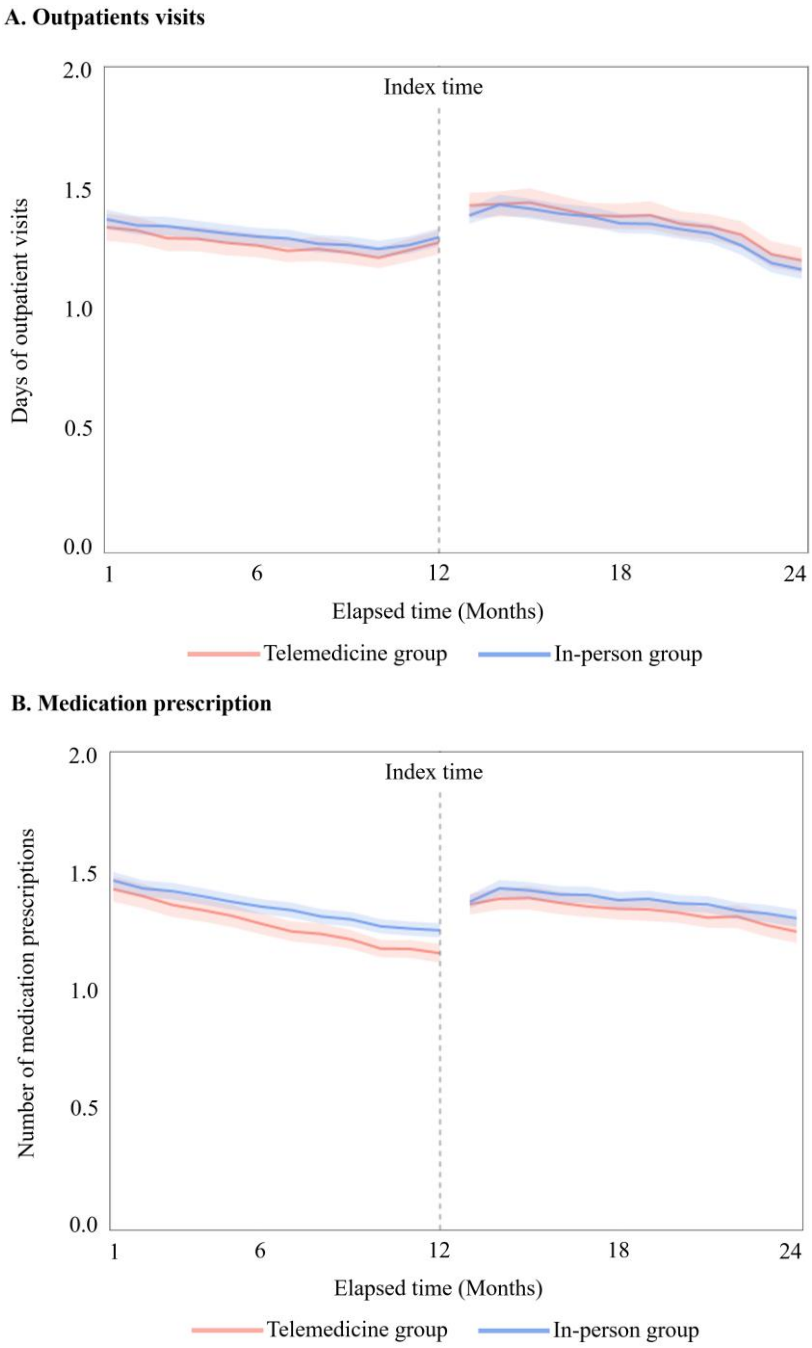
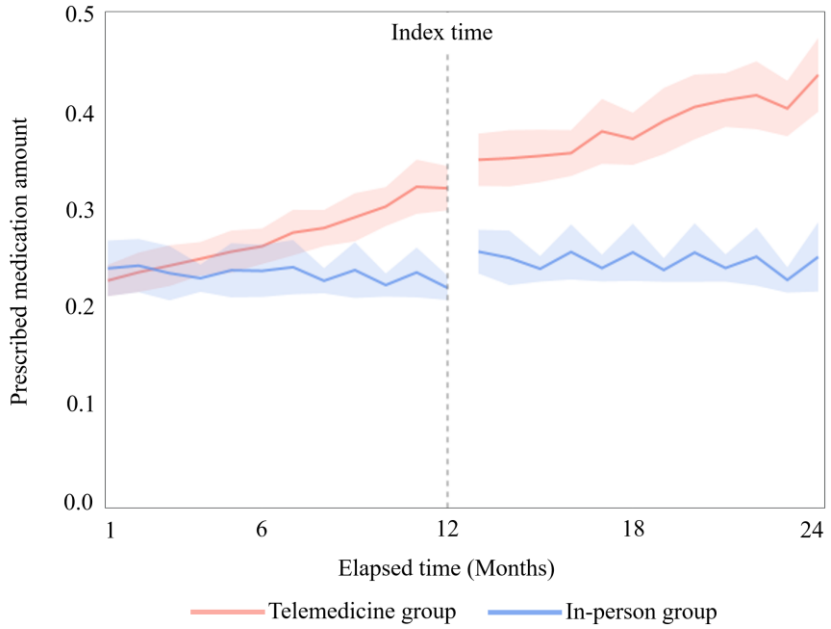


Figure 8. Visualization of Predicted Values Before and After Index Time in Patients with Schizophrenia

C. Medication amount



D. Medication adherence

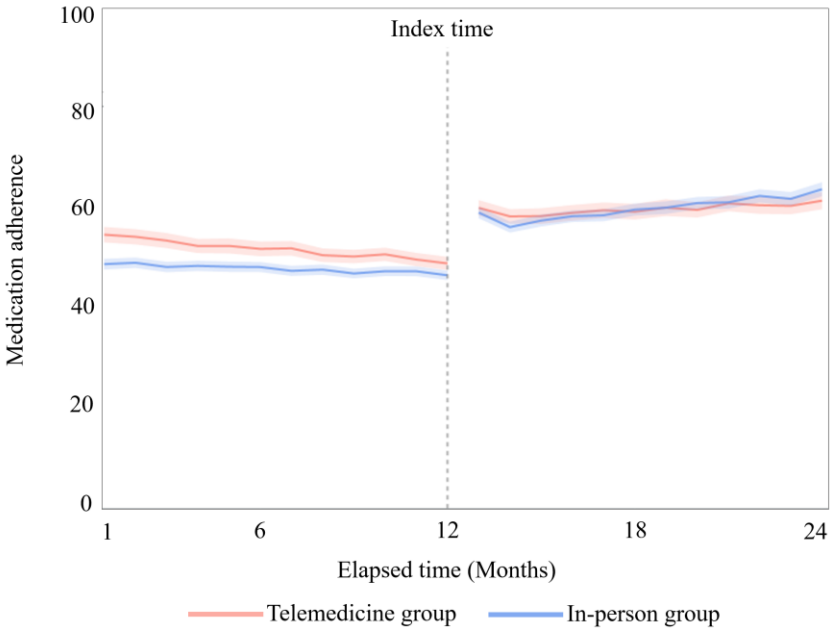
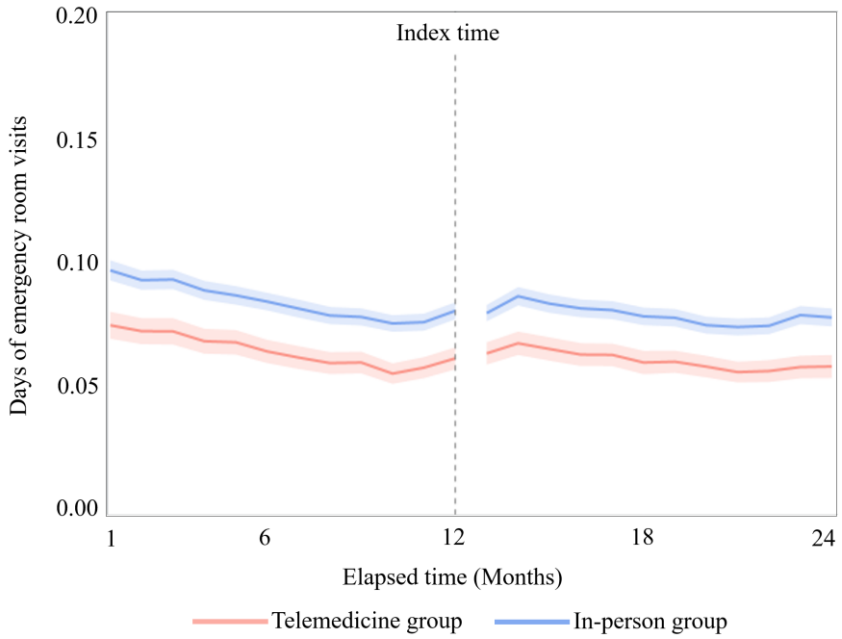


Figure 8. (Continued)

E. Hospitalization



F. Emergency room visits

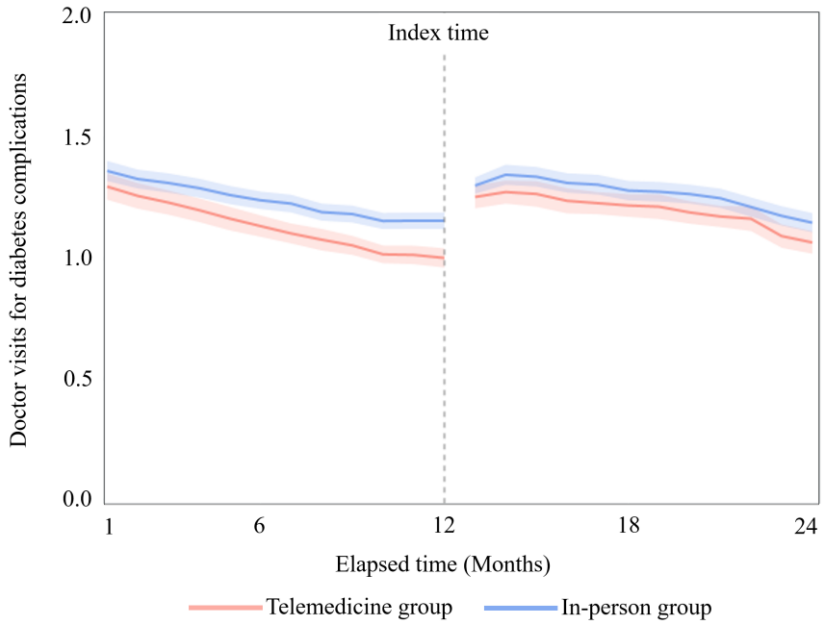


Figure 8. (Continued)

G. Visits for depression

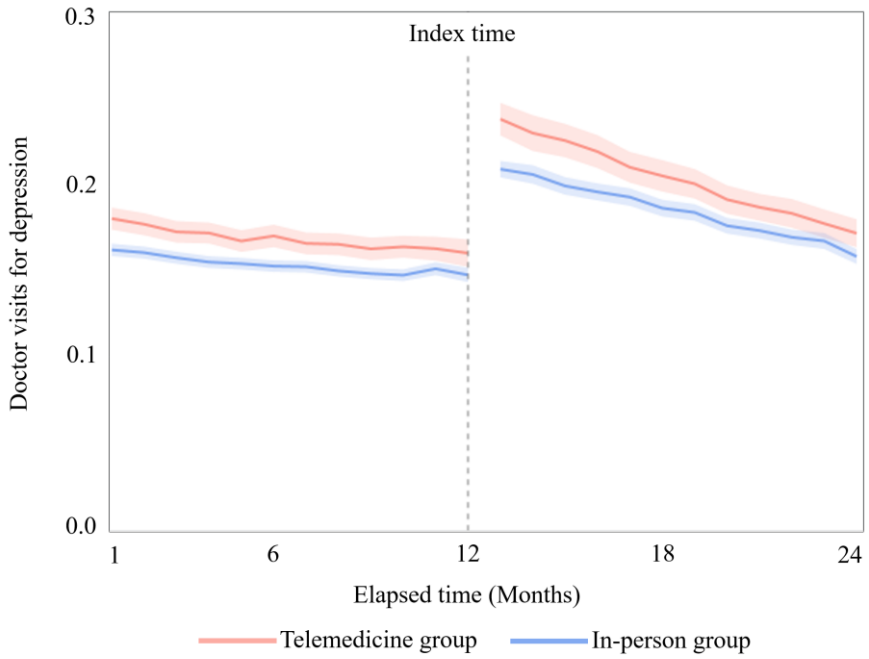


Figure 8. (Continued)

4. Differences in Policy Effects

The differences in policy effects between telemedicine and in-person groups are presented. Policy effects are presented as immediate policy effects and policy effects over time. Immediate policy effects were calculated as the interaction between the group and policy intervention. Policy effects over time were calculated as the triple interaction between the group, policy intervention, and time. The policy effects in the telemedicine, in-person, and total groups are presented in Appendix 7 and 8.

4.1. Telemedicine vs. In-Person Consultations in Patients with Diabetes

Table 16 shows the policy effects by outcome in the telemedicine group compared to the in-person group for patients with diabetes. For outcomes other than medication adherence, the differences in the policy effects between the telemedicine and in-person groups were not statistically significant. The telemedicine group had a 4.2% decrease in medication adherence over time compared with the in-person group (Exp(β)=0.958, 95% CI: 0.927–0.991). Although the policy effects over time were not statistically significant for outcomes other than medication adherence and hospitalization, the 95% CIs were narrow.

4.2. Telemedicine vs. In-Person Consultations in Patients with Schizophrenia

Table 17 shows the policy effect differences between the telemedicine and in-person groups for patients with schizophrenia. Although the policy effects on the outcomes were not statistically significant in the telemedicine group compared to the in-person group, the 95% CI of the policy effects over time was narrower for outcomes other than medication amount.

Table 16. Differences in Policy Effects Between Telemedicine and In-Person Consultations in Patients with Diabetes

Effect Type	Patients with diabetes				
	Telemedicine/in-person difference				
	Exp(β)	95% CI			SE(β)
Health utilization					
Outpatient visits					
Immediate policy effects	1.007	(0.847	–	1.197)	*0.088*
Policy effects over time	1.002	(0.989	–	1.015)	*0.006*
Medication prescription					
Immediate policy effects	0.998	(0.822	–	1.212)	*0.099*
Policy effects over time	0.996	(0.983	–	1.011)	*0.007*
Medication amount					
Immediate policy effects	0.924	(0.223	–	3.832)	*0.726*
Policy effects over time	0.938	(0.848	–	1.038)	*0.052*
Health outcomes					
Medication adherence					
Immediate policy effects	1.048	(0.654	–	1.680)	*0.241*
Policy effects over time	0.958	(0.927	–	0.991)	*0.017*
Hospitalization					
Immediate policy effects	1.001	(0.199	–	5.035)	*0.824*
Policy effects over time	1.004	(0.862	–	1.168)	*0.078*
Emergency room visits					
Immediate policy effects	1.005	(0.821	–	1.230)	*0.103*
Policy effects over time	0.993	(0.979	–	1.008)	*0.008*
Visits for diabetes complications					
Immediate policy effects	1.216	(0.928	–	1.592)	*0.138*
Policy effects over time	0.990	(0.970	–	1.010)	*0.010*
Visits for depression					
Immediate policy effects	1.010	(0.374	–	2.730)	*0.507*
Policy effects over time	0.986	(0.915	–	1.063)	*0.038*

Table 17. Differences in Policy Effects Between Telemedicine and In-Person Consultations in Patients with Schizophrenia

Effect Type	Patients with diabetes				
	Telemedicine/in-person difference				
	Exp(β)	95% CI			SE(β)
Health utilization					
Outpatient visits					
Immediate policy effects	1.022	(0.835	–	1.250)	*0.103*
Policy effects over time	1.000	(0.986	–	1.015)	*0.007*
Medication prescription					
Immediate policy effects	1.003	(0.820	–	1.226)	*0.103*
Policy effects over time	1.004	(0.990	–	1.019)	*0.007*
Medication amount					
Immediate policy effects	1.034	(0.043	–	24.948)	*1.623*
Policy effects over time	0.992	(0.785	–	1.253)	*0.119*
Health outcomes					
Medication adherence					
Immediate policy effects	1.000	(0.647	–	1.546)	*0.222*
Policy effects over time	0.999	(0.967	–	1.031)	*0.016*
Hospitalization					
Immediate policy effects	1.004	(0.375	–	2.689)	*0.502*
Policy effects over time	1.002	(0.935	–	1.075)	*0.036*
Emergency room visits					
Immediate policy effects	1.006	(0.814	–	1.244)	*0.108*
Policy effects over time	1.006	(0.990	–	1.021)	*0.008*
Visits for depression					
Immediate policy effects	1.132	(0.672	–	1.907)	*0.266*
Policy effects over time	0.994	(0.956	–	1.035)	*0.020*

5. Subgroup Analysis

Sub-analyses were performed on the groups that experienced telemedicine once, twice or more, and received in-person consultations. The sub-analyses included predicted values and trend analyses for whether telemedicine was repeated. Sequentially, the differences in policy effects between the groups that experienced telemedicine repeatedly and those that received in-person consultations were analyzed.

Sub-analyses of covariates for the areas in which the policy effect differed between the telemedicine and in-person groups are presented in Appendix 9. The analyses examining the predicted values of the outcomes by tertile are presented in Appendix 10 and 11. The outcomes by disease according to calendar time are presented in Appendix 12 and 13.

5.1. Subgroup Analysis of Predicted Outcomes

The predicted values and trends are presented for the group treated once with telemedicine, the group treated twice or more with telemedicine, and the group treated in person.

5.1.1. Subgroup Analysis of Predicted Values and Trends in Patients with Diabetes

The predicted values by treatment type in patients with diabetes are shown in Table 18 and the predicted trends are shown in Figure 9. The outcomes showed similar patterns in the predicted values and trends between the patients who received telemedicine once and those who received telemedicine twice or more.

Table 18. Sub-analysis of Predicted Values Before and After Index Time in Patients with Diabetes [a]

Outcomes	Patients with diabetes					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Health utilization						
Outpatient visits (days)						
Telemedicine, once	1.27	(1.26 – 1.28)	0.27	1.34	(1.33 – 1.35)	0.28
Telemedicine, twice or more	1.30	(1.28 1.31)	0.36	1.36	(1.35 1.38)	0.35
In-person consultations	1.18	(1.18 – 1.19)	0.35	1.23	(1.22 – 1.23)	0.38
Medication prescription (days)						
Telemedicine, once	1.04	(1.04 – 1.05)	0.17	1.04	(1.04 – 1.05)	0.17
Telemedicine, twice or more	1.07	(1.06 1.08)	0.22	1.05	(1.05 1.06)	0.20
In-person consultations	0.98	(0.98 – 0.99)	0.23	0.96	(0.95 – 0.96)	0.23
Medication amount (grams)						
Telemedicine, one time	7.38	(6.99 – 7.78)	9.64	7.15	(6.75 – 7.56)	9.05
Telemedicine, twice or more	7.22	(6.82 7.62)	9.63	6.30	(5.96 6.63)	8.12
In-person consultations	11.29	(10.79 – 11.80)	21.91	14.24	(13.66 – 14.82)	25.28
Health outcomes						
Medication adherence (%)						
Telemedicine, once	66.81	(65.95 – 67.67)	22.19	60.09	(59.32 – 60.85)	17.78
Telemedicine, twice or more	68.31	(67.54 69.14)	19.95	59.86	(59.28 60.44)	14.42
In-person consultations	73.25	(72.78 – 73.72)	21.28	65.95	(65.53 – 66.36)	18.97
Hospitalization (days)						
Telemedicine, once	0.01	(0.01 – 0.02)	0.02	0.02	(0.02 – 0.02)	0.02
Telemedicine, twice or more	0.01	(0.01 0.01)	0.02	0.02	(0.01 0.02)	0.02
In-person consultations	0.02	(0.02 – 0.03)	0.03	0.03	(0.03 – 0.03)	0.03

Table 18. (Continued)

Outcomes	Patients with diabetes					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Emergency room visits (days)						
Telemedicine, once	0.93	(0.92 – 0.94)	0.23	0.98	(0.97 – 0.99)	0.23
Telemedicine, twice or more	0.95	(0.94 0.96)	0.23	0.98	(0.97 0.99)	0.23
In-person consultations	0.87	(0.86 – 0.88)	0.35	0.88	(0.87 – 0.88)	0.38
Visits for diabetes complications (days)						
Telemedicine, once	0.54	(0.54 – 0.55)	0.20	0.52	(0.51 – 0.53)	0.22
Telemedicine, twice or more	0.56	(0.55 0.57)	0.21	0.51	(0.51 0.52)	0.21
In-person consultations	0.49	(0.49 – 0.50)	0.20	0.46	(0.46 – 0.46)	0.21
Visits for depression (days)						
Telemedicine, once	0.03	(0.03 – 0.03)	0.02	0.04	(0.04 – 0.04)	0.03
Telemedicine, twice or more	0.04	(0.03 0.04)	0.02	0.04	(0.04 0.04)	0.02
In-person consultations	0.03	(0.03 – 0.03)	0.02	0.04	(0.04 – 0.05)	0.03

[a] The period of the predicted values is monthly except for the medication amount, which is daily.

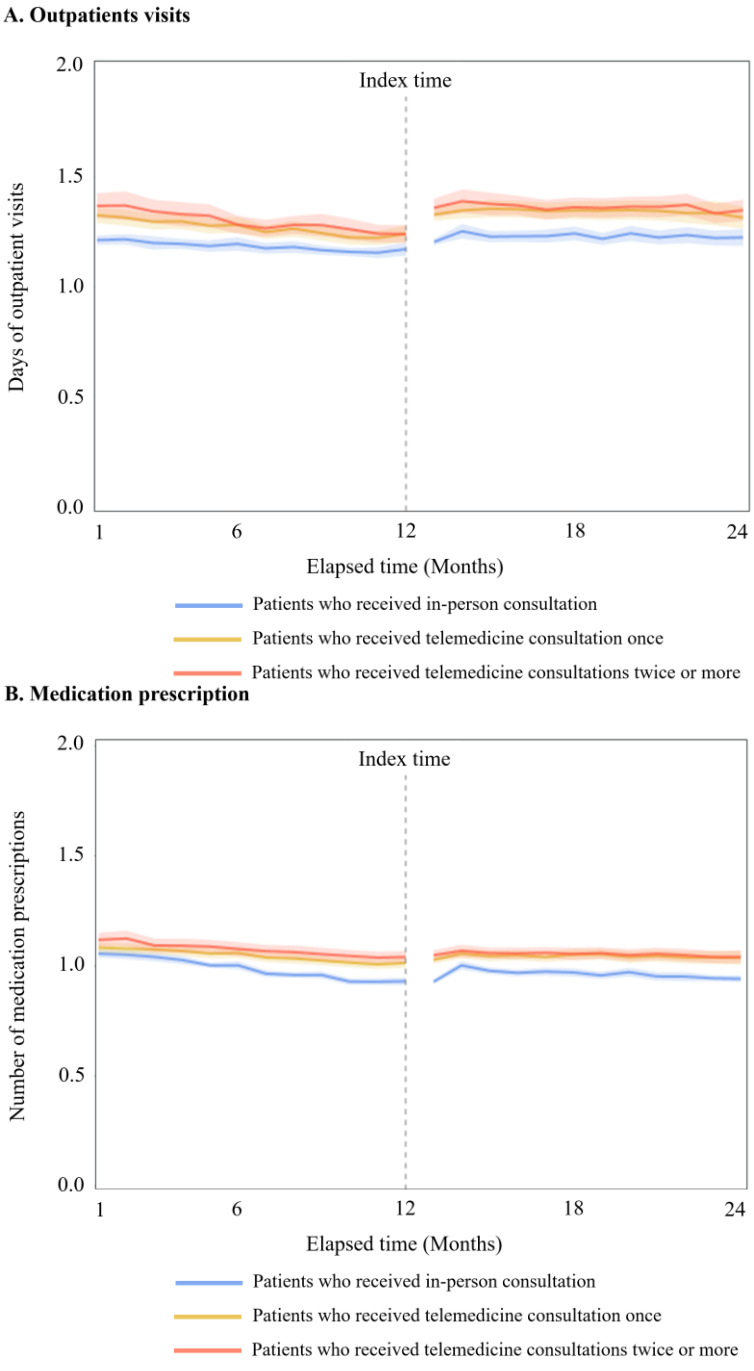
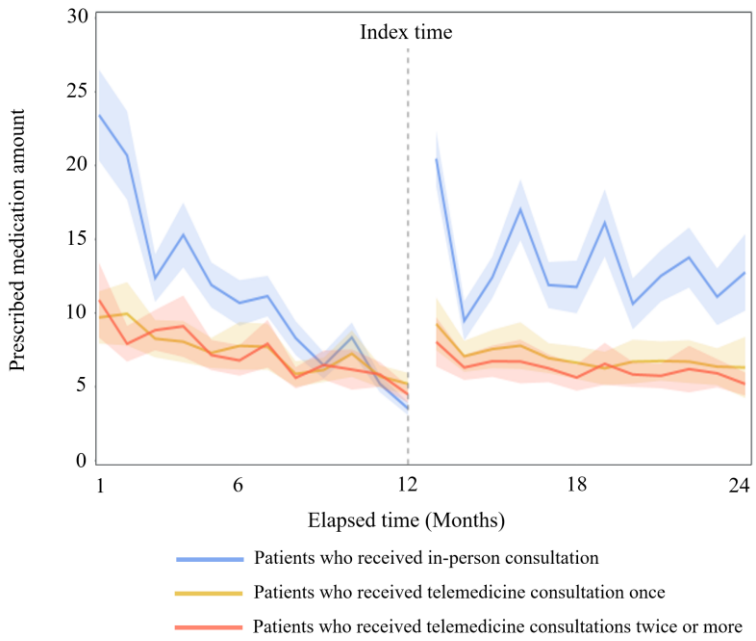


Figure 9. Outcomes by In-Person Consultations and Telemedicine Usage Frequency in Patients with Diabetes

C. Medication amount



D. Medication adherence

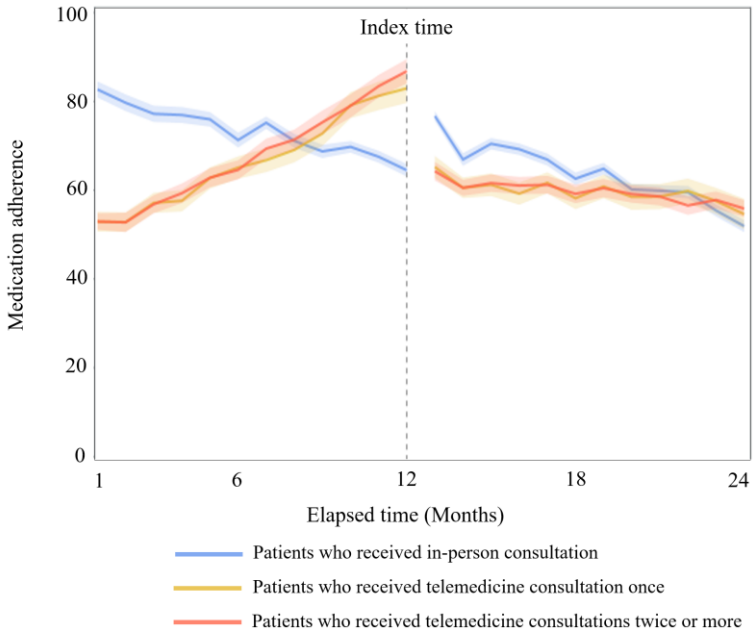
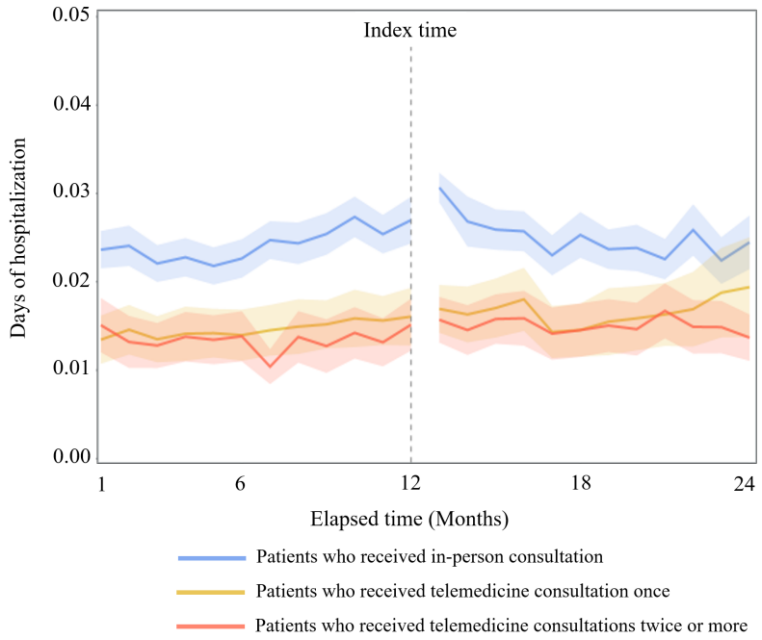


Figure 9. (Continued)

E. Hospitalization



F. Emergency room visits

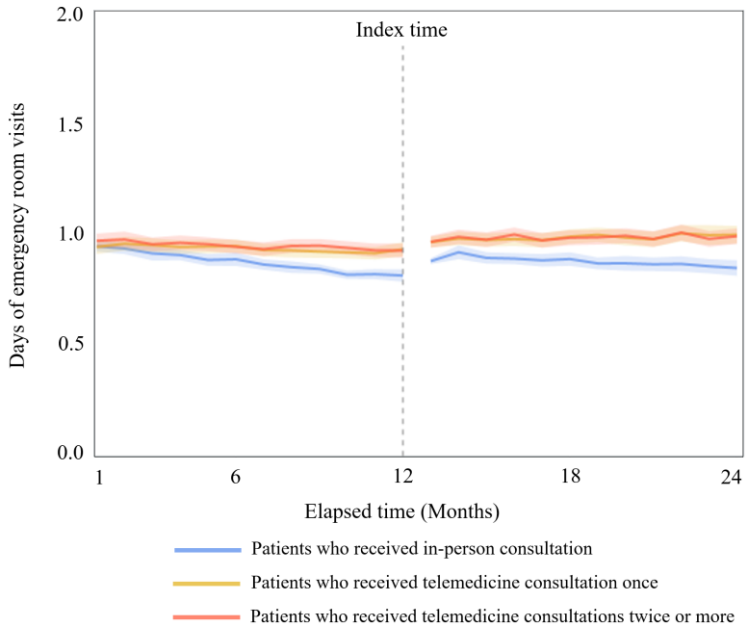
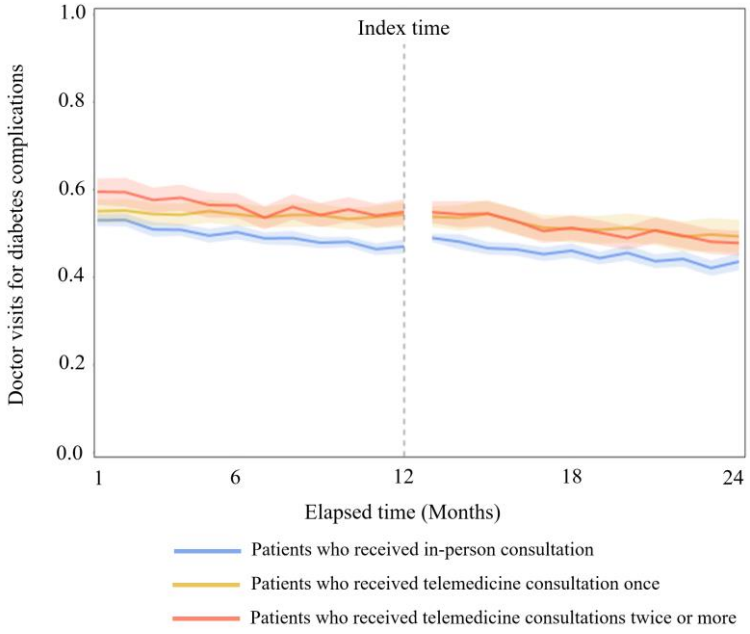


Figure 9. (Continued)

G. Visits for diabetes complications



H. Visits for depression

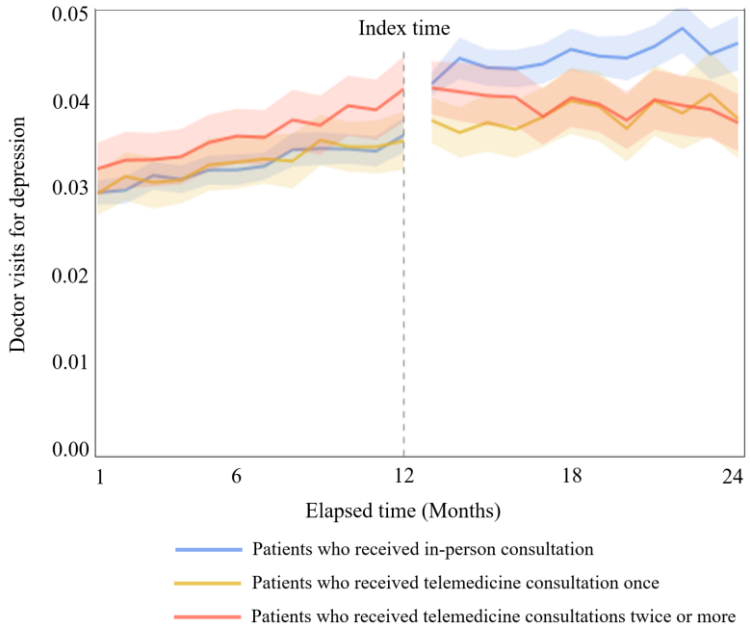


Figure 9. (Continued)

5.1.2. Subgroup Analysis of Predicted Values and Trends in Patients with Schizophrenia

The predicted values of the consultation type in patients with schizophrenia are shown in Table 19, and the predicted trends are shown in Figure 10.

Medication amounts tended to be high in the order of patients who experienced telemedicine once (before exposure: mean 0.31 grams, 95% CI 0.30–0.32; after exposure: mean 0.43 grams, 95% CI 0.41–0.45), patients who experienced telemedicine more than twice (before exposure: mean 0.25 grams, 95% CI 0.25–0.26; after exposure: mean 0.36 grams, 95% CI 0.35–0.37), and patients who received in-person consultations (before exposure: mean 0.24 grams, 95% CI 0.23–0.24; after exposure: mean 0.25 grams, 95% CI 0.24–0.26). The gap among the three groups increased as the elapsed time passed.

Patients who experienced telemedicine once were more likely to visit their doctor for depression (before exposure: mean 0.18 visits; after exposure: mean 0.23 visits) than those who experienced telemedicine more than twice (before exposure: mean 0.16 visits; after exposure: mean 0.19 visits). In the period after index time, the number of doctor visits for depression among patients who experienced telemedicine more than twice was similar to that among those receiving in-person consultations (before exposure: mean 0.15 visits; after exposure: mean 0.19 visits).

The hospitalization visits tended to be slightly high in the following order in the study period: patients who received in-person consultations (overall mean 0.08 visits), patients who experienced telemedicine more than twice (overall mean 0.07 visits), and patients who experienced telemedicine once (before exposure: mean 0.06 visits; after exposure: mean 0.05 visits). The hospitalization patterns of the three groups were similar; however, there were small differences in the y-intercepts.

Table 19. Sub-analysis of Predicted Values Before and After Index Time in Patients with Schizophrenia [a]

Outcomes	Patients with schizophrenia					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Health utilization						
Outpatient visits (days)						
Telemedicine, once	1.24	(1.21 – 1.27)	0.50	1.34	(1.31 – 1.37)	0.53
Telemedicine, twice or more	1.30	(1.29 1.32)	0.35	1.40	(1.38 1.41)	0.40
In-person consultations	1.31	(1.30 – 1.32)	0.52	1.35	(1.34 – 1.36)	0.56
Medication prescription (days)						
Telemedicine, once	1.25	(1.22 – 1.27)	0.40	1.33	(1.30 – 1.35)	0.42
Telemedicine, twice or more	1.30	(1.29 1.32)	0.37	1.36	(1.34 1.37)	0.37
In-person consultations	1.35	(1.34 – 1.36)	0.46	1.38	(1.37 – 1.39)	0.48
Medication amount (grams)						
Telemedicine, once	0.31	(0.30 – 0.32)	0.21	0.43	(0.41 – 0.45)	0.31
Telemedicine, twice or more	0.25	(0.25 0.26)	0.14	0.36	(0.35 0.37)	0.19
In-person consultations	0.24	(0.23 – 0.24)	0.32	0.25	(0.24 – 0.26)	0.32
Health outcomes						
Medication adherence (%)						
Telemedicine, once	53.04	(52.30 – 53.78)	13.44	61.64	(60.82 – 62.46)	15.10
Telemedicine, twice or more	51.25	(50.76 51.75)	10.92	59.13	(58.59 59.67)	12.08
In-person consultations	48.01	(47.71 – 48.30)	14.18	60.19	(59.83 – 60.56)	17.22
Hospitalization (days)						
Telemedicine, once	0.06	(0.06 – 0.06)	0.04	0.05	(0.05 – 0.05)	0.03
Telemedicine, twice or more	0.07	(0.07 0.07)	0.04	0.07	(0.07 0.07)	0.04
In-person consultations	0.08	(0.08 – 0.09)	0.05	0.08	(0.08 – 0.08)	0.05

Table 19. (Continued)

Outcomes	Patients with schizophrenia					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Emergency room visits (days)						
Telemedicine, once	1.11	(1.09 – 1.14)	0.42	1.21	(1.18 – 1.23)	0.46
Telemedicine, twice or more	1.14	(1.12 1.16)	0.36	1.20	(1.19 1.22)	0.38
In-person consultations	1.24	(1.23 – 1.25)	0.52	1.27	(1.26 – 1.29)	0.55
Visits for depression (days)						
Telemedicine, once	0.18	(0.18 – 0.18)	0.07	0.23	(0.22 – 0.23)	0.09
Telemedicine, twice or more	0.16	(0.16 0.16)	0.04	0.19	(0.19 0.19)	0.07
In-person consultations	0.15	(0.15 – 0.15)	0.05	0.19	(0.19 – 0.19)	0.07

[a] The period of the predicted values is monthly except for the medication amount, which is daily.

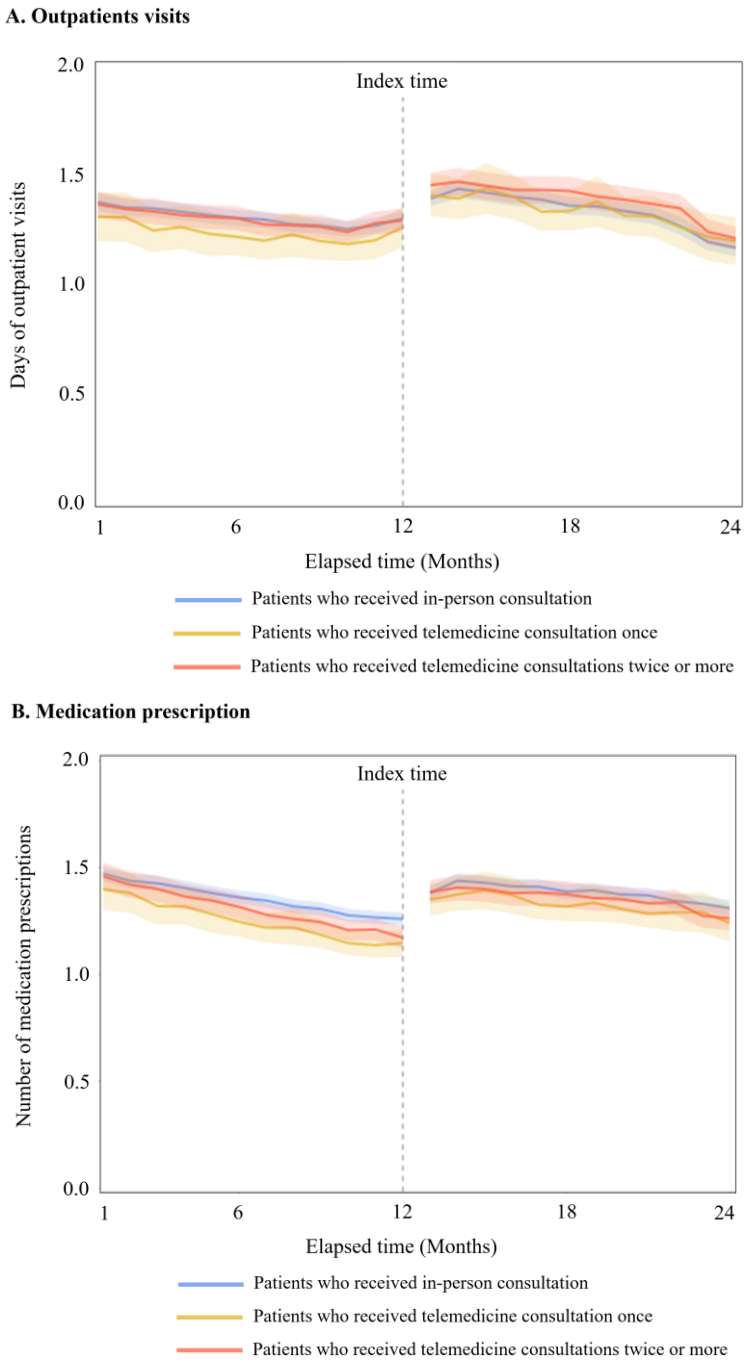
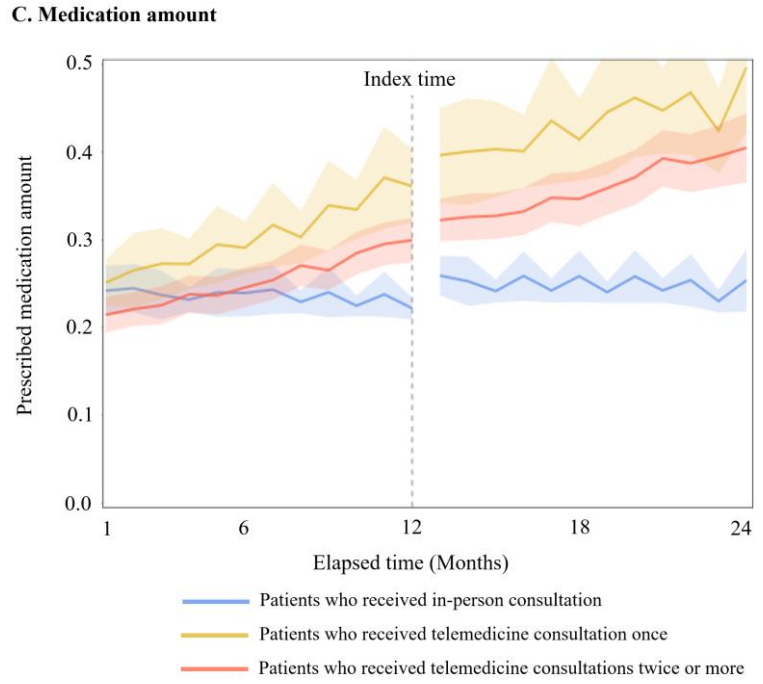


Figure 10. Outcomes by In-Person Consultations and Telemedicine Usage Frequency in Patients with Schizophrenia



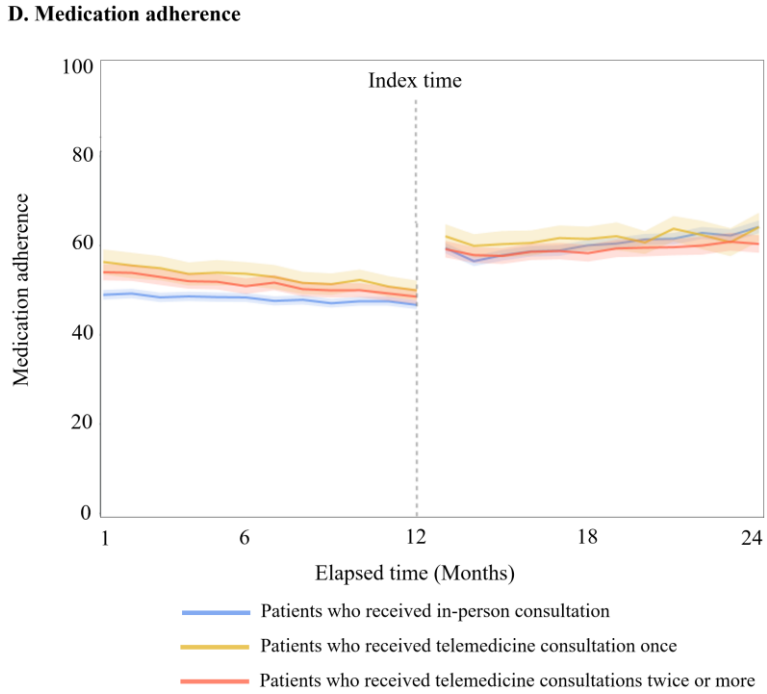
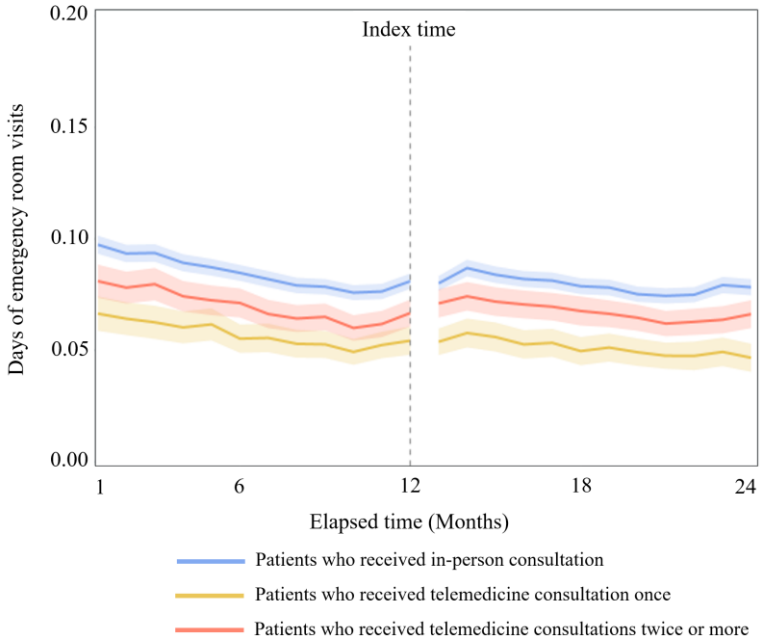


Figure 10. (Continued)

E. Hospitalization



F. Emergency room visits

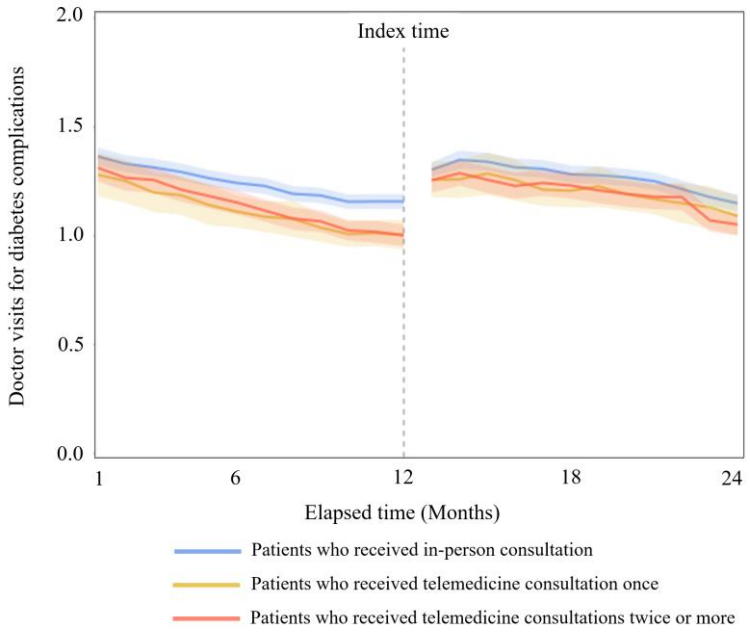


Figure 10. (Continued)

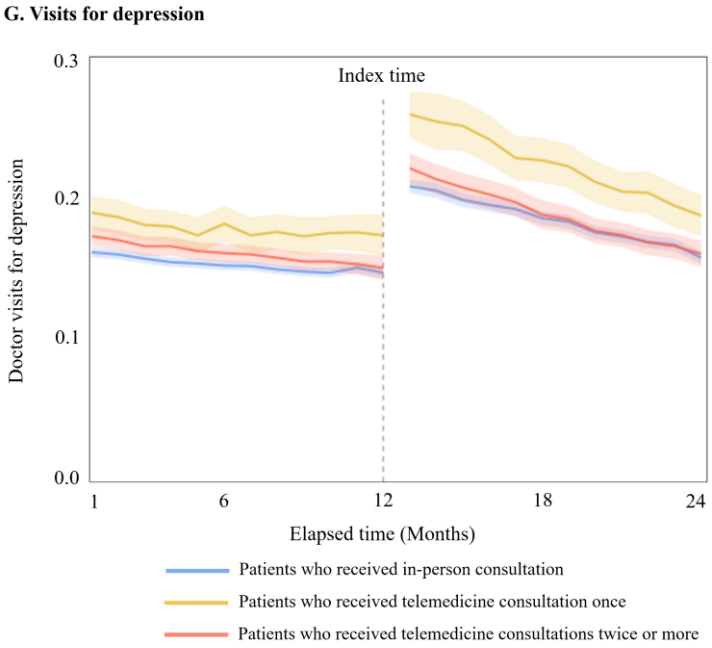


Figure 10. (Continued)

5.2. Subgroup Analyses of Telemedicine Repetition

The following are the sub-analyses of the predicted value, trend, and policy effect, presenting the differences in policy effects between the repeated telemedicine group and the in-person group. To secure sufficient participants, we matched the telemedicine repetition and in-person groups and performed the following sub-analyses. The characteristics of the participants in the telemedicine repeat and in-person groups are presented in Appendix 14 and 15.

5.2.1. Predicted Outcomes Regarding Telemedicine Repetition

A. Patients with Diabetes

In patients with diabetes, the predicted values and trends for the group that repeatedly used telemedicine consultations more than twice and the group that only used in-person consultations are shown in Table 20 and Figure 11.

B. Patients with Schizophrenia

Table 21 and Figure 12 show the predicted values and trends by group of patients with schizophrenia who used telemedicine consultations more than twice and those who used only in-person consultations, respectively.

Table 20. Predicted Values Regarding Telemedicine Repetition in Patients with Diabetes

Outcomes	Patients with diabetes					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Health utilization						
Outpatient visits (days)						
Telemedicine, twice or more	1.27	(1.27 – 1.28)	0.29	1.40	(1.39 – 1.41)	0.32
In-person consultations	1.17	(1.17 – 1.18)	0.29	1.22	(1.22 – 1.23)	0.32
Medication prescription (days)						
Telemedicine, twice or more	1.06	(1.05 – 1.06)	0.18	1.06	(1.06 – 1.07)	0.17
In-person consultations	1.00	(0.99 – 1.00)	0.20	0.94	(0.94 – 0.95)	0.18
Medication amount (grams)						
Telemedicine, twice or more	5.98	(5.77 – 6.18)	6.94	6.36	(6.15 – 6.57)	7.09
In-person consultations	12.23	(11.61 – 12.85)	25.03	14.84	(14.18 – 15.51)	28.30
Health outcomes						
Medication adherence (%)						
Telemedicine, twice or more	66.68	(66.06 – 67.31)	21.68	60.14	(59.68 – 60.59)	15.67
In-person consultations	75.99	(75.50 – 76.48)	20.76	63.96	(63.55 – 64.37)	18.13
Hospitalization (days)						
Telemedicine, twice or more	0.01	(0.01 – 0.01)	0.02	0.01	(0.01 – 0.01)	0.02
In-person consultations	0.03	(0.03 – 0.03)	0.03	0.03	(0.03 – 0.03)	0.03
Emergency room visits (days)						
Telemedicine, twice or more	0.99	(0.99 – 1.00)	0.29	0.91	(0.91 – 0.92)	0.27
In-person consultations	0.84	(0.83 – 0.85)	0.34	0.91	(0.90 – 0.92)	0.35
Visits for diabetes complications (days)						
Telemedicine, twice or more	0.50	(0.50 – 0.51)	0.23	0.58	(0.57 – 0.58)	0.27
In-person consultations	0.47	(0.46 – 0.47)	0.26	0.50	(0.50 – 0.51)	0.29
Visits for depression (days)						
Telemedicine, twice or more	0.04	(0.04 – 0.04)	0.03	0.04	(0.04 – 0.04)	0.03
In-person consultations	0.04	(0.04 – 0.04)	0.03	0.04	(0.04 – 0.04)	0.03

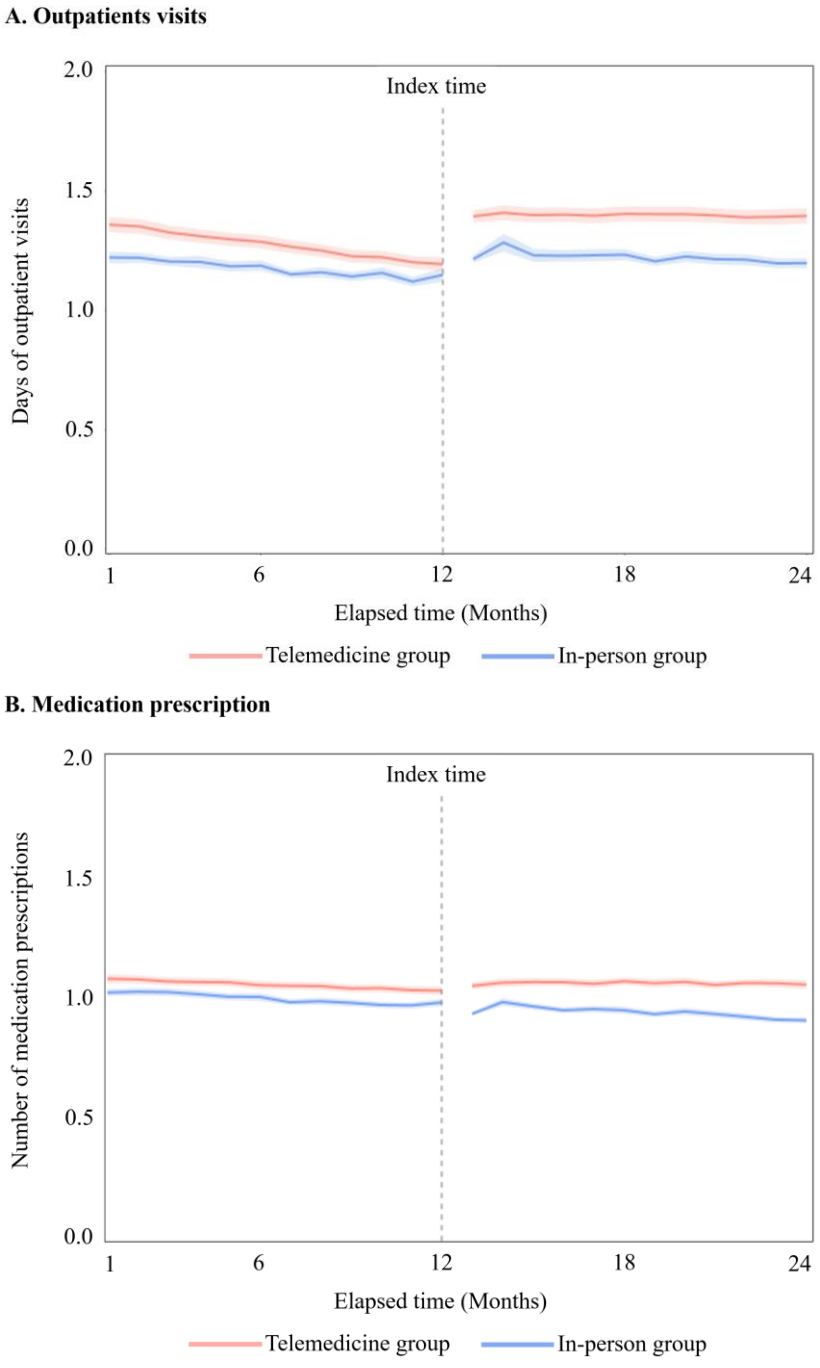
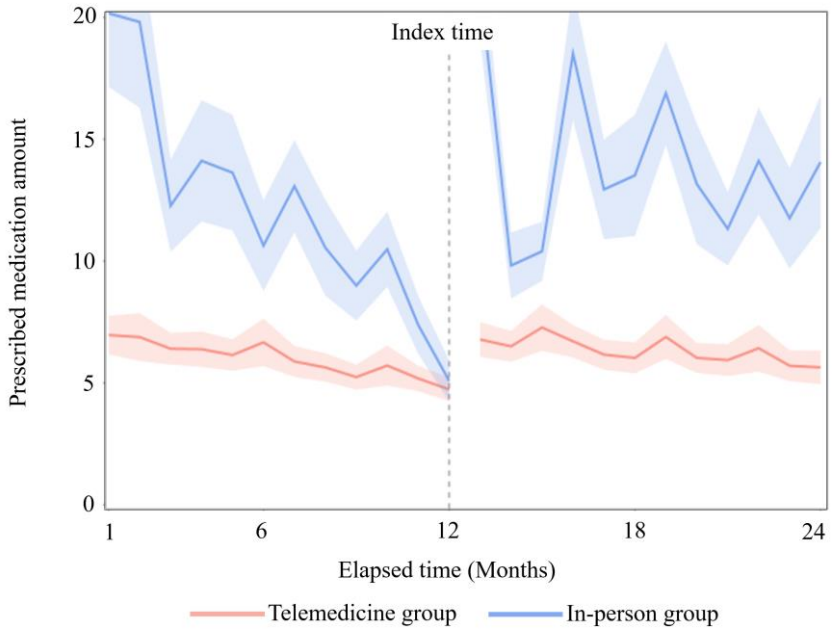


Figure 11. Visualization of Predicted Values in Patients with Diabetes Regarding Telemedicine Repetition

C. Medication amount



D. Medication adherence

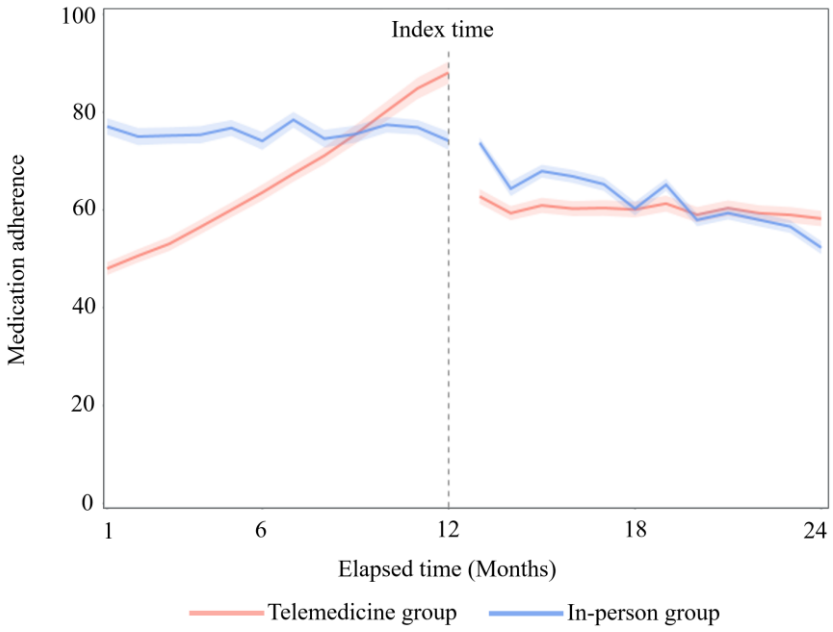
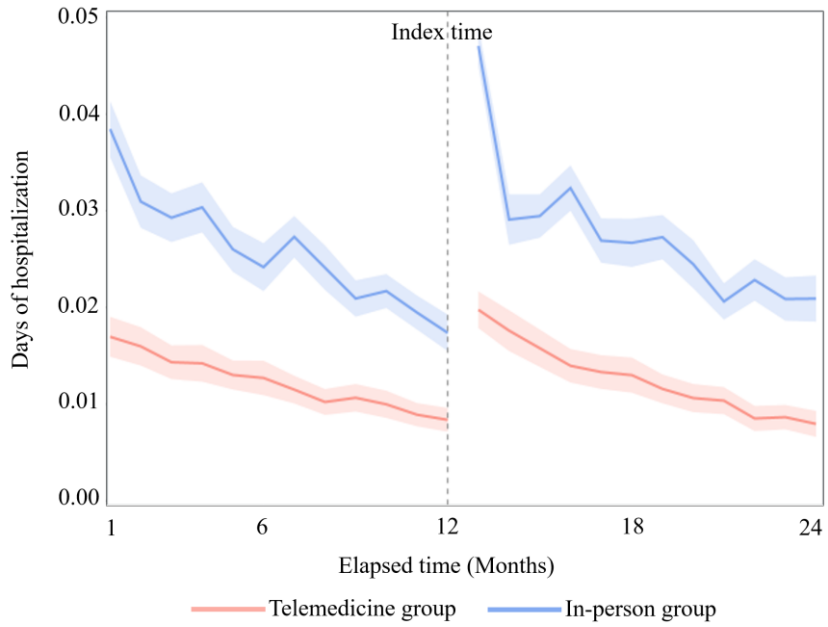


Figure 11. (Continued)

E. Hospitalization



F. Emergency room visits

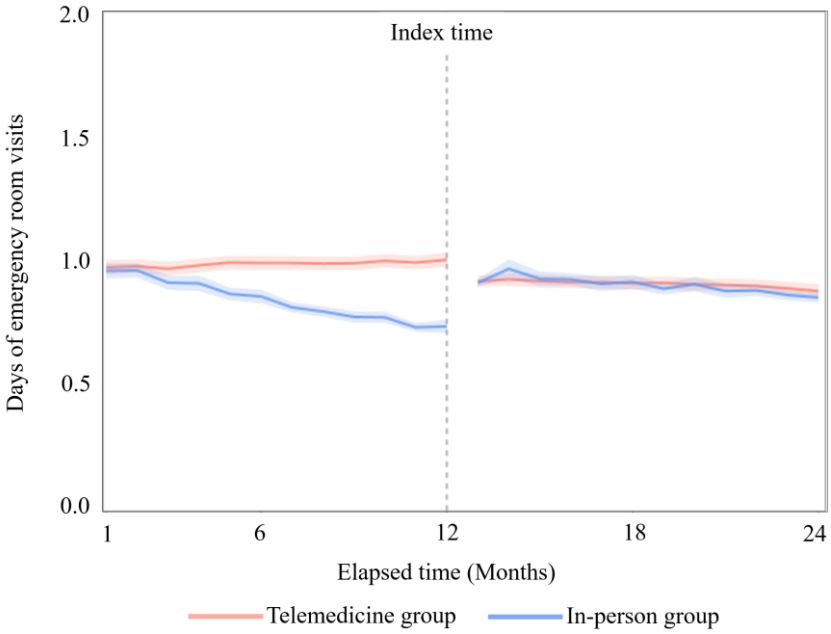
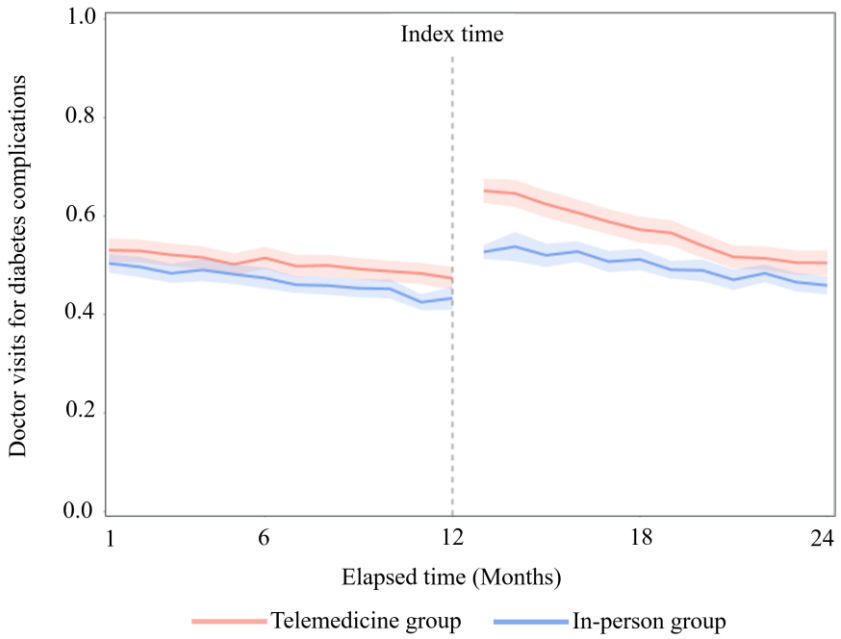


Figure 11. (Continued)

G. Visits for diabetes complications



H. Visits for depression

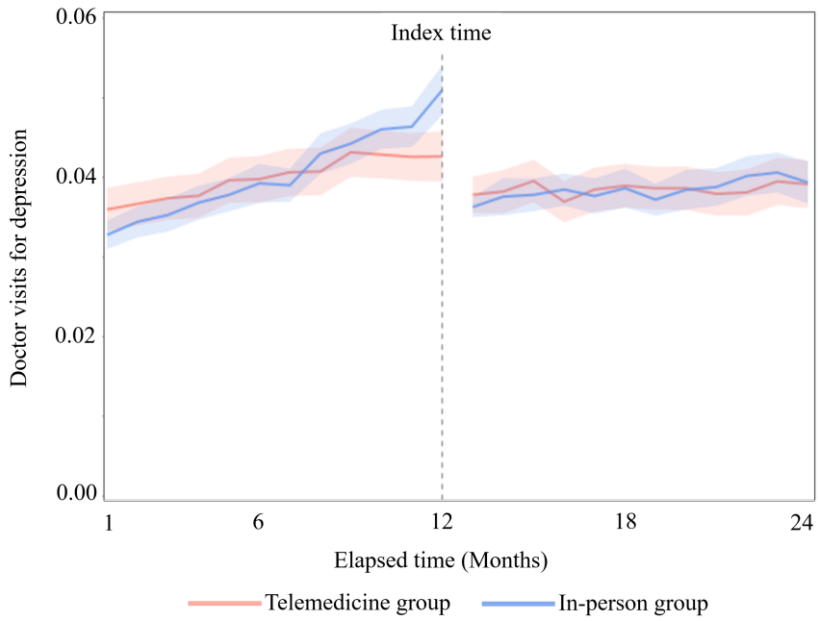


Figure 11. (Continued)

Table 21. Predicted Values Regarding Telemedicine Repetition in Patients with Schizophrenia

Outcomes	Patients with schizophrenia					
	Predicted values					
	Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD
Health utilization						
Outpatient visits (days)						
Telemedicine, twice or more	1.34	(1.32 – 1.35)	0.41	1.48	(1.47 – 1.50)	0.48
In-person consultations	1.32	(1.31 – 1.33)	0.46	1.39	(1.38 – 1.40)	0.51
Medication prescription (days)						
Telemedicine, twice or more	1.31	(1.29 – 1.32)	0.41	1.43	(1.41 – 1.45)	0.46
In-person consultations	1.36	(1.35 – 1.37)	0.42	1.41	(1.40 – 1.43)	0.46
Medication amount (grams)						
Telemedicine, twice or more	0.17	(0.16 – 0.17)	0.15	0.40	(0.39 – 0.42)	0.38
In-person consultations	0.32	(0.31 – 0.33)	0.39	0.26	(0.25 – 0.26)	0.30
Health outcomes						
Medication adherence (%)						
Telemedicine, twice or more	40.12	(39.53 – 40.71)	15.64	66.90	(66.25 – 67.56)	17.28
In-person consultations	46.95	(46.62 – 47.29)	14.68	61.29	(60.86 – 61.71)	18.60
Hospitalization (days)						
Telemedicine, twice or more	0.06	(0.06 – 0.06)	0.04	0.05	(0.05 – 0.06)	0.04
In-person consultations	0.08	(0.08 – 0.08)	0.05	0.06	(0.06 – 0.06)	0.05
Emergency room visits (days)						
Telemedicine, twice or more	1.13	(1.12 – 1.14)	0.39	1.35	(1.34 – 1.37)	0.43
In-person consultations	1.26	(1.25 – 1.27)	0.48	1.33	(1.31 – 1.34)	0.52
Visits for depression (days)						
Telemedicine, twice or more	0.16	(0.16 – 0.17)	0.06	0.16	(0.16 – 0.16)	0.06
In-person consultations	0.21	(0.21 – 0.21)	0.11	0.21	(0.21 – 0.22)	0.13

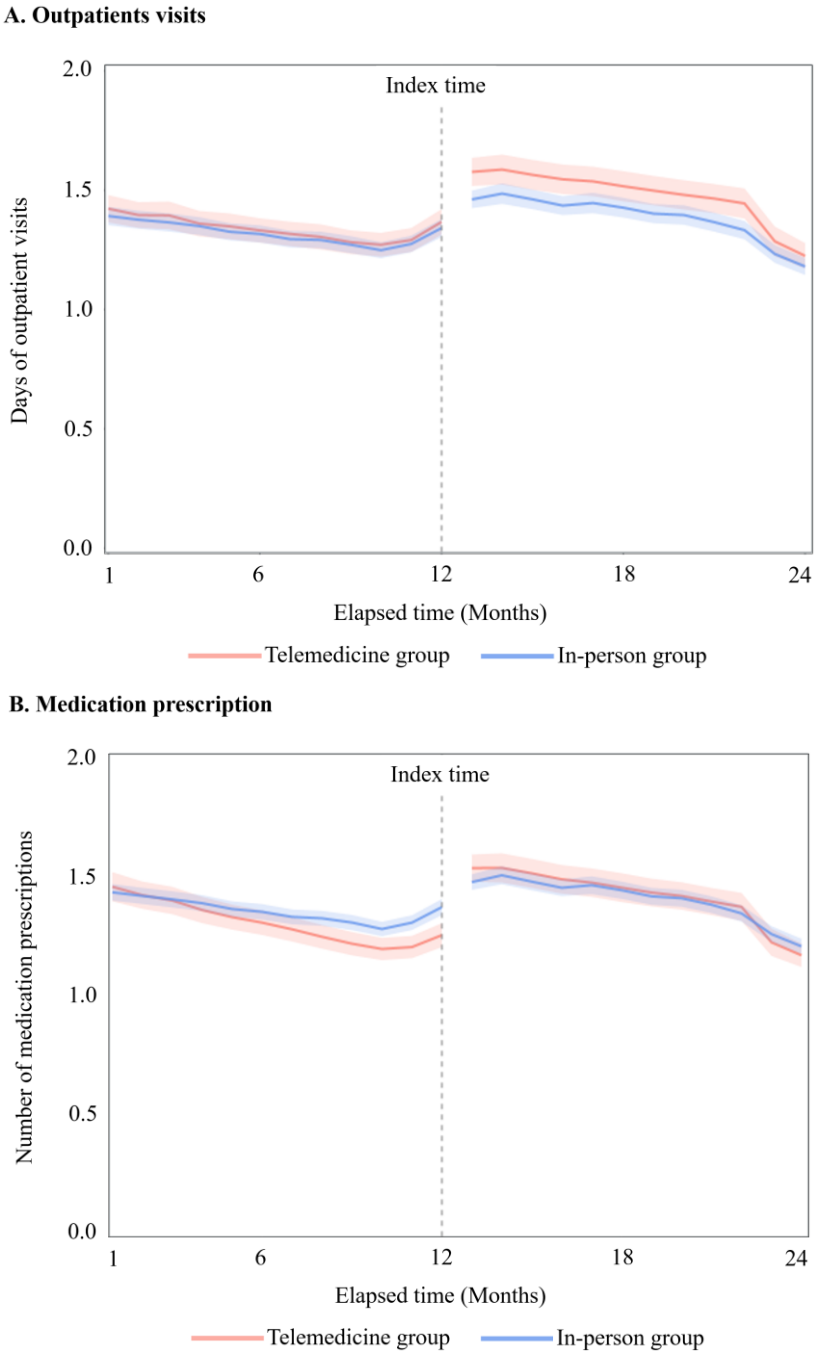
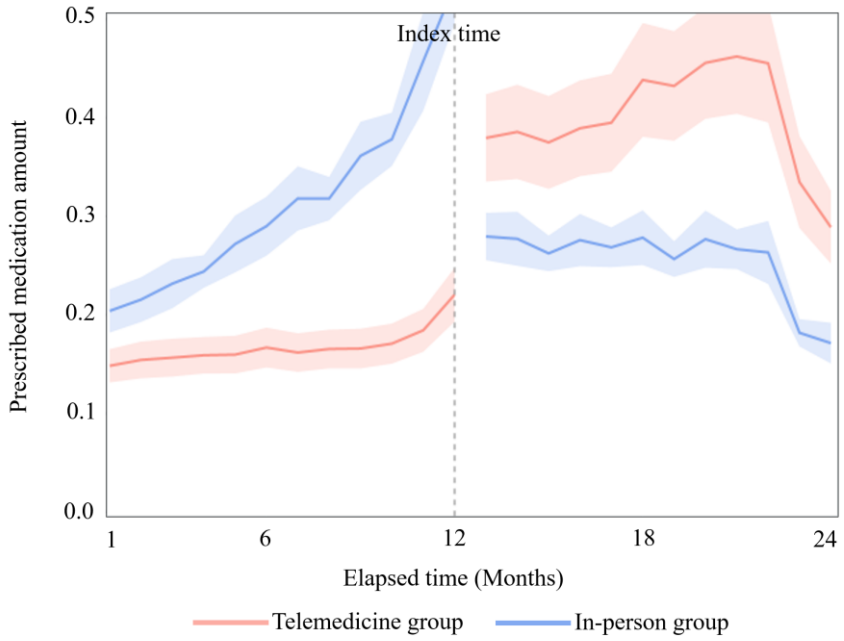


Figure 12. Visualization of Predicted Values in Patients with Schizophrenia Regarding Telemedicine Repetition

C. Medication amount



D. Medication adherence

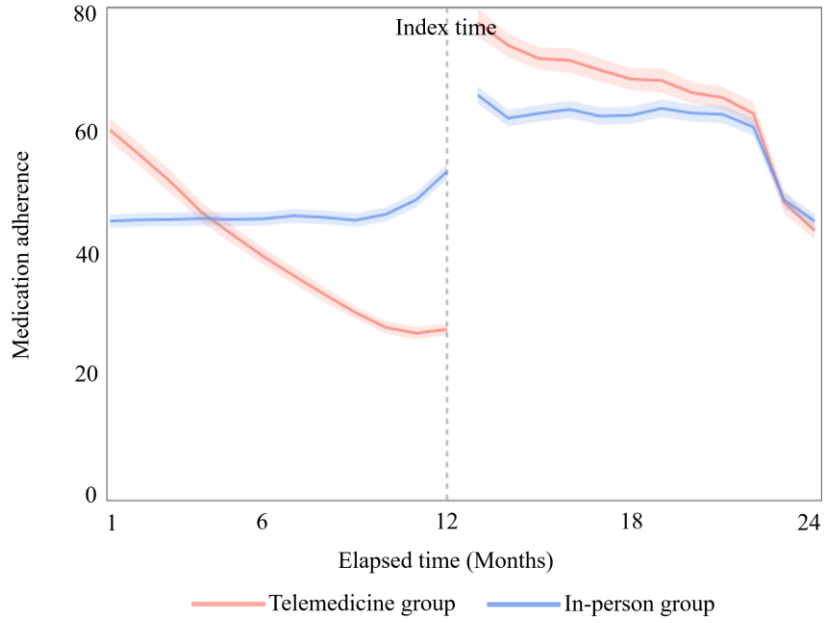
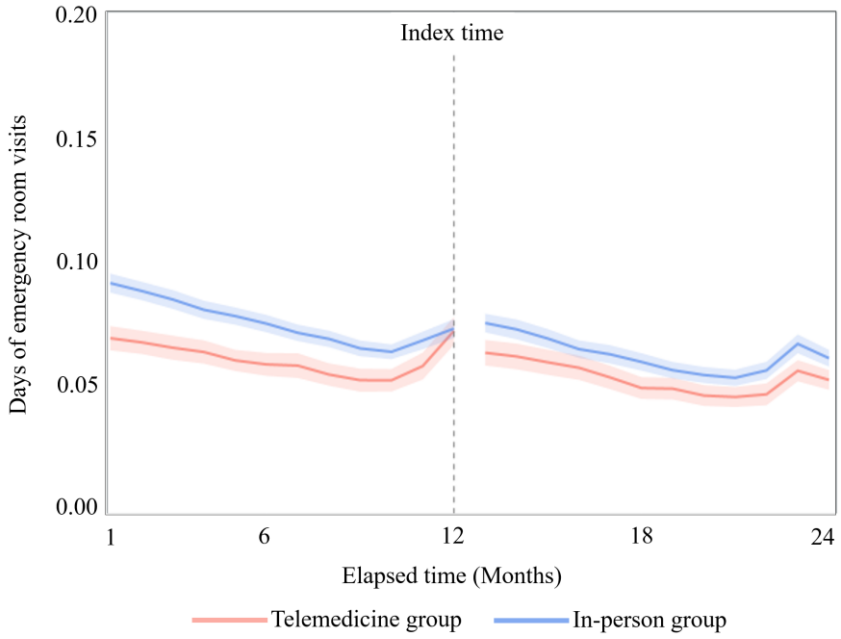


Figure 12. (Continued)

E. Hospitalization



F. Emergency room visits

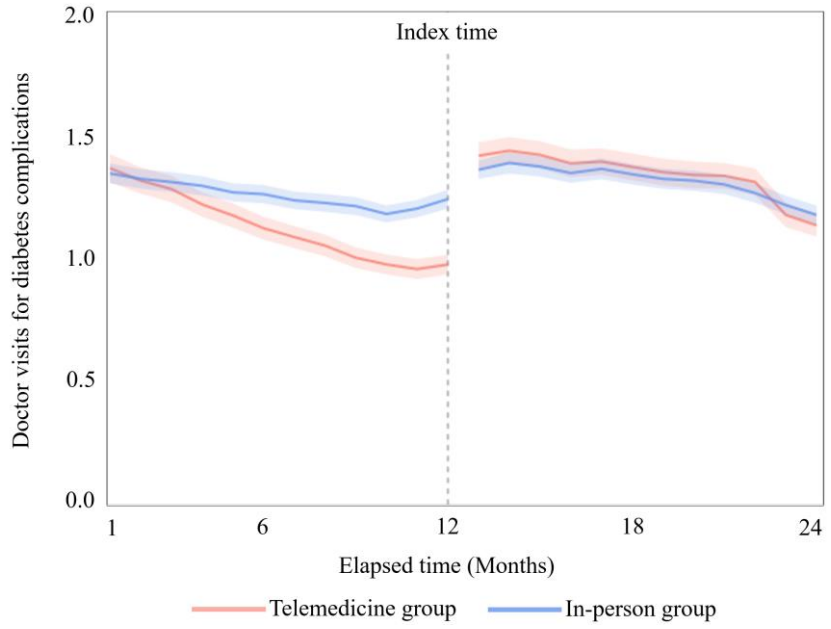


Figure 12. (Continued)

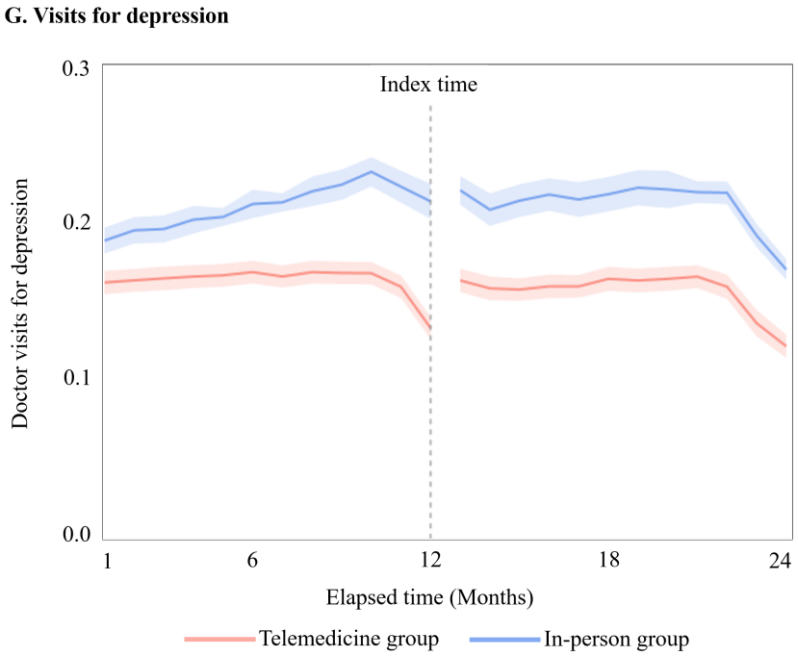


Figure 12. (Continued)

5.2.2. Difference in Policy Effects Regarding Telemedicine Repetition

A. Patients with Diabetes

In patients with diabetes, Table 20 shows the differences in policy effects between the groups that received telemedicine repeatedly more than twice and those that received in-person consultations. Patients who received repeated telemedicine consultations more than twice had a 2.9% decrease (Exp(β)=0.971, 95% CI: 0.956–0.986) in ER visits over time compared to patients who received only in-person consultations. For the other outcomes, the differences in policy effects over time were not statistically significant, whereas the 95% CIs were narrow. Policy effects within the group of telemedicine two or more times, in-person group, and total among patients with diabetes are presented in Appendix 16. Sub-analyses of covariates for an outcome where the policy effect differed between the repeated telemedicine and in-person groups are presented in Appendix 18.

B. Patients with Schizophrenia

The differences in the policy effects between the group that experienced telemedicine consultations twice or more and the in-person consultation group for patients with schizophrenia are shown in Table 21. Patients who received telemedicine consultations repeatedly more than twice had a 7.4% increase (Exp(β)=1.074, 95% CI: 1.028–1.121) in medication adherence over time compared to patients who received only in-person consultations. In addition, ER visits increased by 2.1% (Exp(β)=1.021, 95% CI: 1.005–1.038) over time. Other outcomes for which the differences in policy effects over time were not statistically significant had narrow 95% CIs. Group-specific policy effects among patients with schizophrenia are presented in Appendix 17. Sub-analyses of covariates examining differences in policy effects across groups are presented in Appendix 19 and 20.

Table 22. Table 22. Differences in Policy Effects Between Telemedicine Repetition and In-Person in Patients with Diabetes

Effect Type	Patients with diabetes				
	Telemedicine twice or more/ in-person difference				
	Exp(β)	95% CI			SE(β)
Health utilization					
Outpatient visits					
Immediate policy effects	1.009	(0.848	–	1.201)	*0.089*
Policy effects over time	1.004	(0.991	–	1.017)	*0.007*
Medication prescription					
Immediate policy effects	1.000	(0.822	–	1.217)	*0.100*
Policy effects over time	1.002	(0.988	–	1.017)	*0.007*
Medication amount					
Immediate policy effects	0.982	(0.232	–	4.162)	*0.736*
Policy effects over time	0.967	(0.872	–	1.073)	*0.053*
Health outcomes					
Medication adherence					
Immediate policy effects	1.035	(0.641	–	1.671)	*0.244*
Policy effects over time	0.970	(0.937	–	1.003)	*0.017*
Hospitalization					
Immediate policy effects	1.000	(0.210	–	4.758)	*0.795*
Policy effects over time	0.996	(0.858	–	1.157)	*0.076*
Emergency room visits					
Immediate policy effects	1.003	(0.815	–	1.234)	*0.106*
Policy effects over time	0.971	(0.956	–	0.986)	*0.008*
Visits for diabetes complications					
Immediate policy effects	1.144	(0.872	–	1.501)	*0.138*
Policy effects over time	0.995	(0.974	–	1.015)	*0.010*
Visits for depression					
Immediate policy effects	1.007	(0.369	–	2.752)	*0.513*
Policy effects over time	1.014	(0.942	–	1.093)	*0.038*

Table 23. Differences in Policy Effects Between Telemedicine Repetition and In-Person in Patients with Schizophrenia

Effect Type	Patients with diabetes				
	Telemedicine twice or more/ in-person difference				
	Exp(β)	95% CI			SE(β)
Health utilization					
Outpatient visits					
Immediate policy effects	1.028	(0.829	–	1.275)	*0.110*
Policy effects over time	1.001	(0.986	–	1.017)	*0.008*
Medication prescription					
Immediate policy effects	1.021	(0.822	–	1.268)	*0.111*
Policy effects over time	1.007	(0.992	–	1.023)	*0.008*
Medication amount					
Immediate policy effects	1.057	(0.025	–	45.422)	*1.917*
Policy effects over time	1.097	(0.829	–	1.451)	*0.142*
Health outcomes					
Medication adherence					
Immediate policy effects	1.022	(0.580	–	1.801)	*0.289*
Policy effects over time	1.074	(1.028	–	1.121)	*0.022*
Hospitalization					
Immediate policy effects	1.001	(0.285	–	3.510)	*0.639*
Policy effects over time	0.992	(0.912	–	1.079)	*0.043*
Emergency room visits					
Immediate policy effects	1.014	(0.810	–	1.268)	*0.114*
Policy effects over time	1.021	(1.005	–	1.038)	*0.008*
Visits for depression					
Immediate policy effects	1.010	(0.564	–	1.811)	*0.297*
Policy effects over time	1.016	(0.974	–	1.059)	*0.022*

V. Discussion

1. Methodological Considerations

This study aimed to determine the impact of telemedicine on healthcare utilization and health outcomes. To achieve our research objectives, we focused on patients with chronic diseases who are representative targets of telemedicine. Patients aged 19 years or older had diabetes for one year or more as a physical illness or schizophrenia as a mental illness.

We designed the CITS by selecting the telemedicine group as the exposed group and the in-person group as the non-exposed group to control for external factors and strengthen internal validity.[100,101] We constructed a dynamic cohort by performing risk set matching to reflect real-world situations in which patients' dates of first telemedicine consultation vary. In addition, we performed PS and exact matching to minimize confounding factors and establish comparability between the telemedicine and in-person groups.[82,102,103] The customized cohort was analyzed using a remote computer with 2 GB of memory. We sampled the data for statistical analysis within the memory limits. We excluded the 99.5 percentile of the outcomes as outliers to avoid distortion of the results.[74]

We selected the Tweedie, Generalized Poisson, ZINB, and ZIP distributions to accurately represent the outcome characteristics. However, there were challenges in reflecting appropriate distributions, including zero inflation, repeated participants, and autocorrelation, as confirmed by hypothesis testing. We overcome these challenges by utilizing a mixed-effects model, GLMM, with AR(1) reflected in the log-likelihood function, which is a robust statistical method.

2. Discussion of the Results

2.1. Summary of Results

This study investigated the impact of telemedicine compared with in-person consultations on healthcare utilization and health outcomes among patients with chronic diabetes or schizophrenia. Specifically, we examined trends in healthcare utilization and health outcomes between telemedicine and in-person consultations and whether there were differences in policy effects. The impact was also investigated based on the degree of repetition of telemedicine consultations. Healthcare utilization was examined for outpatient visits and medication prescriptions or amounts, while health outcomes were examined for medication adherence, hospitalization, ER visits, and visits for diabetes complications or depression.

Key findings include:

A few patients continuously used telemedicine. In the telemedicine group with chronic diabetes, 52.4% and 47.6% had experienced telemedicine once and repeatedly, respectively. In the telemedicine group with chronic schizophrenia, 42.5% experienced telemedicine once and 57.5% experienced it repeatedly.

In addition, the effects of telemedicine on patients with chronic diabetes or schizophrenia have been mixed.

A. Patients with chronic diabetes

Among patients with chronic diabetes who underwent telemedicine consultations, medication adherence decreased by approximately 4.2% over time compared to those who received in-person consultations. The average monthly medication adherence in the telemedicine group decreased from 67.55% before the telemedicine consultations to 59.97% after the telemedicine consultations. In the in-person group, the average monthly medication adherence decreased from 73.25% to 65.95%.

Meanwhile, the number of ER visits decreased by approximately 2.9% over time in the group that underwent repeated telemedicine consultations compared to the group that underwent in-person consultations. The monthly average ER visits in the telemedicine group decreased from 0.99 days before telemedicine consultations to 0.91 days after telemedicine consultations. The in-person group showed an increase in average monthly ER visits from 0.84 days to 0.91 days.

Additionally, in patients with chronic diabetes, the trends in healthcare utilization and outcomes were similar between those who used telemedicine and those who used it repeatedly.

B. Patients with chronic schizophrenia

In contrast, among patients with chronic schizophrenia who had repeated telemedicine consultations, the policy effect on medication adherence improved over time by approximately 7.4% compared with the in-person consultation group. The telemedicine group showed an increase in monthly average medication adherence from 40.1% before to 66.9% after the telemedicine consultations. In the in-person group, average monthly medication adherence increased from 47.0% to 61.3%.

By contrast, ER visits worsened over time, increasing by 2.1%. The telemedicine group had an increase in average monthly ER visits from 1.13 days before telemedicine consultations to 1.35 days after telemedicine consultations. The in-person group had an increase in average monthly ER visits from 1.26 days to 1.33 days.

Additionally, patients with chronic schizophrenia tended to use more medication amounts in the once-experienced group than in the repeat group. However, the repeat group tended to have more monthly visits due to hospitalization and depression than the once-experience group.

2.2. Comparison with Previous Studies

Despite its timeliness and significance, there are numerous aspects of telemedicine that require further research. We investigated medication prescriptions, medication amounts, medication adherence, complications, and comorbidities, which, to our knowledge, have been little studied, including outpatient visits, hospitalization, and ER visits, and areas in which some research has been conducted.

Most previous studies on telemedicine have reported that telemedicine has a positive effect on healthcare utilization and health outcomes.[49-57,59,61] However, in the present study, the effects of telemedicine were inconsistent across chronic diseases and health outcome indicators. Additionally, there were significant areas in which the telemedicine group did not differ from the in-person group in terms of healthcare utilization and health outcome indicators.

Specifically, we found that telemedicine worsened medication adherence compared to in-person medication adherence in patients with chronic diabetes. In contrast, in patients with chronic schizophrenia, repeated telemedicine use improved medication adherence. However, studies on telemedicine and medication adherence are limited. The identified prior studies were telemedicine and telehealth studies that involved proactive and continuous contact with healthcare providers. These studies reported that medication adherence improved when interventions such as text messages, phone calls, mobile applications, flashcards, and educational videos were used.[51,52,61] However, this study differs from previous studies in that it focused on consultations, one of the most direct areas of telemedicine in healthcare, and patients voluntarily contacted their healthcare providers. In addition, prior studies were experimental, in which patients' telemedicine or telehealth interventions were usually assigned by investigators or computers.[47,52,57,104] However, our quasi-experimental study included both telemedicine and in-person episodes in the telemedicine group, which was closer to the patterns of real-world telemedicine use. In addition, previous studies tended to measure medication adherence by calculating the

medication possession ratio or PDC for single or few drugs or indirectly using the Morisky Medication Adherence Scale (MMAS) or Morisky Green Adherence Questionnaire (MAQ).[14,105-107] For diabetes, antihypertensive medication was measured or the MMAS method, which is efficient but difficult to measure quantitatively, was used.[107,108] In the case of schizophrenia, medication adherence was measured indirectly using the MAQ or smart pill bottles without specifying specific drugs.[105,109] Our study investigated medication adherence for 50 common medications in PDC; therefore, it reflected patients' polypharmacy adherence.

In our study, repeat telemedicine consultations improved ER visits for patients with diabetes compared to in-person consultations but worsened ER visits for patients with schizophrenia. Previous studies on telemedicine and ER visits have included programs, experiments, and screenings for ER patient classification or rapid responses before ER visits.[45,55,58] Few studies have been conducted on telemedicine consultations and ER visits. Limited studies related to telehealth consultations and ER visits in patients with diabetes have reported reductions in ER visits, including a study on coordination/home-telehealth programs for veterans and a study on online telemedicine clinics with education for children.[110,111] We found no studies on telemedicine consultations and ER visits in patients with schizophrenia. Meanwhile, when examining telemedicine and ER visits from a chronic disease perspective, there was a report that ER visits were non-inferior to the secondary outcome of maintaining functional angina grade in an RCT of patients with stable coronary artery disease.[112]

Our study focused on diabetes as a representative chronic physical disease and schizophrenia as a representative chronic mental disease. We investigated how telemedicine affects adverse events, such as ER visits, in patients with chronic diseases. The contrasting effects of telemedicine on medication adherence and ER visits for patients with diabetes and schizophrenia in this study may be attributed to the differing characteristics of these diseases, with diabetes as a physical condition and schizophrenia as a mental disorder. The mixed effects of telemedicine on the same disease may occur

because the characteristics of the outcome indicators are different. Medication adherence is a long-term management indicator that patients need to adhere voluntarily and continuously.[113] However, ER visits are an indicator of adverse events owing to worsening health conditions that can occur acutely. In addition, the other outcomes of healthcare utilization and health outcomes investigated in our study did not differ significantly between telemedicine and in-person consultations. This result is similar to those of previous studies reporting that the telemedicine group was not different from the in-person group.[104,114] Previous studies have reported that the telemedicine group was non-inferior or better than the in-person group; however, these were usually continuous programs or experimental studies, and the possibility of publication bias cannot be ruled out.[115]

2.3. Implications of the Results

This study was conducted during the transitional period of telemedicine in Korea. There are pending bills on telemedicine, and opinions on telemedicine are divided, even within the medical community.[11] Although the public is aware of telemedicine, it is less common.[5] Among those who underwent telemedicine consultations in this study, 52.4% of the patients with chronic diabetes and 57.5% of those with chronic schizophrenia repeatedly used telemedicine.

Telemedicine did not significantly differ from in-person effects over time for most indicators selected to be representative of healthcare utilization and health outcomes. There was no statistically significant difference in the duration of hospitalization. In particular, gaps in outpatient visits, medication prescriptions, medication use, and visits for diabetes-related complications or depression were reduced. This may be due to the small effect size or the absence of an actual difference. Alternatively, this could be because the optimal follow-up period for capturing policy impact differs according to the frequency of telemedicine use.

Notable findings from the results were medication adherence and ER visits. Compared with in-person adherence, medication adherence to telemedicine decreased in patients with chronic diabetes and increased in patients with schizophrenia. This may be because the appropriateness of telemedicine varies according to disease characteristics. In the telemedicine group, the medication adherence of patients with diabetes decreased from 67.55% to 59.97%, and medication compliance increased from relatively good to poor. Medication adherence in patients with diabetes is affected by the degree of interaction between the doctor and the medication plan.[116,117] Telemedicine consultations were not long, with 45.8% taking less than 5 minutes and 39.5% taking 5 to 10 minutes.[20] In addition, patients using telemedicine may have limited psychological closeness and information exchange with doctors compared to in-person consultations.[118] When using telemedicine, patients with chronic physical diseases who require complex and frequent medication may have limited interactions with doctors and medication, which may lead to decreased medication adherence.[116]

In contrast, the medication adherence of patients with schizophrenia increased from 51.97% to 60.14%, indicating an improvement from an inadequate level. This may be because telemedicine can alleviate the psychological resistance of patients with schizophrenia to in-person consultations and prevent social stigma.[119,120] For caregivers of patients with low awareness of their illness, telemedicine can facilitate the treatment of patients with schizophrenia. In addition, it can improve accessibility to treatment for patients who have difficulty visiting clinics in person because of fear of stigmatization of mental illness.[121] As the frequency of consultations increases, medication management can be strengthened for patients with schizophrenia who lack insight into their illness or do not recognize the importance of taking medication.[117]

For ER visits, patients who repeatedly used telemedicine consultations showed slight differences compared with those who relied on in-person consultations. Specifically, ER visits improved in patients with diabetes but worsened in those with schizophrenia. This

may be because telemedicine has different effects on the continuity of care and prevention of emergencies, depending on the nature of the disease.

Chronic diabetes requires blood sugar control, which can change quickly. Patients with diabetes may lose consciousness or show serious symptoms when their blood sugar levels suddenly increase, or when hyperglycemic shock occurs, requiring urgent emergency treatment.[122] Telemedicine can reduce waiting times for medical treatment at medical institutions and provide early responses. People with diabetes may be relatively self-aware of their disease and routinely practice self-management in their daily lives.[15,120,123] As a result, they are more likely to contact healthcare providers and respond appropriately in the event of a hyperglycemic shock. The speed of telemedicine and the self-management ability of patients with diabetes can lead to the prevention of ER visits.[44]

However, patients with schizophrenia may have difficulty using telemedicine consultations on their own when acute deterioration occurs in terms of amnesia, hallucinations, disorganized behavior, and speech,[124] which can lead to ER visits because it is difficult for patients to respond on their own. In addition, telemedicine may provide less rapport or psychological support to the doctor than in person,[41] which may lead to stressful situations for the patient,[125] which may not meet psychological care needs and may lead to ER visits.

2.4. Implications for Future Research

Therefore, qualitative studies on telemedicine are required. Studies on patients' and providers' experiences and interactions with telemedicine, legal and institutional issues, and technology-related studies are needed, which may be better suited for qualitative research.[126] There are abstract factors concerning telemedicine, specifically patients' motivation and satisfaction, the quality of telemedicine, healthcare providers' stress and efficiency, the mechanisms of rapport and trust building between providers and patients, and responsibility.

In addition, telemedicine requires multifaceted studies as it integrates multidisciplinary factors, such as healthcare, legal responsibility, and technological infrastructure.[41]

However, further quantitative studies are required. Future research on healthcare utilization, such as the time zone and cycle of telemedicine, services, and geographical types, can help identify patient needs and contribute to improved healthcare services and policies. In addition, health outcome studies on the safety of telemedicine are needed, as previous studies on adverse effects such as complications and comorbidities are rare. Studies on the transitional and mature stages of telemedicine and comparative analyses are necessary to understand telemedicine.

3. Policy Implications

3.1. Policy Considerations

Telemedicine is a new paradigm that should be safely and effectively embedded into healthcare delivery systems. In this study, the effects of telemedicine were mixed depending on the type of chronic disease, and there were areas where telemedicine had worse health outcomes than in-person consultations. Telemedicine should be used conservatively and cautiously as a complementary measure of patient safety and the quality of medical care.

The following specific conditions can be considered prerequisites for telemedicine policy targets: returning patients with mild and chronic diseases; patients with disabilities who have difficulty moving; patients at home; elderly patients considering accompanying a caregiver for communication; patients with infectious diseases who are not children and are in isolation; islands or mountainous areas; medically vulnerable areas designated by the government; military bases in remote areas; and those overseas, such as deep-sea fishing vessels. In-person consultations should be recommended for children to ensure safety and for patients requiring care at the hospital level or higher to prevent overcrowding in specific institutional types.

Because telemedicine is a new entry into the healthcare delivery system, it requires a legal framework developed through discussions and agreements. During the drafting process, committees and task force teams that fit the policy's purpose can be created. A Delphi survey can be conducted to gain consensus among medical, technical, and legal experts.

Therefore, it is important to establish policies to substantially improve medical accessibility. Beneficiaries' situations should be considered to ensure that medical equity is not undermined by the digital divide. Technological infrastructure support for establishing and maintaining telemedicine should be limited when necessary to create a

health safety net to eliminate blind spots in medical care. It is also necessary to conduct localized pilot projects by benchmarking policies in Australia, Canada, and Norway to improve medical accessibility in remote areas through telemedicine.

The telemedicine policy considers selective negative regulation based on positive regulation. Owing to the nature of telemedicine, diagnosis, and treatment are limited, and our study confirmed some negative health outcomes due to telemedicine. To ensure the safety of national health and prevent the misdiagnosis and abuse of telemedicine, it is appropriate to allow only what is explicitly permitted in the basic direction and application targets of telemedicine regulations. Subsequently, efficiency can be added by considering the detailed sub-factors that allow the rest, excluding what is explicitly prohibited, depending on selective needs.

3.2. Policy Challenges

Korea's telemedicine policy may face challenges during the transitional period. To respond proactively to the social confusion regarding the introduction of telemedicine, the following factors should be considered:

The first is legal responsibility. As telemedicine relies on ICT, medical staff obtain limited information and provide constrained treatment compared with traditional medical care. This may have led to medical errors. In addition, medical problems may occur because of defects in ICT equipment, information, and communication errors. When medical disputes arise owing to telemedicine, it may be difficult for medical staff to prove responsibility, which may lead to defensive medical care. In addition, there is an issue of personal information leakage during digital information processing,[48] which may lead to refusal of telemedicine. It is necessary to specifically define exemptions or mitigation provisions for medical professionals depending on the degree of medical accidents or errors caused by factors beyond the control of medical professionals, including ICT.

The second is the prevention of misuse and abuse. Telemedicine can be misused or abused due to information limitations, excessive patient utilization of medical services, regulatory management issues, and technological limitations. There can also be overtreatment due to patient attraction or patients' medical shopping on private platforms, and moral hazard due to hospitals' pursuit of profit.[127] Accordingly, pilot projects in Korea prohibited the prescription of emergency contraceptives, narcotics, and drugs with potential for abuse and prohibited the downloading of original prescriptions. In addition, the government has specified guidelines for soliciting customers through private platforms.

Third, there is a technical infrastructure. Doctors are concerned that telemedicine, mediated by private platforms, incurs construction and maintenance costs and problems with patient identification. They are also concerned that the management of medical information is complicated and cumbersome because of the variety of private platforms and electronic medical record programs and their limited interoperability.[11] Accordingly, the government may consider providing standard guidelines for what is needed across platforms and supporting intersystem linkages through government-managed public programs or technologies.

Fourth, there is financial soundness. The cost and level of insurance coverage for telemedicine may affect patients' access to healthcare and health outcomes. In Korea, the cost of telemedicine consultations is 30% higher than in-person consultations.[19] In contrast, telemedicine fees are usually the same as or lower than in-person fees.[6,26,31] It is necessary to discuss telemedicine within the medical community to maintain sustainable finances and improve accessibility to patient healthcare.

Additionally, there are response guidelines or protocols. The use of telemedicine as an emergency response measure in emergencies can contribute to patient health outcomes through effective guidelines or protocols.

4. Limitations and strengths

4.1. Limitations

This study has the following limitations.

First, administrative claims data were used. Although the data were comprehensive, they did not capture subjective clinical details such as motivation, satisfaction, and perceived quality of telemedicine or in-person consultations. It also could not identify patients' digital access, information acquisition on telemedicine consultations, or utilization channels such as mobile apps. In addition, although it is not common in the Korean medical system, we could not identify some uncovered items for patients with schizophrenia. Concerning the study period, information on the testing, diagnosis, and isolation of Coronavirus disease 2019 was limited for reasons such as anonymity protection.

Second, there are some considerations regarding the generalizability of the telemedicine pilot project situation and participant selection. Telemedicine is currently under the legislative process and is permitted only as a pilot project in South Korea. If telemedicine is legislated and becomes a part of our daily lives in the near future, its impact may differ from what it is now. In addition, since this study targeted chronic diabetes and schizophrenia in adults, it may be difficult to apply it to acute and short-term diseases, other diseases even if they are chronic diseases, and adolescents. Since the study participants were matched based on the characteristics of the telemedicine group, their attributes may differ from those of the general patient population. For instance, while the average age of adults with schizophrenia was 35 to 44 years in Korea,[128,129] the study participants had an average age of 58.8 years.

Third, we could not analyze cases in which only telemedicine and in-person services were used. This was because the study unit was an individual and not an episode. We wanted to reflect on the reality of using telemedicine and in-person in combination. In

addition, there were a few episodes of continuous telemedicine use, and the outcomes were not independent of episodes by treatment type.

4.2. Strengths

Despite the above limitations, this study has the following strengths. First, we used representative customized data. These data were obtained from the NHIS, a national health insurance system and single insurer covering the entire population. We targeted diabetes as a physical aspect and schizophrenia as a mental aspect among the chronic diseases that can be mainly applied to telemedicine. In addition, customized data that could distinguish telemedicine by billing code and notes included schizophrenia, a sensitive disease. We obtained the latest data that could be claimed at the time of the data application.

Second, we conducted analyses appropriate for the study objectives using advanced methods. We carefully reviewed the study design, model, and statistical methods, and thoroughly examined the assumptions underlying the methods.

Third, the study was conducted in a timely manner. As the legalization of telemedicine is considered in Korea, there are concerns regarding its efficacy and safety. This study fills this knowledge gap by providing a comprehensive understanding of the impact of telemedicine on healthcare utilization and health outcomes. This can contribute to policy considerations before telemedicine becomes a routine practice.

VI. Conclusion

This study aimed to determine the impact of telemedicine on healthcare utilization and health outcomes. The suitability of telemedicine varies, depending on the nature of the disease. Telemedicine consultations may not be feasible for complex and frequent medication needs, such as for patients with chronic diabetes, because the information and interaction between doctors and patients are limited compared with in-person consultations. However, for patients with chronic schizophrenia who have difficulty with in-person consultations due to psychological resistance caused by a lack of awareness of the disease or fear of social stigma, telemedicine can improve medical accessibility for the patient or the patient's guardian and contribute to continuous management, such as medication compliance. However, telemedicine may lack rapport between doctors and patients or psychological care. In diseases such as schizophrenia, where psychological care is important, there is a risk of health deterioration, such as ER visits. In addition, when an acute exacerbation of a mental illness that is difficult to control occurs, it may be difficult to cope through telemedicine, leading to ER visits. However, even in ER situations, such as acute shock in patients with chronic diabetes, rapid contact through telemedicine is possible; if patients respond to an emergency on their own with feedback from their physician, it can have a positive effect in preventing health outcomes such as ER visits. Accordingly, telemedicine should be appropriately used as a complementary means to improve practical medical accessibility and respond to emergency situations that can be handled by considering the patients' disease characteristics.

ABBREVIATIONS

ADF - Augmented Dickey-Fuller

AR(1) - Autoregressive model of order one

CCI - Charlson Comorbidity Index

CDC - Centers for Disease Control and Prevention

CI - Confidence Interval

CITS - Comparative Interrupted Time Series

cloglog - complementary log-log

DW - Durbin-Watson

ER - Emergency Room

Exp(β) - exponentiated parameter estimates

HIPAA - Health Insurance Portability and Accountability Act

ICD-10 - International Classification of Diseases, 10th revision

ICT - Information and Communications Technology

MAQ - Morisky Green Adherence Questionnaire

MMAS - Morisky Medication Adherence Scale

MOHW - Ministry of Health and Welfare

NHIS - National Health Insurance Service

PDC - Percentage of Covered Days

PS - Propensity score

Q-Q - quantile-quantile

SAS - Statistical Analysis System

SD - standard deviation

SMD - Standardized Mean Difference

VIF - Variance inflation factors

ZINB - Zero-inflated Negative Binomial

ZINB - Zero-Inflated Negative Binomial

ZIP - Zero-inflated Poisson

ZIP - Zero-Inflated Poisson

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APPENDIX

Appendix 1. Frequency of Telehealth Visits by Type for Patients with Diabetes

No.	Types of Telemedicine Consultations	Freq.
1	Telephone consultation management fee (re-visit) - medical clinic, medical department in health center	351,197
2	Ongoing care fee for patients with chronic diseases - telephone consultation [per day]	35,326
3	Telephone consultation management fee (first visit) - medical clinic, medical department in health center	5,500
4	Home care telephone consultation and prescription telephone consultation management fee - medical clinic, medical department in health center	4,046
5	Home care telephone consultation and prescription telephone consultation management fee - re-visit - medical clinic, medical department in health center	2,436
6	Home care patient management fee - tertiary hospitals, general hospitals, hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	683
7	Home care patient management fee - medical clinic, medical department in health center	266
8	Home care telephone consultation and prescription telephone consultation management fee - first visit - medical clinic, medical department in health center	243
9	Home care telephone consultation and prescription telephone consultation management fee - re-visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	67
10	Home care telephone consultation and prescription telephone consultation management fee - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	49
11	Telephone consultation management fee for home treatment medical consultation center - first time - general hospitals	26
12	Home care local government-led telephone counseling management fee - re-visit - medical clinic, medical department in health center	25
13	Home care telephone consultation and prescription telephone consultation management fee - first visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	17
14	Telephone consultation management fee for home treatment medical consultation center - re-visit - medical clinic, medical department in health center	17
15	Telephone consultation management fee for home treatment medical consultation center - re-visit - general hospitals	12

Appendix 1. (Continued)

No.	Types of Telemedicine Consultations	Freq.
16	Telephone consultation management fee for home treatment medical consultation center - medical clinic, medical department in health center	11
17	Medical institution-type clinic telephone consultation management fee - re-visit - medical clinic	10
18	Inter-medical institution remote collaboration treatment fee [after transfer] - requesting institution - medical clinic, medical department in health center	10
19	Home care local government-led telephone counseling management fee - first visit - medical clinic, medical department in health center	9
20	Telephone consultation management fee for home treatment medical consultation center - re-visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	9
21	Telehealth consultation fee - commission fee - general hospitals	9
22	Inter-medical institution emergency remote collaboration treatment fee - telephone - advisory body - tertiary hospitals	9
23	Home care patient management fee - 24 hours Type II - tertiary hospitals, general hospitals, hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	8
24	Telephone consultation management fee for home treatment medical consultation center - general hospitals	7
25	Inter-medical institution emergency remote collaboration treatment fee - telephone - requesting institution - general hospitals	7
26	Home care patient management fee - daytime - medical clinic, medical department in health center	6
27	Medical institution-type clinic telephone consultation management fee - re-visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	6
28	Telehealth consultation fee - commission fee - when sharing video information	6
29	Inter-medical institution emergency remote collaboration treatment fee - video - advisory body - general hospitals	5
30	Telephone consultation management fee for home treatment medical consultation center - during night and public holidays and on Saturdays at medical clinics - general hospitals	4
31	Telephone consultation management fee for home treatment medical consultation center - first visit - medical clinic, medical department in health center	4
32	Inter-medical institution emergency remote collaboration treatment fee - video - requesting institution - medical departments in hospitals	4
33	Inter-medical institution emergency remote collaboration treatment fee - video - advisory body - tertiary hospitals	4

Appendix 1. (Continued)

No.	Types of Telemedicine Consultations	Freq.
34	Telephone consultation management fee for home treatment medical consultation center - first visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	3
35	Home care local government-led telephone counseling management fee - first visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	2
36	Home care local government-led telephone counseling management fee - re-visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	2
37	Telephone consultation management fee for home treatment medical consultation center - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	2
38	Medical institution-type clinic telephone consultation management fee - first visit - hospitals, medical departments in oriental medicine hospitals	2
39	Telehealth consultation fee - commission fee - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	2
40	Inter-medical institution emergency remote collaboration treatment fee - telephone - advisory body - general hospitals	2
41	Home care patient management fee - daytime - tertiary hospitals, general hospitals, hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	1
42	Medical institution-type clinic telephone consultation management fee - first visit - medical clinic	1
43	Inter-medical institution emergency remote collaboration treatment fee - video - requesting institution - general hospitals	1
44	Inter-medical institution remote collaboration treatment fee [after transfer] - requesting institution - general hospitals	1

Appendix 2. Frequency of Telehealth Visits by Type for Patients with Schizophrenia

No.	Types of Telemedicine Consultations	Freq.
1	Telephone consultation management fee (re-visit) - medical clinic, medical department in health center	4,543
2	Telephone consultation management fee (first visit) - medical clinic, medical department in health center	97
3	Home care telephone consultation and prescription telephone consultation management fee - re-visit - medical clinic, medical department in health center	77
4	Home care telephone consultation and prescription telephone consultation management fee - medical clinic, medical department in health center	43
5	Home care patient management fee - tertiary hospitals, general hospitals, hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	7
6	Home care telephone consultation and prescription telephone consultation management fee - re-visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	4
7	Home care telephone consultation and prescription telephone consultation management fee - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	3
8	Home care local government-led telephone counseling management fee - re-visit - medical clinic, medical department in health center	1
9	Home care telephone consultation and prescription telephone consultation management fee - first visit - hospitals, psychiatric hospitals, medical departments in nursing hospitals, oriental medicine hospitals, and dental hospitals	1

Appendix 3. Ingredients, ATC Codes, and Contents of the Top 50 Pharmaceuticals Frequently Prescribed to Patients with Diabetes

Rank	Pharmaceutical code	Ingredient	ATC code	Contents
1	191502AT	Metforminhydrochloride hydrochloride	A10	Drugs used in diabetes
2	165702AT	Glimepiride	A10	Drugs used in diabetes
3	191504AT	Metforminhydrochloride hydrochloride	A10	Drugs used in diabetes
4	616401AT	Linagliptin	A10	Drugs used in diabetes
5	165704AT	Glimepiride	A10	Drugs used in diabetes
6	474300AT	Metformin hydrochloride	A10	Drugs used in diabetes
7	431901AT	Pioglitazone hydrochloride	A10	Drugs used in diabetes
8	165701AT	Glimepiride	A10	Drugs used in diabetes
9	513700AT	Metformin hydrochloride	A10	Drugs used in diabetes
10	619101AT	Gemigliptin tartrate sesquihydrate	A10	Drugs used in diabetes
11	527302AT	Dapagliflozin propanediol hydrate	A10	Drugs used in diabetes
12	191501AT	Metformin hydrochloride hydrochloride	A10	Drugs used in diabetes
13	632000AT	Metformin hydrochloride	A10	Drugs used in diabetes
14	191505AT	Metforminhydrochloride hydrochloride	A10	Drugs used in diabetes
15	520700AT	Metformin hydrochloride	A10	Drugs used in diabetes
16	501103AT	Sitagliptin phosphate hydrate	A10	Drugs used in diabetes
17	101430AT	Acetaminophen	N02	Analgesics
18	502300AT	Metformin hydrochloride	A10	Drugs used in diabetes
19	645000AT	Metformin	A10	Drugs used in diabetes

Appendix 3. (Continued)

Rank	Pharmaceutical code	Ingredient	ATC code	Contents
20	165603AT	Gliclazide	A10	Drugs used in diabetes
21	524700AT	Metformin hydrochloride	A10	Drugs used in diabetes
22	242330BI	Tramadol hydrochloride	N02	Analgesics
23	639800AT	Metformin hydrochloride	A10	Drugs used in diabetes
24	165604AT	Gliclazide	A10	Drugs used in diabetes
25	525901AT	Lobeglitazone sulfate	A10	Drugs used in diabetes
26	520500AT	Metformin hydrochloride	A10	Drugs used in diabetes
27	627301AT	Teneligliptin hydrobromide hydrate	A10	Drugs used in diabetes
28	626830BI	Insulin degludec	A10	Drugs used in diabetes
29	628201AT	Empagliflozin	A10	Drugs used in diabetes
30	250501AT	Zolpidem tartrate	N05	Psycholeptics
31	520600AT	Metformin hydrochloride	A10	Drugs used in diabetes
32	523800AT	Metformin hydrochloride	A10	Drugs used in diabetes
33	461830BI	Insulin glargine	A10	Drugs used in diabetes
34	480401AC	Pregabalin	N02	Analgesics
35	191503AT	Metforminhydrochloride hydrochloride	A10	Drugs used in diabetes
36	502900AT	Metformin hydrochloride	A10	Drugs used in diabetes
37	461832BI	Insulin glargine	A10	Drugs used in diabetes
38	628202AT	Empagliflozin	A10	Drugs used in diabetes
39	519600AT	Metformin hydrochloride	A10	Drugs used in diabetes
40	641400AT	Metformin hydrochloride	A10	Drugs used in diabetes
41	642000AT	Metformin	A10	Drugs used in diabetes
42	513000AT	Acetaminophen	N02	Analgesics

Appendix 3. (Continued)

Rank	Pharmaceutical code	Ingredient	ATC code	Contents
43	624203AT	Alogliptin benzoate	A10	Drugs used in diabetes
44	507100AT	Metformin hydrochloride	A10	Drugs used in diabetes
45	645301AT	Evogliptin tartrate	A10	Drugs used in diabetes
46	507000AT	Metformin hydrochloride	A10	Drugs used in diabetes
47	105502AT	Alprazolam	N05	Psycholeptics
48	480600AT	Acetaminophen	N02	Analgesics
49	441330BI	Insulin aspart	A10	Drugs used in diabetes
50	649900AT	Metformin	A10	Drugs used in diabetes

Appendix 4. Ingredients, ATC Codes, and Contents of the Top 50 Pharmaceuticals Frequently Prescribed to Patients with Schizophrenia

Rank	Pharmaceutical code	Ingredient	ATC code	Contents
1	185501AT	Lorazepam	N05	Psycholeptics
2	224202AT	Risperidone	N05	Psycholeptics
3	224203AT	Risperidone	N05	Psycholeptics
4	204001AT	Olanzapine	N05	Psycholeptics
5	185504AT	Lorazepam	N05	Psycholeptics
6	378602AT	Quetiapine fumarate	N05	Psycholeptics
7	224201AT	Risperidone	N05	Psycholeptics
8	378601AT	Quetiapine fumarate	N05	Psycholeptics
9	160601AT	Flunitrazepam	N05	Psycholeptics
10	142903AT	Diazepam	N05	Psycholeptics
11	378603AT	Quetiapine fumarate	N05	Psycholeptics
12	142902AT	Diazepam	N05	Psycholeptics
13	250501AT	Zolpidem tartrate	N05	Psycholeptics
14	204002AT	Olanzapine	N05	Psycholeptics
15	105502AT	Alprazolam	N05	Psycholeptics
16	184701AT	Lithium carbonate	N05	Psycholeptics
17	451502AT	Aripiprazole	N05	Psycholeptics
18	474802AT	Escitalopram oxalate	N06	Psychoanaleptics
19	451501AT	Aripiprazole	N05	Psycholeptics
20	167908AT	Haloperidol	N05	Psycholeptics
21	137501AT	Clozapine	N05	Psycholeptics
22	378604AT	Quetiapine fumarate	N05	Psycholeptics
23	451503AT	Aripiprazole	N05	Psycholeptics
24	105505AT	Alprazolam	N05	Psycholeptics
25	167904AT	Haloperidol	N05	Psycholeptics

Appendix 4. (Continued)

Rank	Pharmaceutical code	Ingredient	ATC code	Contents
26	131901AT	Chlorpromazine hydrochloride	N05	Psycholeptics
27	451504AT	Aripiprazole	N05	Psycholeptics
28	378605AT	Quetiapine fumarate	N05	Psycholeptics
29	242902AT	Trazodone hydrochloride	N06	Psychoanaleptics
30	131908AT	Chlorpromazine hydrochloride	N05	Psycholeptics
31	420002AT	Amisulpride	N05	Psycholeptics
32	167903AT	Haloperidol	N05	Psycholeptics
33	242901AC	Trazodone hydrochloride	N06	Psychoanaleptics
34	161502AC	Fluoxetine hydrochloride	N06	Psychoanaleptics
35	167906AT	Haloperidol	N05	Psycholeptics
36	503202AT	Paliperidone	N05	Psycholeptics
37	243502AT	Triazolam	N05	Psycholeptics
38	204004AT	Olanzapine	N05	Psycholeptics
39	211401AT	Perphenazine	N05	Psycholeptics
40	131905AT	Chlorpromazine hydrochloride	N05	Psycholeptics
41	378610AT	Quetiapine fumarate	N05	Psycholeptics
42	233401AT	Sulpiride	N05	Psycholeptics
43	224204AT	Risperidone	N05	Psycholeptics
44	118501AT	Bromazepam	N05	Psycholeptics
45	137502AT	Clozapine	N05	Psycholeptics
46	503201AT	Paliperidone	N05	Psycholeptics
47	242901AT	Trazodone hydrochloride	N06	Psychoanaleptics
48	107501AT	Amitriptyline hydrochloride	N06	Psychoanaleptics
49	227001AT	Sertraline hydrochloride	N06	Psychoanaleptics
50	503203AT	paliperidone	N05	Psycholeptics

Appendix 5. Targeted Diseases and ICD-10 Codes by Type

Type	Diseases		ICD-10 codes
Physical side	Diabetes		E10.x-E14.x
	Diabetes Complications Related	Retinopathy	E10.3, E11.3, E12.3, E13.3, E14.3, H28.x, H33.x-H36.x, H54.x
		Neurological	E10.4, E11.4, E12.4, E13.4, E14.4, G32.2, G53.8, G56.x- G59.x, G60.9, G62.9, G64.x, G90.0, G90.8, G90.9, G99.0, G99.1, H49.x, K31.8, M14.6, N31.9, S04.x
		Hyperosmolarity	E10.0, E11.0, E12.0, E13.0, E14.0
		Ketoacidosis	E10.1, E11.1, E12.1, E13.1, E14.1
		Peripheral circulatory	E10.5, E11.5, E12.5, E13.5, E14.5, I72.4, I73.8, I73.9, I74.3, I77.1, I79.0, I79.2, I79.8
		Myocardial infarction	I20.x-I24.x, I46.x-I50.x, I70.x
		Cerebrovascular disease	I60.x-I67.x, G45.x
		Renal	E10.2, E11.2, E12.2, E13.2, E14.2, N04.9, N05.9, N08.3, N17.x-N19.x, N26.x, N28.9, T86.1, Z49.x, Z94.0, Z99.2
		Diabetic foot	E10.7, E11.7, E12.7, E13.7, E14.7, L97.x, R02.x, Z89.4, Z89.8
		Other	E10.6-E10.8, E11.6-E11.8, E12.6-E12.8, E13.6-E13.8, E14.6-E14.8
Psychiatric side	Schizophrenia		F20.x- F29.x
	Depression		F32.x- F33.x

Appendix 6. Weighted Index Applied to Calculate CCI Score

Conditions	Assigned weights for each condition
Myocardial infarction Congestive heart failure Peripheral vascular disease Cerebrovascular disease Dementia Chronic pulmonary disease Connective tissue disease Ulcer disease Mild liver disease Diabetes	1
Hemiplegia Moderate or severe renal disease Diabetes with end organ damage Any tumor Leukemia / Lymphoma	2
Moderate or severe liver disease	3
Metastatic solid tumor AIDS	6

Appendix 7. Policy Effects by Telemedicine, In-Person, and Total Groups in Patients with Diabetes

Effect Type	Patients with diabetes								
	Total			Telemedicine group			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Health utilization									
Outpatient visits									
Immediate policy effects	1.02	(0.93 – 1.11)	*0.05*	1.02	(0.89 – 1.17)	*0.07*	1.01	(0.91 – 1.13)	*0.05*
Policy effects over time	1.01	(1.00 – 1.01)	*0.00*	1.01	(1.00 – 1.02)	*0.00*	1.00	(1.00 – 1.01)	*0.00*
Medication prescription									
Immediate policy effects	1.00	(0.90 – 1.10)	*0.05*	1.00	(0.85 – 1.17)	*0.08*	1.00	(0.89 – 1.12)	*0.06*
Policy effects over time	1.01	(1.00 – 1.01)	*0.00*	1.00	(0.99 – 1.02)	*0.01*	1.01	(1.00 – 1.02)	*0.00*
Medication amount									
Immediate policy effects	0.91	(0.38 – 2.20)	*0.45*	0.86	(0.17 – 4.42)	*0.83*	0.93	(0.42 – 2.09)	*0.41*
Policy effects over time	1.09	(1.02 – 1.16)	*0.03*	1.03	(0.92 – 1.16)	*0.06*	1.10	(1.04 – 1.17)	*0.03*
Health outcomes									
Medication adherence									
Immediate policy effects	1.16	(0.92 – 1.47)	*0.12*	1.21	(0.82 – 1.78)	*0.20*	1.15	(0.87 – 1.52)	*0.14*
Policy effects over time	0.99	(0.97 – 1.01)	*0.01*	0.96	(0.93 – 0.98)	*0.01*	1.00	(0.98 – 1.02)	*0.01*

Appendix 7. (Continued)

Effect Type	Patients with diabetes								
	Total			Telemedicine group			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Hospitalization									
Immediate policy effects	1.01	(0.49 – 2.06)	*0.37*	1.01	(0.24 – 4.21)	*0.73*	1.01	(0.45 – 2.26)	*0.41*
Policy effects over time	1.00	(0.94 – 1.06)	*0.03*	1.00	(0.87 – 1.15)	*0.07*	1.00	(0.94 – 1.06)	*0.03*
Emergency room visits									
Immediate policy effects	1.01	(0.91 – 1.12)	*0.05*	1.02	(0.86 – 1.20)	*0.08*	1.01	(0.89 – 1.14)	*0.06*
Policy effects over time	1.01	(1.00 – 1.02)	*0.00*	1.00	(0.99 – 1.02)	*0.01*	1.01	(1.00 – 1.02)	*0.00*
Visits for diabetes complications									
Immediate policy effects	1.58	(1.38 – 1.82)	*0.07*	1.83	(1.47 – 2.28)	*0.11*	1.51	(1.27 – 1.78)	*0.09*
Policy effects over time	0.98	(0.97 – 0.99)	*0.01*	0.97	(0.96 – 0.99)	*0.01*	0.98	(0.97 – 0.99)	*0.01*
Visits for depression									
Immediate policy effects	1.06	(0.56 – 2.03)	*0.33*	1.07	(0.34 – 3.36)	*0.58*	1.06	(0.58 – 1.95)	*0.31*
Policy effects over time	0.99	(0.94 – 1.04)	*0.03*	0.98	(0.89 – 1.07)	*0.05*	0.99	(0.94 – 1.04)	*0.02*

Appendix 8. Policy Effects by Telemedicine, In-Person, and Total Groups in Patients with Schizophrenia

Effect Type	Patients with schizophrenia								
	Total			Telemedicine group			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Health utilization									
Outpatient visits									
Immediate policy effects	1.08	(0.97 – 1.20)	*0.05*	1.10	(0.92 – 1.32)	*0.09*	1.08	(0.96 – 1.21)	*0.06*
Policy effects over time	1.00	(1.00 – 1.01)	*0.00*	1.00	(0.99 – 1.02)	*0.01*	1.00	(1.00 – 1.01)	*0.00*
Medication prescription									
Immediate policy effects	1.01	(0.89 – 1.15)	*0.06*	1.01	(0.84 – 1.21)	*0.09*	1.01	(0.90 – 1.13)	*0.06*
Policy effects over time	1.01	(1.00 – 1.02)	*0.00*	1.01	(1.00 1.03)	*0.01*	1.01	(1.00 – 1.02)	*0.00*
Medication amount									
Immediate policy effects	1.01	(0.17 – 6.10)	*0.92*	1.03	(0.06 – 17.01)	*1.43*	1.00	(0.13 – 7.83)	*1.05*
Policy effects over time	1.00	(0.89 – 1.14)	*0.06*	1.00	(0.81 – 1.22)	*0.10*	1.01	(0.87 – 1.16)	*0.07*
Health outcomes									
Medication adherence									
Immediate policy effects	1.00	(0.76 – 1.32)	*0.14*	1.00	(0.60 – 1.66)	*0.26*	1.00	(0.77 – 1.30)	*0.13*
Policy effects over time	1.01	(0.99 – 1.03)	*0.01*	1.01	(0.98 – 1.05)	*0.02*	1.01	(1.00 – 1.03)	*0.01*

Appendix 8. (Continued)

Effect Type	Patients with schizophrenia								
	Total			Telemedicine group			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Hospitalization									
Immediate policy effects	1.04	(0.66 – 1.65)	*0.23*	1.05	(0.42 – 2.58)	*0.46*	1.04	(0.63 – 1.72)	*0.26*
Policy effects over time	1.00	(0.97 – 1.04)	*0.02*	1.00	(0.94 – 1.07)	*0.03*	1.00	(0.97 – 1.04)	*0.02*
Emergency room visits									
Immediate policy effects	1.04	(0.93 – 1.15)	*0.06*	1.04	(0.86 – 1.26)	*0.10*	1.03	(0.92 – 1.17)	*0.06*
Policy effects over time	1.01	(1.01 – 1.02)	*0.00*	1.02	(1.00 – 1.03)	*0.01*	1.01	(1.00 – 1.02)	*0.00*
Visits for depression									
Immediate policy effects	1.53	(1.15 – 2.04)	*0.15*	1.68	(1.04 – 2.71)	*0.24*	1.48	(1.08 – 2.05)	*0.16*
Policy effects over time	0.99	(0.97 – 1.01)	*0.01*	0.98	(0.95 – 1.02)	*0.02*	0.99	(0.97 – 1.01)	*0.01*

Appendix 9. Predictive Value of Medication Adherence by Covariates in Patients with Diabetes

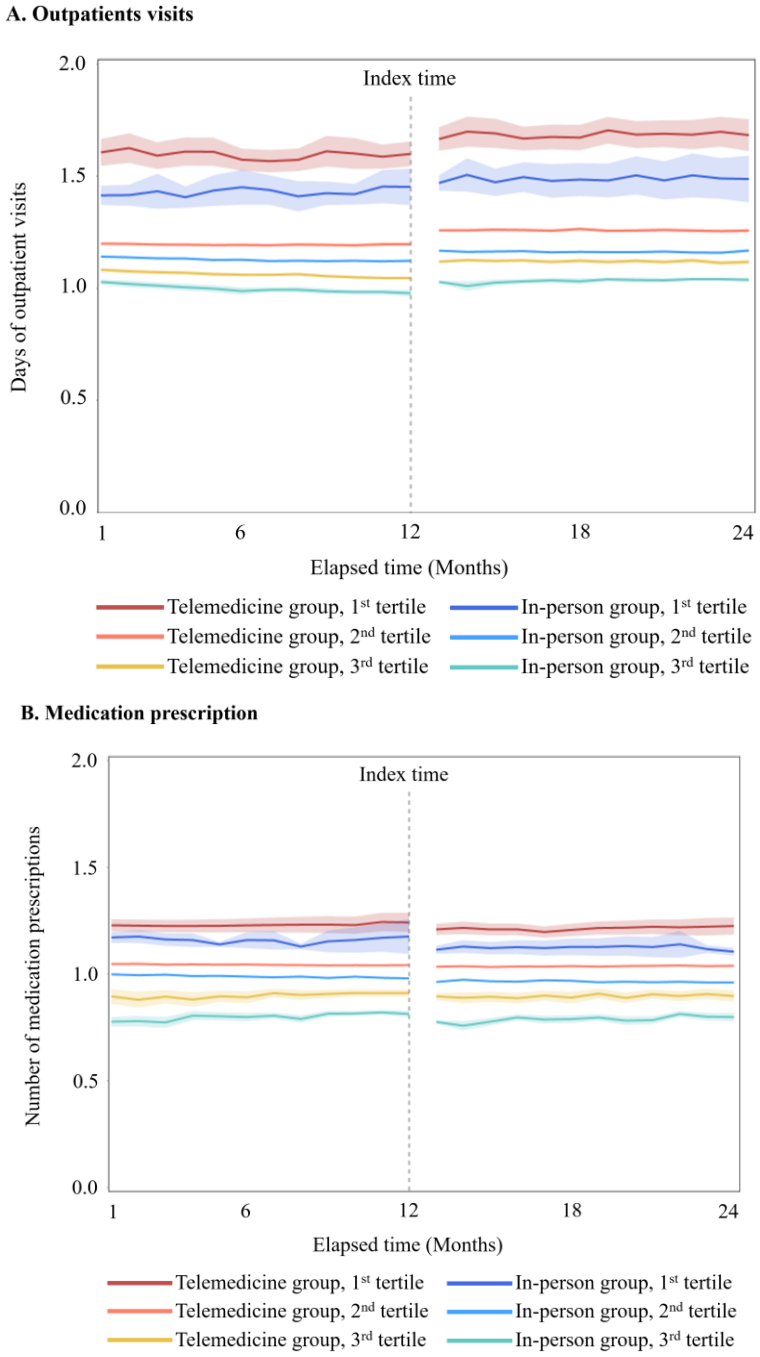
Parameters	Patients with diabetes											
	Predicted value of the medication prescription											
	Telemedicine group						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Sex												
Male	68.85	(68.04 – 69.66)	*20.44*	61.29	(60.65 – 61.94)	*15.51*	72.85	(72.21 – 73.49)	*20.95*	66.30	(65.72 – 66.88)	*18.72*
Female	66.26	(65.40 – 67.12)	*21.77*	58.63	(57.94 – 59.32)	*16.50*	73.69	(73.00 – 74.39)	*21.64*	65.59	(64.99 – 66.19)	*19.22*
Age												
19 to 29	54.62	(47.23 – 62.01)	*30.97*	41.95	(32.29 – 51.62)	*30.62*	50.33	(45.16 – 55.50)	*33.33*	46.29	(40.61 – 51.96)	*30.17*
30 to 39	61.11	(58.98 – 63.25)	*19.85*	57.26	(55.43 – 59.10)	*16.46*	64.05	(62.31 – 65.79)	*22.87*	59.13	(57.27 – 60.99)	*22.76*
40 to 49	65.87	(64.37 – 67.37)	*19.29*	59.19	(58.12 – 60.25)	*13.50*	73.65	(72.55 – 74.76)	*18.95*	65.11	(64.18 – 66.05)	*16.98*
50 to 59	70.22	(68.94 – 71.50)	*20.21*	61.92	(60.89 – 62.96)	*15.94*	73.94	(72.96 – 74.92)	*20.12*	67.37	(66.51 – 68.22)	*18.27*
60 to 69	70.42	(69.17 – 71.68)	*21.29*	60.57	(59.54 – 61.61)	*16.04*	76.81	(75.87 – 77.74)	*19.21*	66.36	(65.48 – 67.23)	*17.91*
70 or more	66.63	(65.65 – 67.62)	*21.40*	59.78	(59.00 – 60.56)	*16.10*	74.18	(73.37 – 74.98)	*21.33*	67.45	(66.74 – 68.16)	*18.67*
Region												
Metropolis	66.01	(65.16 – 66.87)	*21.31*	59.17	(58.50 – 59.83)	*15.75*	72.93	(72.18 – 73.67)	*21.89*	66.21	(65.57 – 66.84)	*19.02*
Small cities and rural	69.00	(68.19 – 69.82)	*20.91*	60.71	(60.04 – 61.37)	*16.33*	73.49	(72.88 – 74.09)	*20.83*	65.75	(65.20 – 66.30)	*18.93*

Appendix 9. (Continued)

Parameters	Patients with diabetes											
	Predicted value of the medication prescription											
	Telemedicine group						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Employment												
White collar	67.61	(66.04 – 69.19)	*20.91*	59.01	(57.66 – 60.36)	*15.95*	74.14	(73.03 – 75.24)	*19.95*	63.96	(62.92 – 65.00)	*18.80*
Service industry	69.67	(68.27 – 71.07)	*21.18*	61.83	(60.74 – 62.93)	*15.83*	74.99	(73.79 – 76.18)	*22.38*	65.83	(64.74 – 66.92)	*20.66*
Blue collar	68.59	(67.53 – 69.64)	*20.35*	61.18	(60.30 – 62.06)	*15.98*	73.89	(73.03 – 74.76)	*20.93*	67.43	(66.71 – 68.14)	*17.41*
Unemployed	65.79	(64.82 – 66.76)	*21.68*	58.59	(57.86 – 59.33)	*16.13*	71.64	(70.87 – 72.40)	*21.47*	65.72	(65.04 – 66.40)	*19.29*
Income level												
High	68.85	(67.85 – 69.84)	*22.02*	61.40	(60.62 – 62.18)	*16.43*	73.90	(73.20 – 74.60)	*20.98*	67.37	(66.72 – 68.01)	*19.15*
Medium	64.28	(63.23 – 65.33)	*21.07*	58.03	(57.16 – 58.90)	*16.47*	73.15	(72.26 – 74.03)	*21.39*	65.12	(64.35 – 65.89)	*18.74*
Low												
Health insurance type	69.32	(68.32 – 70.33)	*19.68*	60.11	(59.31 – 60.90)	*14.98*	72.35	(71.45 – 73.25)	*21.61*	64.75	(63.99 – 65.50)	*18.82*
Workplace-insured	68.84	(68.11 – 69.57)	*20.80*	60.86	(60.27 – 61.46)	*15.98*	74.00	(73.42 – 74.59)	*21.23*	65.96	(65.45 – 66.48)	*18.84*
Regionally-insured	65.26	(64.11 – 66.41)	*22.19*	58.52	(57.63 – 59.42)	*16.63*	72.80	(71.93 – 73.66)	*21.30*	66.57	(65.82 – 67.33)	*18.65*
Medical aids	65.57	(63.62 – 67.51)	*19.01*	58.45	(57.00 – 59.91)	*14.03*	67.96	(66.15 – 69.78)	*20.99*	63.12	(61.32 – 64.92)	*21.28*

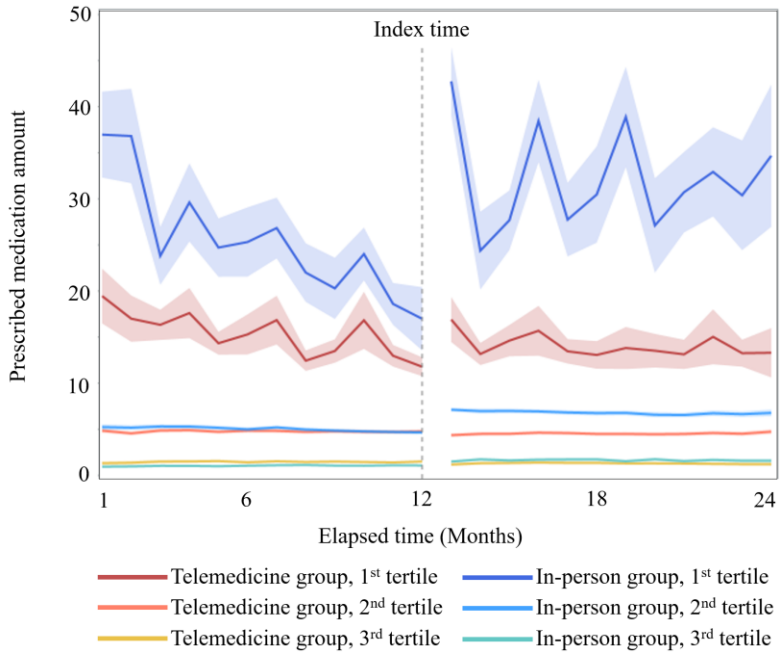
Appendix 9. (Continued)

Parameters	Patients with diabetes											
	Predicted value of the medication prescription											
	Telemedicine group						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Disability												
No	67.60	(66.98 – 68.21)	*21.19*	60.05	(59.55 – 60.55)	*15.99*	73.44	(72.95 – 73.93)	*21.24*	66.04	(65.60 – 66.48)	*18.93*
Yes	67.05	(65.09 – 69.02)	*20.77*	59.32	(57.86 – 60.79)	*16.68*	71.16	(69.49 – 72.84)	*21.69*	65.20	(63.94 – 66.46)	*19.30*
CCI scores												
1	68.98	(68.11 – 69.85)	*21.52*	60.11	(59.43 – 60.78)	*16.03*	73.11	(72.39 – 73.83)	*21.88*	66.54	(65.89 – 67.18)	*19.43*
2	68.18	(67.01 – 69.36)	*20.83*	62.41	(61.46 – 63.36)	*14.57*	75.62	(74.76 – 76.48)	*19.88*	67.49	(66.74 – 68.23)	*17.84*
3 or more	64.52	(63.44 – 65.61)	*20.51*	58.13	(57.24 – 59.02)	*16.84*	71.37	(70.50 – 72.24)	*21.38*	63.63	(62.85 – 64.40)	*19.10*
Prevalence period years												
1 year	59.29	(58.40 – 60.19)	*18.45*	63.96	(62.28 – 65.63)	*14.08*	67.82	(67.16 – 68.47)	*19.01*	66.68	(65.48 – 67.89)	*17.72*
2 year	76.16	(75.14 – 77.19)	*21.20*	66.78	(65.93 – 67.62)	*16.30*	82.00	(81.12 – 82.88)	*22.07*	70.86	(70.13 – 71.59)	*20.08*
3 years or more	67.18	(66.20 – 68.16)	*20.27*	56.04	(55.48 – 56.59)	*14.81*	71.65	(70.80 – 72.51)	*20.52*	62.46	(61.93 – 62.99)	*17.63*
Year												
2019	53.70	(52.69 – 54.71)	*16.24*	83.16	(81.05 – 85.26)	*0.85*	65.58	(64.71 – 66.45)	*18.59*	54.48	(29.79 – 79.17)	*15.52*
2020	75.35	(74.32 – 76.38)	*21.09*	68.40	(67.32 – 69.48)	*16.99*	79.25	(78.39 – 80.10)	*22.14*	74.25	(73.31 – 75.20)	*21.15*
2021	64.99	(64.11 – 65.88)	*18.78*	55.67	(55.02 – 56.33)	*14.00*	72.88	(72.09 – 73.68)	*20.84*	61.17	(60.58 – 61.75)	*16.15*
2022	77.29	(75.56 – 79.01)	*21.13*	59.61	(58.88 – 60.34)	*15.70*	72.21	(70.95 – 73.47)	*19.94*	65.33	(64.69 – 65.97)	*18.31*

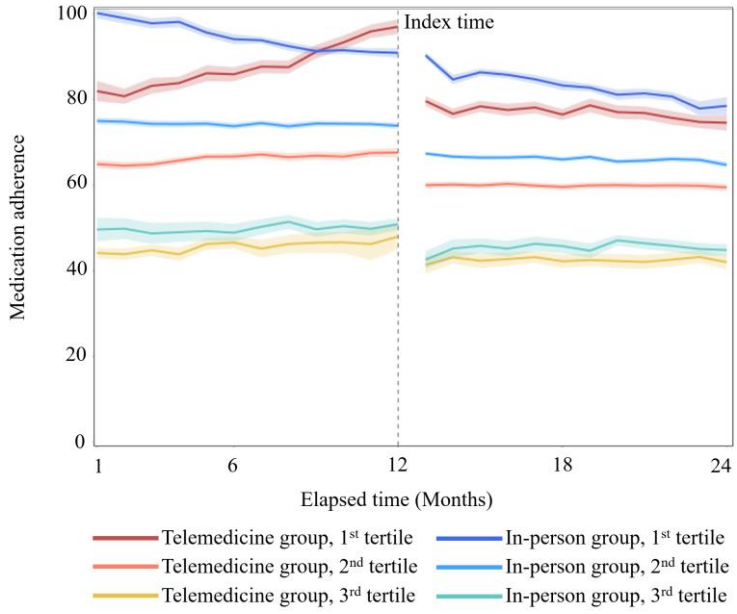


Appendix 10. Outcomes of Predicted Values by Tertiles of Telemedicine Consultations Group and In-Person Consultations Group in Patients with Diabetes

C. Medication amount

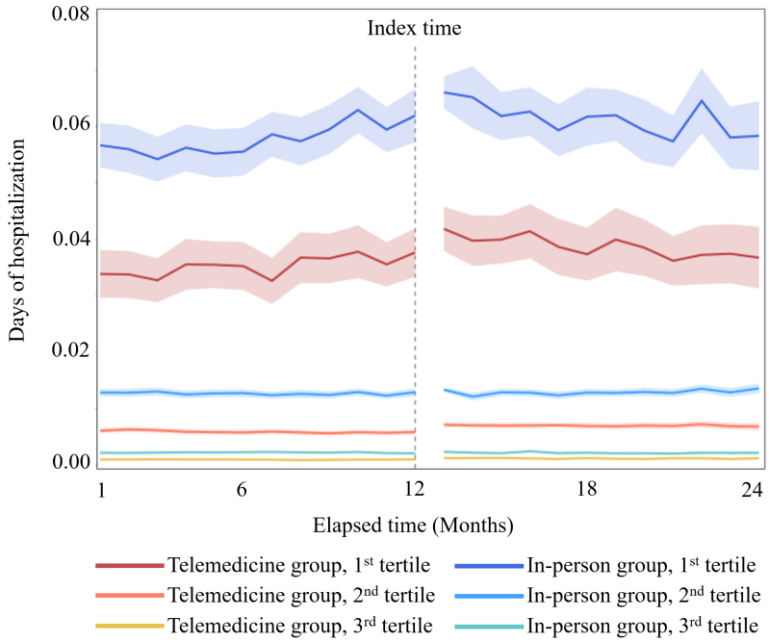


D. Medication adherence

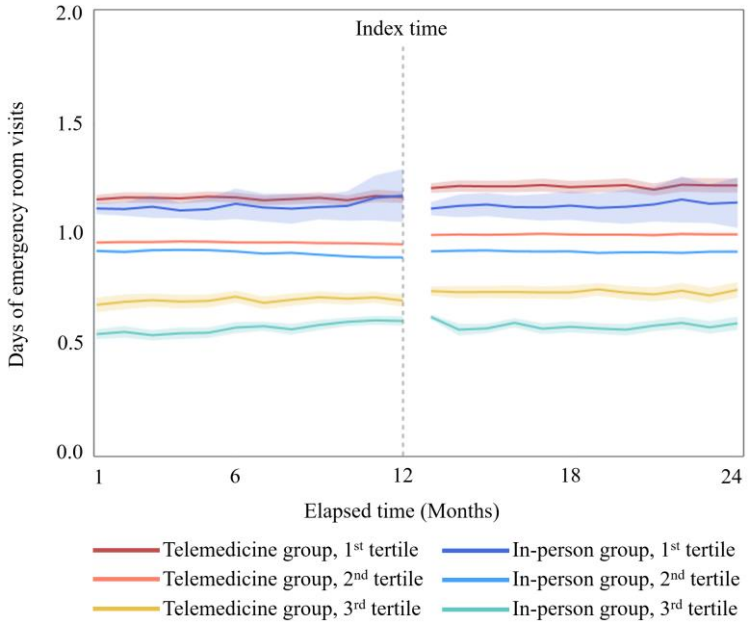


Appendix 10. (Continued)

E. Hospitalization

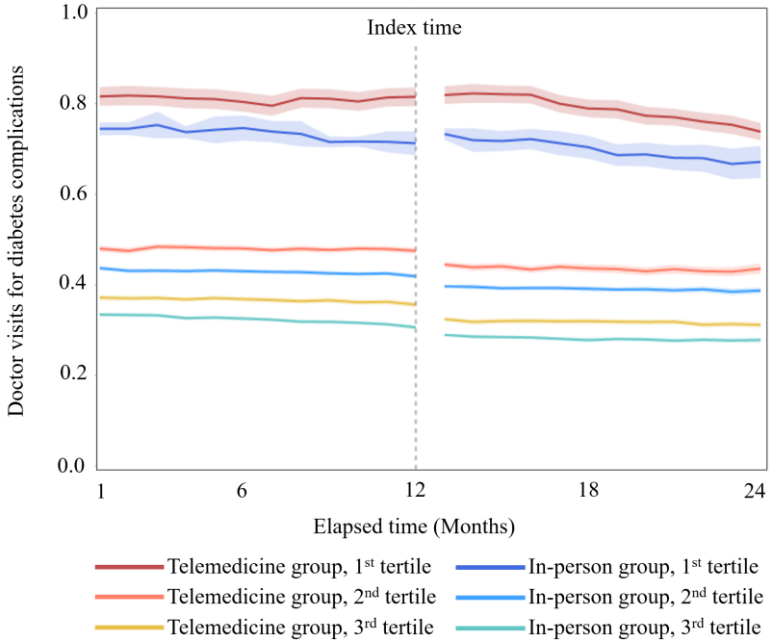


F. Emergency room visits

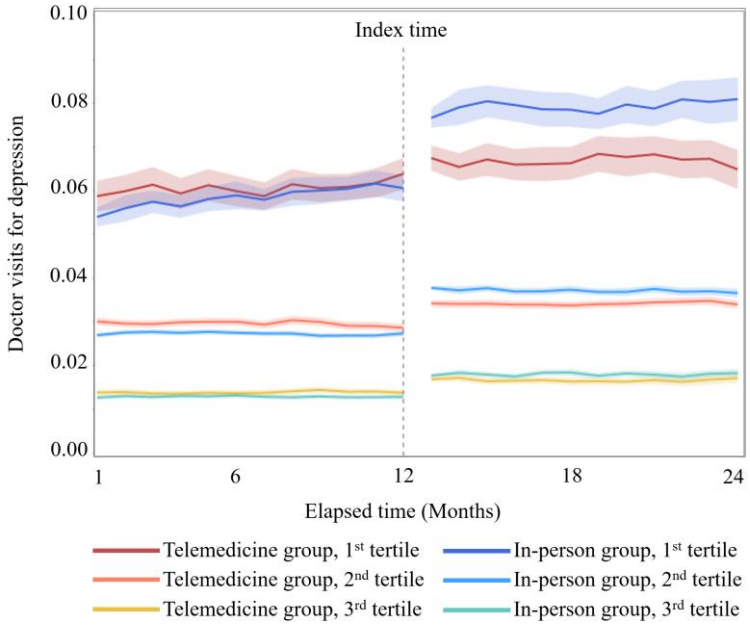


Appendix 10. (Continued)

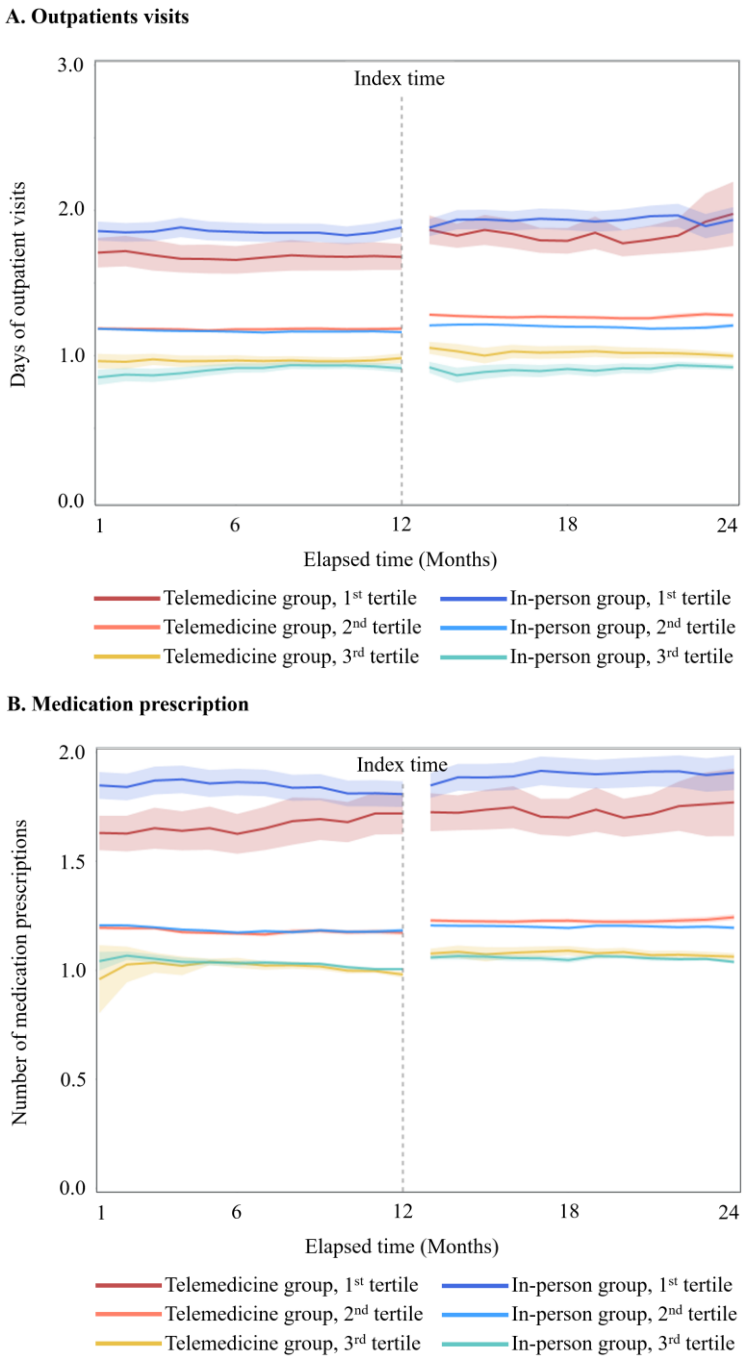
G. Visits for diabetes complications



H. Visits for depression

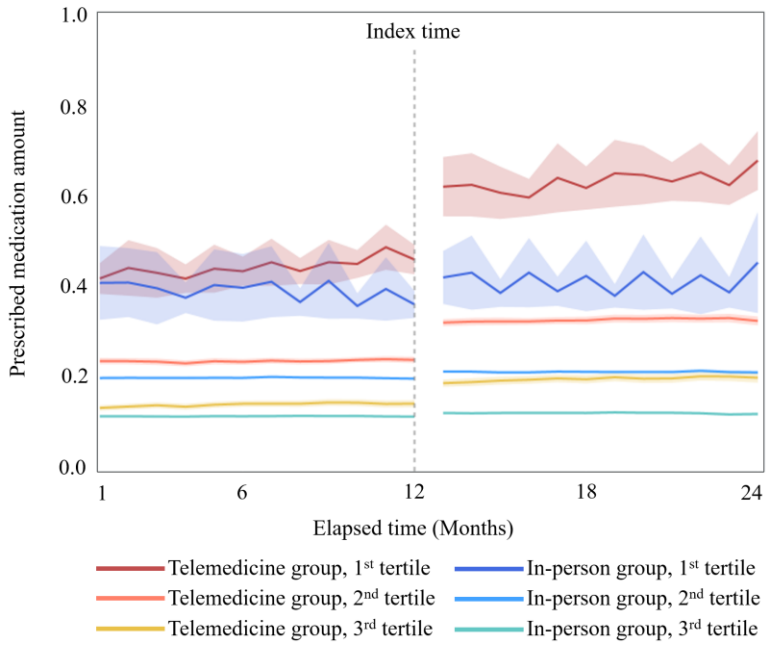


Appendix 10. (Continued)

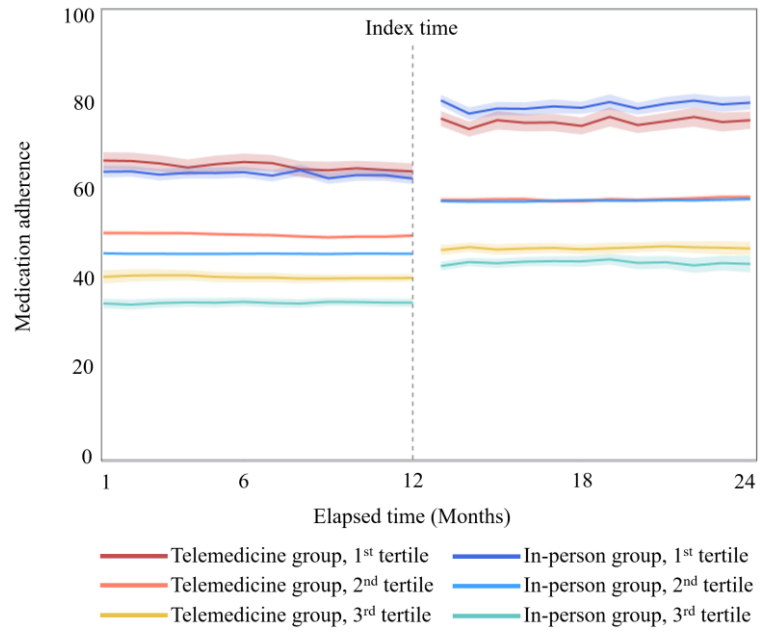


Appendix 11. Outcomes of Predicted Values by Tertiles of Telemedicine Consultations Group and In-Person Consultations Group in Patients with Schizophrenia

C. Medication amount

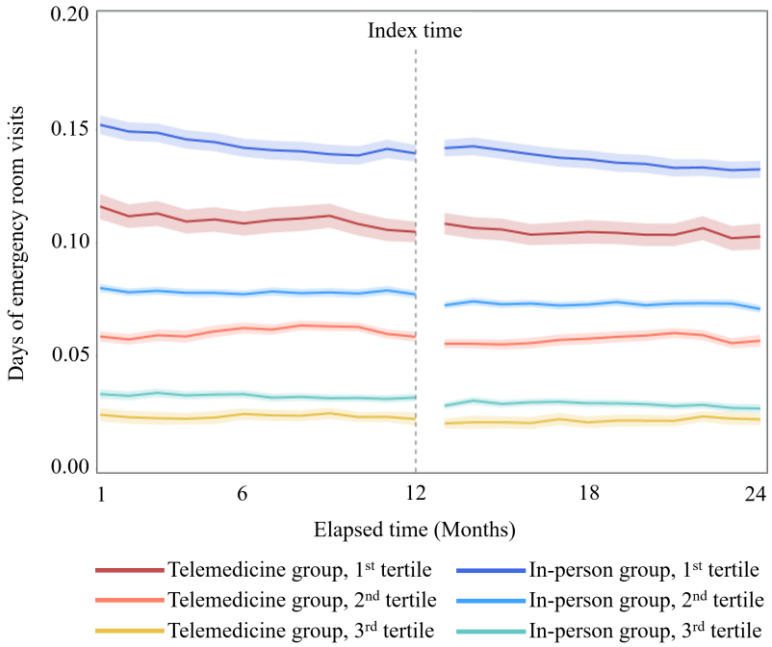


D. Medication adherence

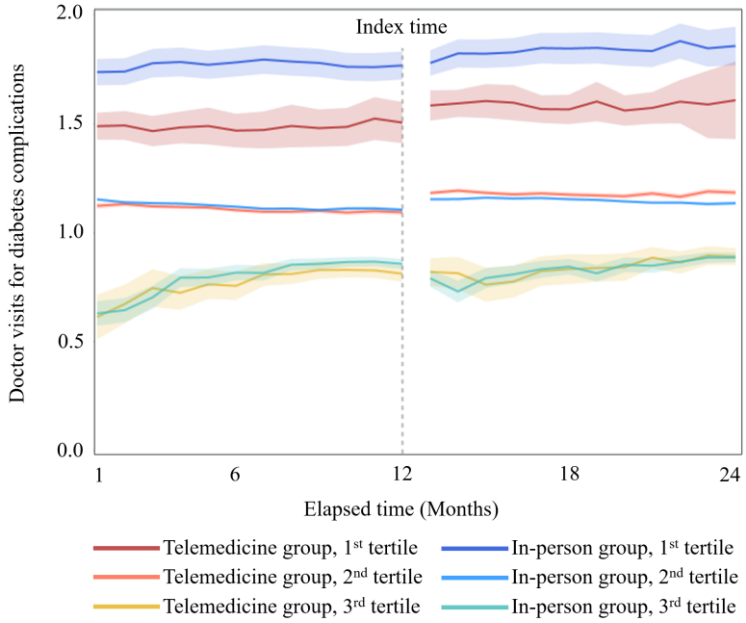


Appendix 11. (Continued)

E. Hospitalization

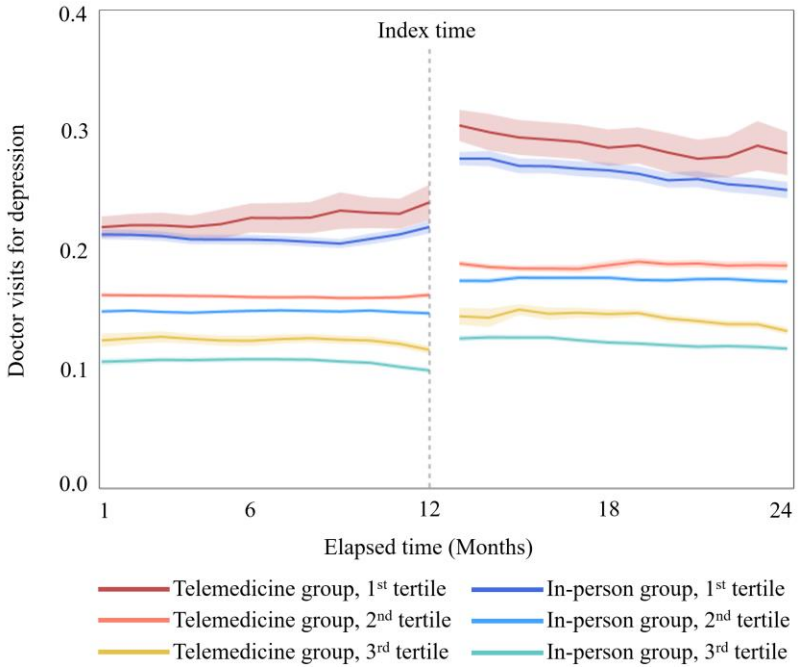


F. Emergency room visits

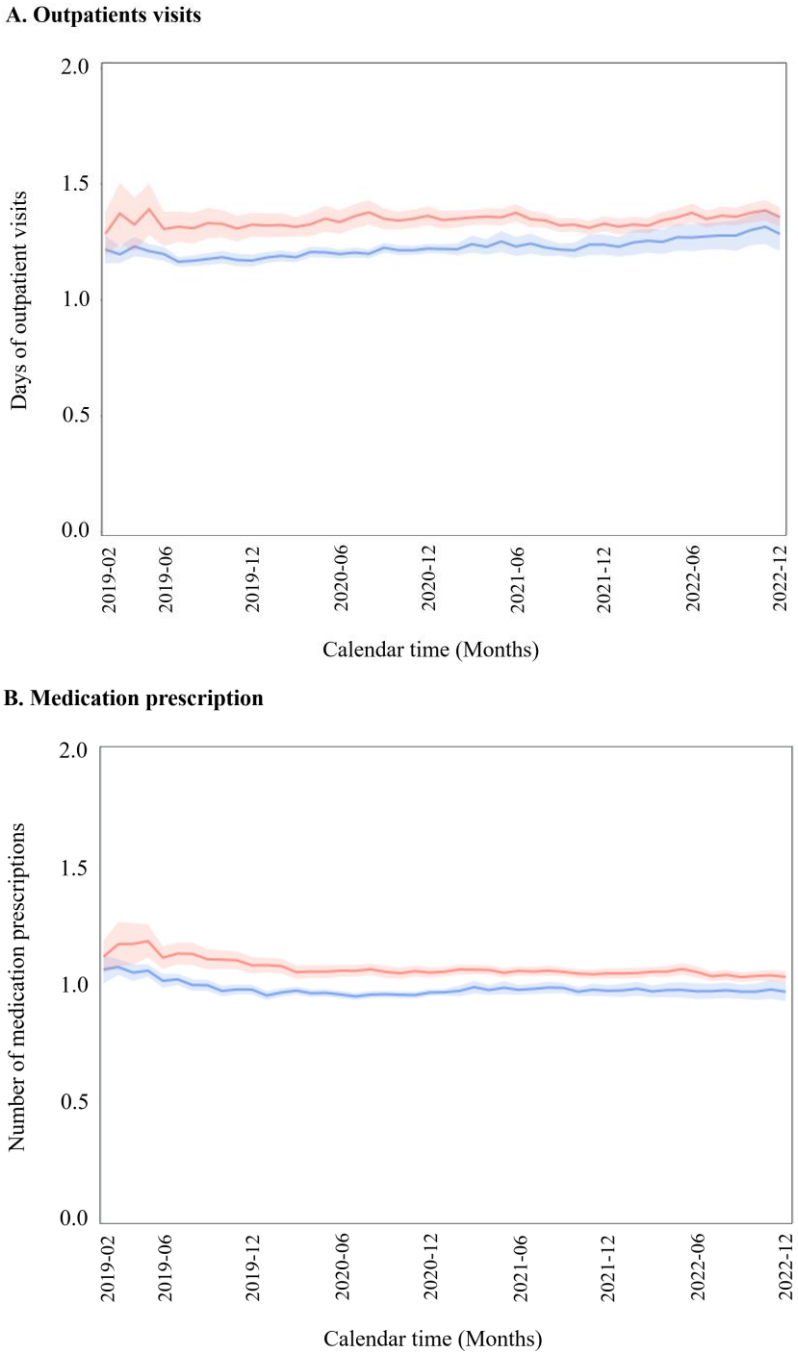


Appendix 11. (Continued)

G. Visits for depression

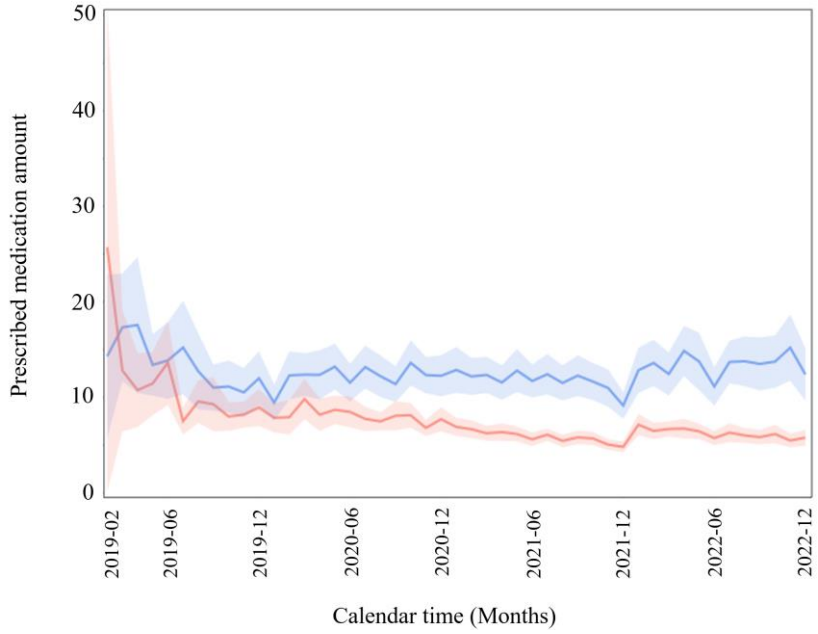


Appendix 11. (Continued)

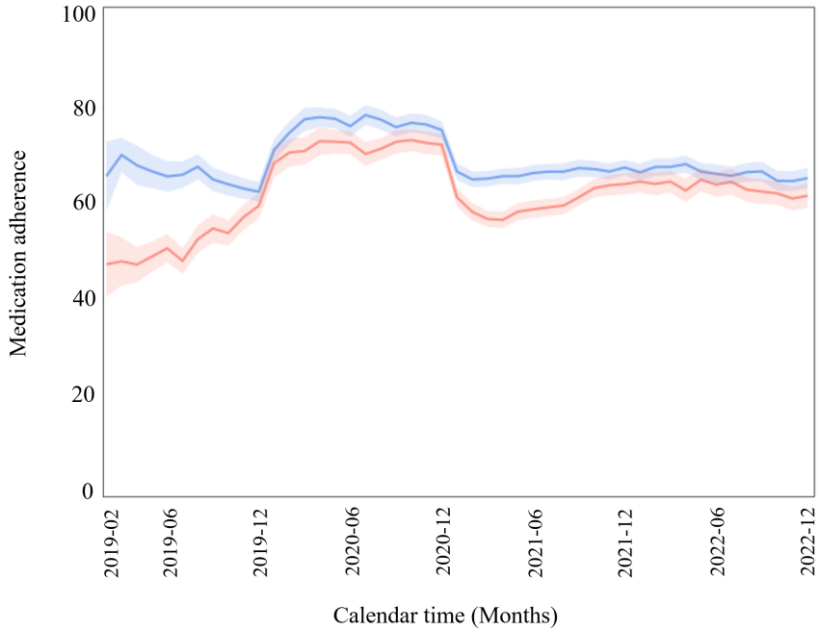


Appendix 12. Outcomes of Telemedicine and In-Person Groups in Patients with Diabetes According to Calendar Time

C. Medication amount

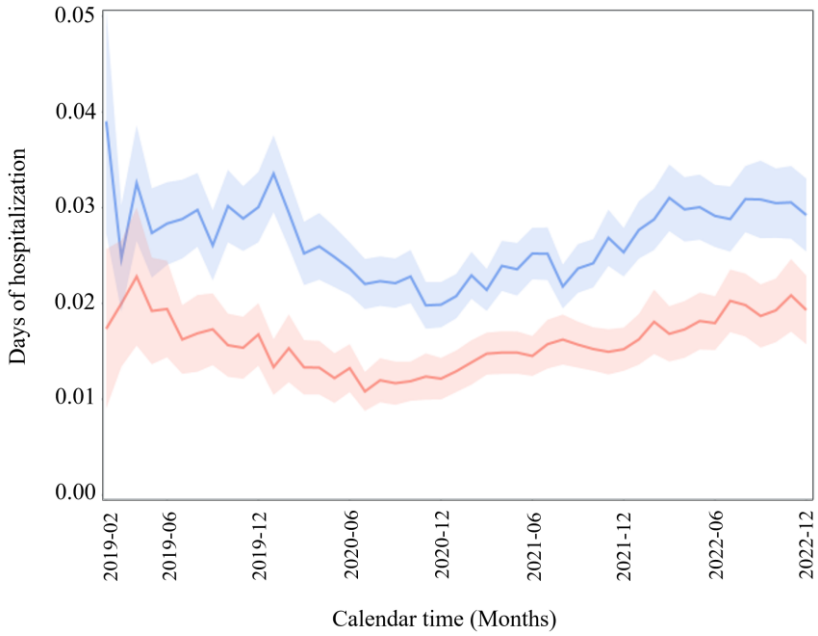


D. Medication adherence

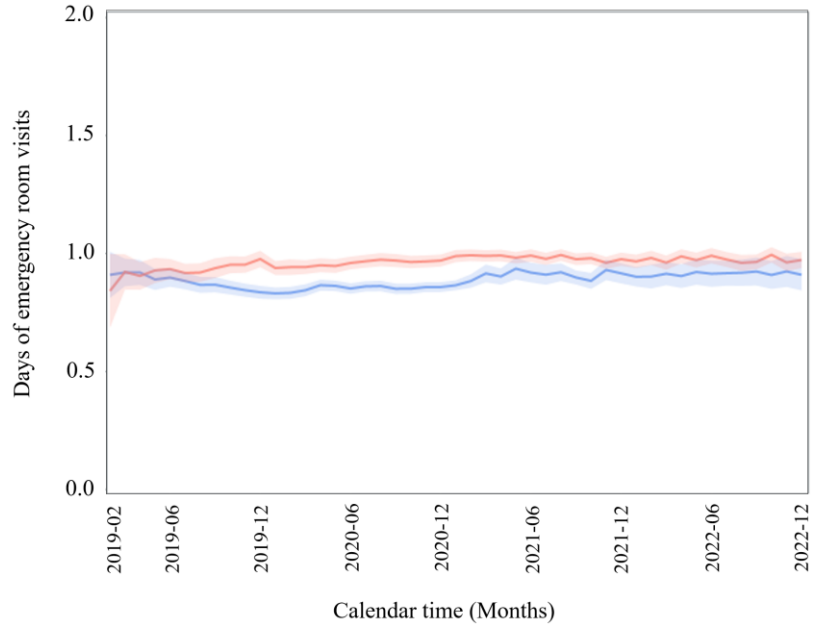


Appendix 12. (Continued)

E. Hospitalization

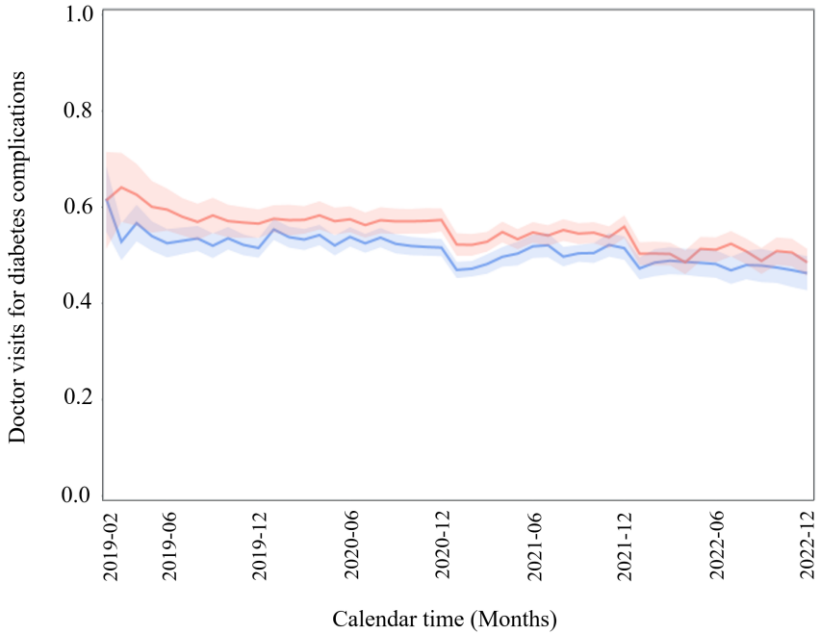


F. Emergency room visits

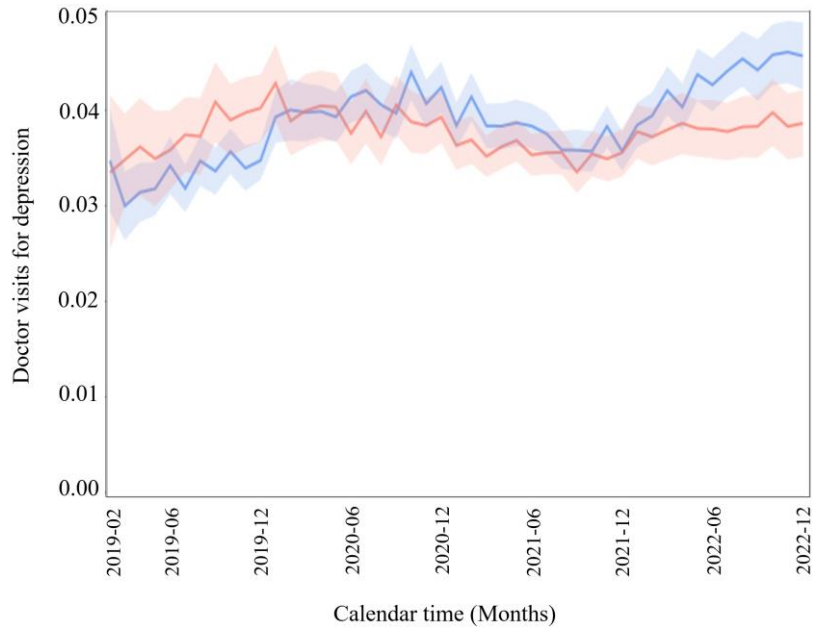


Appendix 12. (Continued)

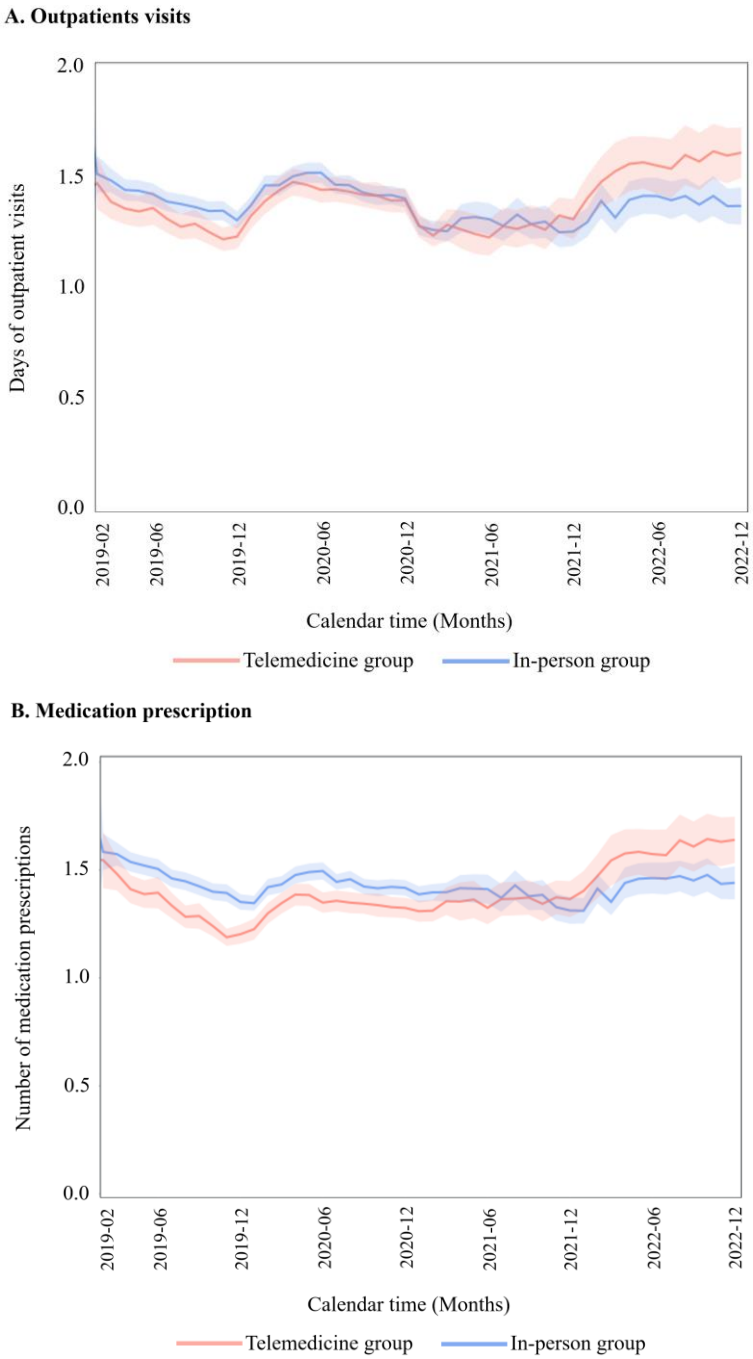
G. Visits for diabetes complications



H. Visits for depression

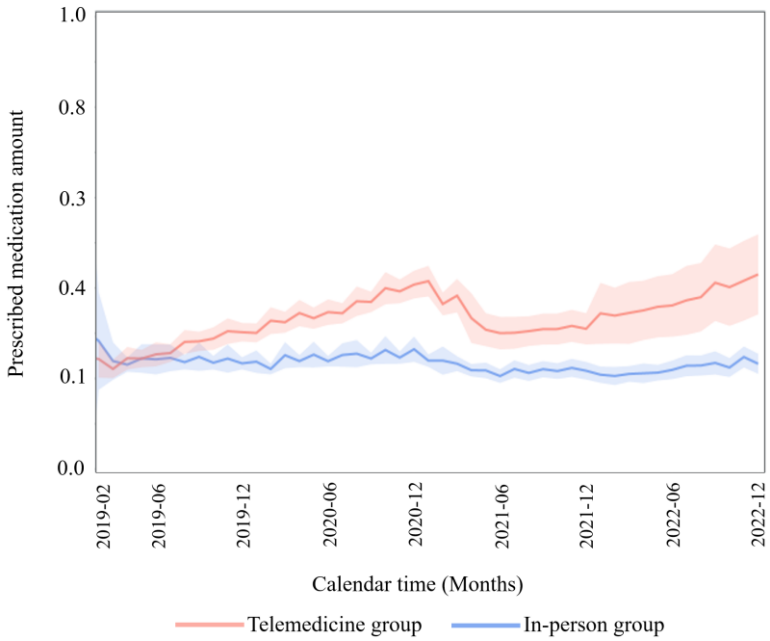


Appendix 12. (Continued)

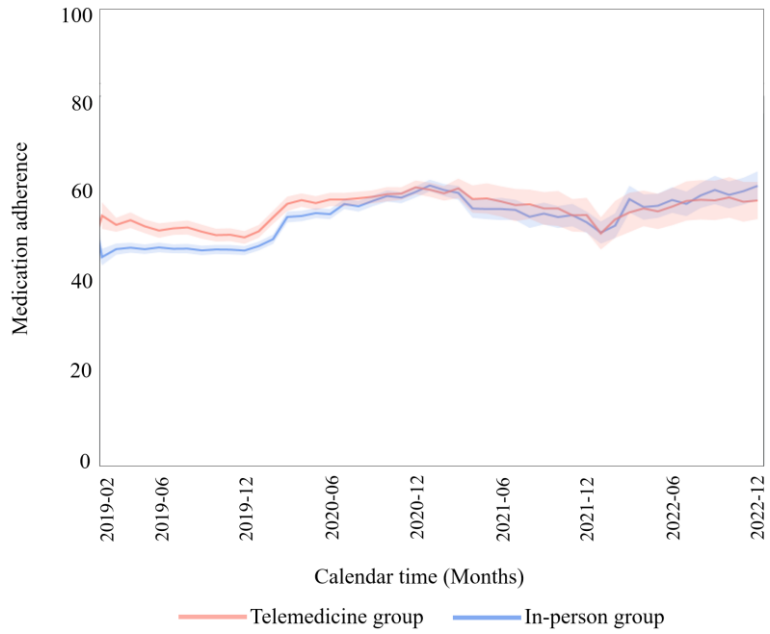


Appendix 13. Outcomes of Telemedicine and In-Person Groups in Patients with Schizophrenia According to Calendar Time

C. Medication amount

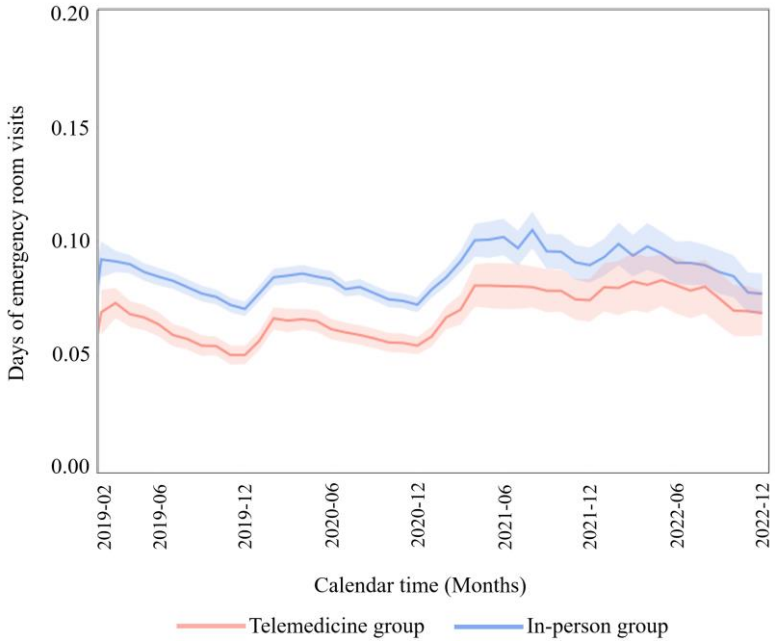


D. Medication adherence

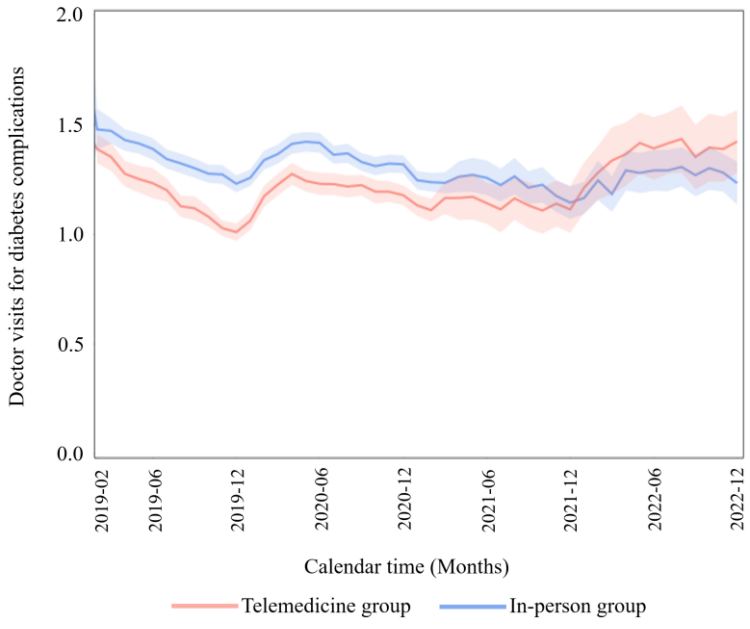


Appendix 13. (Continued)

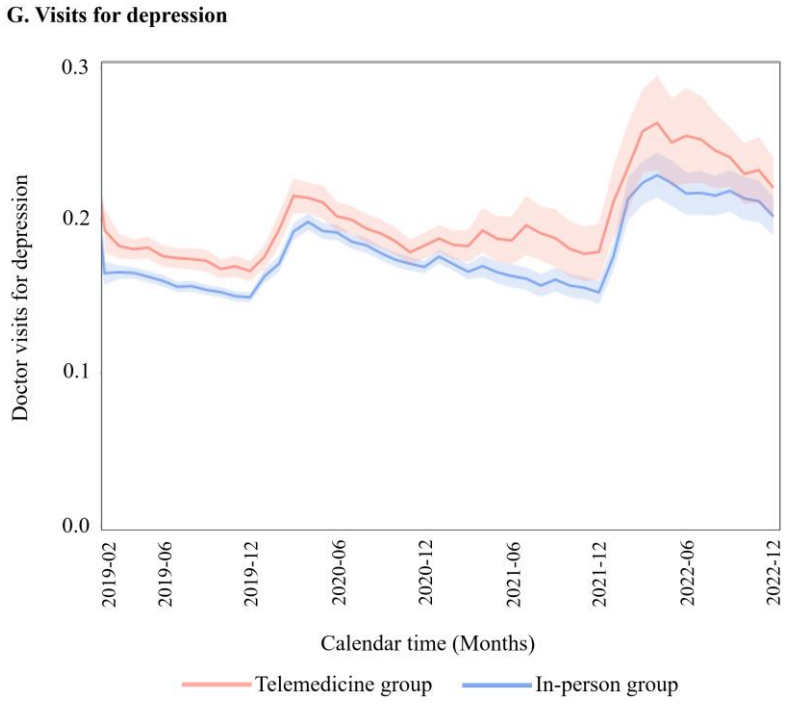
E. Hospitalization



F. Emergency room visits



Appendix 13. (Continued)



Appendix 13. (Continued)

Appendix 14. Study Population Characteristics of Patients with Diabetes in the Group of Telemedicine Consultation Twice or More and the In-Person Group at Index Time

Variables	Patients with diabetes						*SMD*
	Total		Group of telemedicine twice or more		In-person group		
	n	%	n	%	n	%	
Sex							*0.000*
Male	1,236	52.11	309	52.11	927	52.11	
Female	1,136	47.89	284	47.89	852	47.89	
Age (Mean: 63.3, SD: 14.2)							*0.000*
19 to 29	16	0.67	4	0.67	12	0.67	
30 to 39	96	4.05	24	4.05	72	4.05	
40 to 49	308	12.98	77	12.98	231	12.98	
50 to 59	540	22.77	135	22.77	405	22.77	
60 to 69	556	23.44	139	23.44	417	23.44	
70 or more	856	36.09	214	36.09	642	36.09	
Region							*0.109*
Metropolis	1,016	42.83	278	46.88	738	41.48	
Small cities and rural	1,356	57.17	315	53.12	1,041	58.52	
Employment							*0.022*
White collar	321	12.25	78	11.91	243	12.37	
Service industry	452	17.25	117	17.86	335	17.05	
Blue collar	661	25.23	173	26.41	488	24.83	
Unemployed	938	35.80	225	34.35	713	36.28	
Income level							*0.067*
High	1,069	45.07	258	43.51	811	45.59	
Medium	626	26.39	150	25.30	476	26.76	
Low	677	28.54	185	31.20	492	27.66	
Health insurance							*0.071*
Workplace-insured	1,488	62.73	373	62.90	1,115	62.68	
Regionally-insured	729	30.73	161	27.15	568	31.93	
Medical aids	155	6.53	59	9.95	96	5.40	

Appendix 14. (Continued)

Variables	Patients with diabetes						*SMD*
	Total		Group of telemedicine twice or more		In-person group		
	n	%	n	%	n	%	
Disability							*0.097*
No	2,077	87.56	505	85.16	1,572	88.36	
Yes	295	12.44	88	14.84	207	11.64	
CCI scores (Mean: 1.9, SD: 1.5)							*0.000*
1	1,272	53.63	318	53.63	954	53.63	
2	501	21.12	125	21.08	376	21.14	
3 or more	599	25.25	150	25.30	449	25.24	
Prevalence period years (Mean: 2.4, SD: 0.8)							*0.050*
1 year	241	10.16	54	9.11	187	10.51	
2 year	1,223	51.56	304	51.26	919	51.66	
3 years or more	908	38.28	235	39.63	673	37.83	
Year (Mean: 2020.9, SD: 0.8)							*0.133*
2019	859	32.79	201	30.69	658	33.49	
2020	612	23.36	168	25.65	444	22.60	
2021	474	18.09	138	21.07	336	17.10	
2022	427	16.30	86	13.13	341	17.35	
Study participation months (Mean: 11.3, SD: 6.2)							*1.378*
Telemedicine group: Mean 16.801, SD: 5.171							
In- In-person group: Mean: 9.436, SD: 5.399							
Total	2,372	100.00	593	25.00	1,779	75.00	

Appendix 15. Policy Effects by the Group of Telemedicine Consultations Twice or More, In-Person Consultations Group, and Total Group in Patients with Diabetes

Variables	Patients with schizophrenia						*SMD*
	Total		Group of telemedicine twice or more		In-person group		
	n	%	n	%	n	%	
Sex							*0.000*
Male	460	44.92	115	44.92	345	44.92	
Female	564	55.08	141	55.08	423	55.08	
Age (Mean: 56.8, SD: 14.0)							*0.000*
19 to 29	36	3.52	9	3.52	27	3.52	
30 to 39	68	6.64	17	6.64	51	6.64	
40 to 49	180	17.58	45	17.58	135	17.58	
50 to 59	312	30.47	78	30.47	234	30.47	
60 to 69	248	24.22	62	24.22	186	24.22	
70 or more	180	17.58	45	17.58	135	17.58	
Region							*0.419*
Metropolis	407	39.75	63	24.61	344	44.79	
Small cities and rural	617	60.25	193	75.39	424	55.21	
Employment							*0.390*
White collar	75	5.65	11	3.31	64	6.43	
Service industry	93	7.00	16	4.82	77	7.73	
Blue collar	130	9.79	15	4.52	115	11.55	
Unemployed	726	54.67	214	64.46	512	51.41	
Income level							*0.307*
High	216	21.09	41	16.02	175	22.79	
Medium	147	14.36	15	5.86	132	17.19	
Low	661	64.55	200	78.13	461	60.03	
Health insurance							*0.494*
Workplace-insured	309	30.18	44	17.19	265	34.51	
Regionally-insured	234	22.85	45	17.58	189	24.61	
Medical aids	481	46.97	167	65.23	314	40.89	

Appendix 15. (Continued)

Variables	Patients with schizophrenia						*SMD*
	Total		Group of telemedicine twice or more		In-person group		
	n	%	n	%	n	%	
Disability							*0.481*
No	422	41.21	61	23.83	361	47.01	
Yes	602	58.79	195	76.17	407	52.99	
CCI scores (Mean: 0.5, SD: 0.9)							*0.004*
0	669	65.33	167	65.23	502	65.36	
1	244	23.83	61	23.83	183	23.83	
2	69	6.74	18	7.03	51	6.64	
3 or more	42	4.10	10	3.91	32	4.17	
Prevalence period years (Mean: 2.2, SD: 0.7)							*0.006*
1 year	49	4.79	12	4.69	37	4.82	
2 year	836	81.64	209	81.64	627	81.64	
3 years or more	139	10.47	35	10.54	104	10.44	
Year (Mean: 2020.3, SD: 0.7)							*0.014*
2019	126	9.49	23	6.93	103	10.34	
2020	728	54.82	188	56.63	540	54.22	
2021	53	3.99	14	4.22	39	3.92	
2022	117	11.43	31	12.11	86	11.20	
Study participation months (Mean: 19.8, SD: 5.1)							*0.405*
Telemedicine group: Mean 21.305, SD: 3.958							
In- In-person group: Mean: 19.263, SD: 5.352							
Total	1,024	100.00	256	25.00	768	75.00	

Appendix 16. Policy effects by telemedicine consultations two times or more group, in-person consultations group, and total group in patients with diabetes

Effect Type	Patients with diabetes								
	Total			Group of telemedicine twice or more			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Health utilization									
Outpatient visits									
Immediate policy effects	1.02	(0.93 – 1.12)	*0.05*	1.03	(0.89 – 1.18)	*0.07*	1.02	(0.91 – 1.14)	*0.06*
Policy effects over time	1.01	(1.00 – 1.02)	*0.00*	1.01	(1.00 – 1.02)	*0.00*	1.01	(1.00 – 1.02)	*0.00*
Medication prescription									
Immediate policy effects	1.00	(0.90 – 1.11)	*0.05*	1.00	(0.86 – 1.17)	*0.08*	1.00	(0.88 – 1.13)	*0.06*
Policy effects over time	1.00	(0.99 – 1.01)	*0.00*	1.00	(0.99 – 1.01)	*0.01*	1.00	(0.99 – 1.01)	*0.00*
Medication amount									
Immediate policy effects	1.07	(0.43 – 2.65)	*0.46*	1.06	(0.20 – 5.60)	*0.85*	1.08	(0.47 – 2.47)	*0.42*
Policy effects over time	1.05	(0.98 – 1.12)	*0.03*	1.02	(0.91 – 1.15)	*0.06*	1.06	(0.99 – 1.12)	*0.03*
Health outcomes									
Medication adherence									
Immediate policy effects	1.12	(0.88 – 1.43)	*0.12*	1.15	(0.78 – 1.70)	*0.20*	1.11	(0.83 – 1.49)	*0.15*
Policy effects over time	0.98	(0.96 – 1.00)	*0.01*	0.96	(0.93 – 0.98)	*0.01*	0.99	(0.96 – 1.01)	*0.01*

Appendix 16. (Continued)

Effect Type	Patients with diabetes								
	Total			Group of telemedicine twice or more			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Hospitalization									
Immediate policy effects	1.00	(0.48 – 2.07)	*0.37*	1.00	(0.25 – 3.99)	*0.71*	1.00	(0.44 – 2.28)	*0.42*
Policy effects over time	1.01	(0.94 – 1.07)	*0.03*	1.00	(0.87 – 1.15)	*0.07*	1.01	(0.94 – 1.08)	*0.03*
Emergency room visits									
Immediate policy effects	1.01	(0.91 – 1.12)	*0.05*	1.01	(0.86 – 1.20)	*0.09*	1.01	(0.89 – 1.15)	*0.07*
Policy effects over time	1.01	(1.01 – 1.02)	*0.00*	0.99	(0.98 – 1.01)	*0.01*	1.02	(1.01 – 1.03)	*0.00*
Visits for diabetes complications									
Immediate policy effects	1.34	(1.16 – 1.54)	*0.07*	1.48	(1.19 – 1.84)	*0.11*	1.29	(1.09 – 1.54)	*0.09*
Policy effects over time	0.99	(0.98 – 1.00)	*0.01*	0.99	(0.97 – 1.01)	*0.01*	0.99	(0.98 – 1.01)	*0.01*
Visits for depression									
Immediate policy effects	1.02	(0.59 – 1.76)	*0.28*	1.02	(0.47 – 2.20)	*0.39*	1.02	(0.52 – 2.00)	*0.35*
Policy effects over time	0.98	(0.94 – 1.02)	*0.02*	0.99	(0.93 – 1.04)	*0.03*	0.97	(0.92 – 1.02)	*0.03*

Appendix 17. Policy Effects by the Group of Telemedicine Consultations Twice or More, In-Person Consultations Group, and Total Group in Patients with Schizophrenia

Effect Type	Patients with schizophrenia								
	Total			Group of telemedicine twice or more			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Health utilization									
Outpatient visits									
Immediate policy effects	1.09	(0.97 – 1.23)	0.06	1.12	(0.92 – 1.36)	0.10	1.09	(0.95 – 1.24)	0.07
Policy effects over time	1.00	(1.00 – 1.01)	0.00	1.00	(0.99 – 1.02)	0.01	1.00	(0.99 – 1.01)	0.00
Medication prescription									
Immediate policy effects	1.08	(0.96 – 1.21)	0.06	1.09	(0.90 – 1.33)	0.10	1.07	(0.94 – 1.22)	0.07
Policy effects over time	1.01	(1.00 – 1.01)	0.00	1.01	(1.00 – 1.02)	0.01	1.00	(0.99 – 1.01)	0.00
Medication amount									
Immediate policy effects	1.07	(0.14 – 8.45)	1.05	1.11	(0.04 – 30.82)	1.69	1.05	(0.10 – 11.12)	1.20
Policy effects over time	0.96	(0.83 – 1.10)	0.07	1.03	(0.80 – 1.31)	0.13	0.94	(0.80 – 1.09)	0.08
Health outcomes									
Medication adherence									
Immediate policy effects	1.10	(0.81 – 1.48)	0.16	1.11	(0.67 – 1.86)	0.26	1.09	(0.77 – 1.53)	0.17
Policy effects over time	1.02	(1.00 – 1.04)	0.01	1.08	(1.04 – 1.12)	0.02	1.00	(0.98 – 1.03)	0.01

Appendix 17. (Continued)

Effect Type	Patients with schizophrenia								
	Total			Group of telemedicine twice or more			In-person group		
	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)	Exp(β)	95% CI	SE(β)
Hospitalization									
Immediate policy effects	1.08	(0.62 – 1.91)	0.29	1.09	(0.34 – 3.50)	0.60	1.08	(0.59 – 1.98)	0.31
Policy effects over time	1.00	(0.96 – 1.04)	0.02	0.99	(0.92 – 1.07)	0.04	1.00	(0.96 – 1.04)	0.02
Emergency room visits									
Immediate policy effects	1.05	(0.93 – 1.19)	0.06	1.06	(0.87 – 1.30)	0.10	1.05	(0.92 – 1.20)	0.07
Policy effects over time	1.01	(1.00 – 1.02)	0.00	1.03	(1.01 – 1.04)	0.01	1.01	(1.00 – 1.02)	0.00
Visits for depression									
Immediate policy effects	1.04	(0.77 – 1.42)	0.16	1.05	(0.61 – 1.82)	0.28	1.04	(0.75 – 1.45)	0.17
Policy effects over time	0.99	*(0.97 – 1.01)*	*0.01*	1.01	*(0.97 – 1.05)*	*0.02*	0.99	*(0.97 – 1.01)*	*0.01*

Appendix 18. Predictive Value of Emergency Room Visits by Covariates in Patients with Diabetes

Parameters	Patients with diabetes											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Sex												
Male	0.98	(0.97 – 0.99)	*0.29*	0.90	(0.89 – 0.91)	*0.28*	0.84	(0.83 – 0.85)	*0.37*	0.91	(0.89 – 0.92)	*0.38*
Female	1.01	(1.00 – 1.02)	*0.28*	0.92	(0.91 – 0.93)	*0.26*	0.84	(0.83 – 0.85)	*0.31*	0.91	(0.90 – 0.92)	*0.31*
Age												
19 to 29	0.64	(0.53 – 0.75)	*0.26*	0.86	(0.76 – 0.96)	*0.23*	0.93	(0.87 – 0.98)	*0.25*	1.08	(1.01 – 1.14)	*0.26*
30 to 39	0.95	(0.92 – 0.98)	*0.22*	0.84	(0.81 – 0.88)	*0.22*	0.92	(0.89 – 0.95)	*0.28*	0.93	(0.90 – 0.96)	*0.26*
40 to 49	0.93	(0.91 – 0.95)	*0.27*	0.84	(0.83 – 0.86)	*0.24*	0.86	(0.83 – 0.89)	*0.44*	0.92	(0.89 – 0.94)	*0.44*
50 to 59	0.97	(0.95 – 0.99)	*0.27*	0.89	(0.87 – 0.90)	*0.25*	0.83	(0.81 – 0.85)	*0.42*	0.90	(0.89 – 0.92)	*0.40*
60 to 69	1.03	(1.02 – 1.04)	*0.25*	0.95	(0.94 – 0.96)	*0.25*	0.83	(0.82 – 0.84)	*0.25*	0.90	(0.89 – 0.91)	*0.24*
70 or more	1.01	(1.00 – 1.03)	*0.33*	0.93	(0.92 – 0.94)	*0.30*	0.83	(0.82 – 0.85)	*0.30*	0.91	(0.90 – 0.92)	*0.35*
Region												
Metropolis	1.02	(1.01 – 1.04)	*0.28*	0.95	(0.94 – 0.96)	*0.26*	0.85	(0.85 – 0.86)	*0.25*	0.93	(0.92 – 0.94)	*0.30*
Small cities and rural	0.97	(0.95 – 0.98)	*0.29*	0.88	(0.87 – 0.89)	*0.27*	0.83	(0.82 – 0.84)	*0.39*	0.90	(0.89 – 0.91)	*0.38*

Appendix 18. (Continued)

Parameters	Patients with diabetes											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Employment												
White collar	1.00	(0.98 – 1.02)	*0.25*	0.93	(0.91 – 0.95)	*0.24*	0.85	(0.84 – 0.86)	*0.23*	0.93	(0.92 – 0.94)	*0.23*
Service industry	0.99	(0.97 – 1.01)	*0.28*	0.93	(0.91 – 0.94)	*0.25*	0.85	(0.84 – 0.86)	*0.24*	0.90	(0.89 – 0.91)	*0.25*
Blue collar	0.98	(0.96 – 1.00)	*0.31*	0.89	(0.88 – 0.91)	*0.29*	0.80	(0.79 – 0.81)	*0.25*	0.88	(0.87 – 0.90)	*0.33*
Unemployed	1.00	(0.99 – 1.02)	*0.29*	0.91	(0.90 – 0.93)	*0.27*	0.86	(0.85 – 0.88)	*0.46*	0.92	(0.91 – 0.94)	*0.44*
Income level												
High	0.97	(0.96 – 0.99)	*0.31*	0.89	(0.88 – 0.91)	*0.29*	0.85	(0.84 – 0.86)	*0.28*	0.92	(0.91 – 0.93)	*0.33*
Medium	1.00	(0.99 – 1.02)	*0.26*	0.93	(0.91 – 0.94)	*0.24*	0.84	(0.83 – 0.85)	*0.24*	0.90	(0.89 – 0.91)	*0.24*
Low	1.01	(1.00 – 1.02)	*0.27*	0.93	(0.91 – 0.94)	*0.26*	0.83	(0.81 – 0.85)	*0.47*	0.90	(0.89 – 0.92)	*0.46*
Health insurance type												
Workplace-insured	0.99	(0.98 – 1.00)	*0.29*	0.91	(0.90 – 0.92)	*0.27*	0.83	(0.82 – 0.84)	*0.24*	0.90	(0.89 – 0.91)	*0.28*
Regionally-insured	0.99	(0.98 – 1.01)	*0.28*	0.92	(0.91 – 0.94)	*0.27*	0.85	(0.84 – 0.87)	*0.31*	0.92	(0.91 – 0.93)	*0.29*
Medical aids	1.01	(0.99 – 1.04)	*0.31*	0.89	(0.87 – 0.91)	*0.26*	0.90	(0.81 – 0.98)	*0.93*	0.95	(0.87 – 1.03)	*0.92*

Appendix 18. (Continued)

Parameters	Patients with diabetes											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Disability												
No	0.99	(0.98 – 1.00)	*0.29*	0.92	(0.91 – 0.92)	*0.27*	0.83	(0.83 – 0.84)	*0.24*	0.90	(0.89 – 0.90)	*0.24*
Yes	1.01	(0.98 – 1.03)	*0.28*	0.89	(0.88 – 0.91)	*0.26*	0.97	(0.90 – 1.04)	*0.88*	1.01	(0.96 – 1.05)	*0.79*
CCI scores												
1	0.99	(0.98 – 1.00)	*0.28*	0.90	(0.89 – 0.91)	*0.27*	0.82	(0.82 – 0.83)	*0.29*	0.90	(0.89 – 0.91)	*0.29*
2	1.00	(0.98 – 1.01)	*0.27*	0.91	(0.90 – 0.93)	*0.23*	0.82	(0.81 – 0.84)	*0.31*	0.88	(0.87 – 0.89)	*0.24*
3 or more	1.00	(0.98 – 1.02)	*0.32*	0.93	(0.92 – 0.95)	*0.30*	0.88	(0.87 – 0.90)	*0.43*	0.96	(0.94 – 0.98)	*0.51*
Prevalence period years												
1 year	0.95	(0.94 – 0.97)	*0.27*	0.87	(0.84 – 0.91)	*0.26*	0.86	(0.85 – 0.87)	*0.36*	0.91	(0.89 – 0.93)	*0.22*
2 year	1.01	(1.00 – 1.02)	*0.29*	0.89	(0.87 – 0.90)	*0.25*	0.81	(0.80 – 0.82)	*0.29*	0.90	(0.89 – 0.92)	*0.36*
3 years or more	1.03	(1.01 – 1.05)	*0.30*	0.93	(0.92 – 0.94)	*0.28*	0.86	(0.84 – 0.88)	*0.39*	0.91	(0.90 – 0.92)	*0.36*
Year												
2019	0.98	(0.97 – 1.00)	*0.29*	0.92	(0.91 – 0.93)	*0.26*	0.84	(0.83 – 0.84)	*0.33*	0.89	(0.88 – 0.90)	*0.30*
2020	1.00	(0.98 – 1.01)	*0.29*	0.89	(0.87 – 0.91)	*0.27*	0.86	(0.84 – 0.88)	*0.42*	0.92	(0.90 – 0.93)	*0.29*
2021	1.00	(0.98 – 1.02)	*0.28*	0.92	(0.90 – 0.93)	*0.27*	0.87	(0.85 – 0.88)	*0.31*	0.94	(0.91 – 0.96)	*0.48*
2022	1.05	(1.01 – 1.09)	*0.26*	0.91	(0.89 – 0.92)	*0.28*	0.80	(0.77 – 0.82)	*0.26*	0.93	(0.91 – 0.95)	*0.38*

Appendix 19. Predictive Value of Medication Adherence by Covariates in Patients with Schizophrenia

Parameters	Patients with schizophrenia											
	Predicted value of the medication prescription											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Sex												
Male	40.00	(39.18 – 40.82)	*14.95*	67.47	(66.48 – 68.45)	*17.51*	45.96	(45.51 – 46.42)	*13.54*	60.76	(60.15 – 61.38)	*18.15*
Female	40.23	(39.39 – 41.07)	*16.24*	66.43	(65.54 – 67.31)	*17.08*	47.80	(47.32 – 48.28)	*15.53*	61.73	(61.14 – 62.31)	*18.96*
Age												
19 to 29	50.61	(46.55 – 54.68)	*20.17*	83.01	(77.80 – 88.22)	*24.15*	47.36	(46.17 – 48.55)	*9.91*	59.71	(58.04 – 61.37)	*13.90*
30 to 39	42.41	(39.91 – 44.91)	*16.95*	68.53	(64.67 – 72.39)	*24.32*	44.44	(42.97 – 45.91)	*15.94*	55.11	(53.27 – 56.95)	*20.02*
40 to 49	38.19	(36.98 – 39.39)	*13.94*	67.27	(65.91 – 68.64)	*15.02*	46.41	(45.69 – 47.14)	*14.16*	61.87	(60.90 – 62.85)	*18.30*
50 to 59	40.08	(39.07 – 41.10)	*15.20*	64.85	(63.76 – 65.94)	*15.90*	46.87	(46.23 – 47.51)	*15.60*	59.58	(58.77 – 60.38)	*19.31*
60 to 69	38.63	(37.47 – 39.80)	*15.00*	66.07	(64.87 – 67.27)	*16.02*	45.79	(45.22 – 46.36)	*12.06*	61.83	(61.06 – 62.60)	*16.81*
70 or more	41.40	(39.83 – 42.97)	*16.57*	68.00	(66.31 – 69.68)	*17.70*	50.42	(49.46 – 51.39)	*16.71*	65.73	(64.62 – 66.85)	*19.52*
Region												
Metropolis	41.90	(40.57 – 43.22)	*17.04*	68.61	(67.03 – 70.19)	*20.04*	46.04	(45.56 – 46.52)	*14.26*	60.28	(59.65 – 60.91)	*18.47*
Small cities and rural	39.58	(38.93 – 40.23)	*15.16*	66.38	(65.67 – 67.09)	*16.31*	47.72	(47.26 – 48.19)	*14.98*	62.12	(61.54 – 62.70)	*18.67*

Appendix 19. (Continued)

Parameters	Patients with schizophrenia											
	Predicted value of the medication prescription											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Employment												
White collar	43.81	(39.96 – 47.66)	*20.92*	65.58	(61.45 – 69.71)	*20.91*	50.24	(48.76 – 51.72)	*17.64*	65.35	(63.44 – 67.27)	*22.62*
Service industry	40.77	(37.71 – 43.83)	*17.07*	66.46	(63.79 – 69.13)	*16.94*	47.41	(46.32 – 48.50)	*14.21*	61.79	(60.42 – 63.16)	*18.28*
Blue collar	42.20	(39.56 – 44.83)	*16.33*	64.82	(61.56 – 68.08)	*19.23*	46.52	(45.77 – 47.28)	*12.45*	60.63	(59.68 – 61.58)	*15.70*
Unemployed	39.77	(39.15 – 40.39)	*15.19*	67.12	(66.42 – 67.82)	*17.00*	46.63	(46.22 – 47.03)	*14.77*	60.92	(60.41 – 61.44)	*18.68*
Income level												
High	42.40	(40.83 – 43.97)	*16.31*	70.35	(68.21 – 72.49)	*19.96*	47.00	(46.30 – 47.70)	*14.33*	63.10	(62.20 – 64.01)	*18.40*
Medium	38.55	(36.22 – 40.88)	*15.68*	65.51	(63.13 – 67.90)	*15.82*	45.93	(45.20 – 46.67)	*14.05*	59.90	(58.86 – 60.95)	*18.64*
Low	39.80	(39.15 – 40.46)	*15.47*	66.47	(65.76 – 67.19)	*16.88*	47.26	(46.81 – 47.70)	*14.99*	61.02	(60.48 – 61.57)	*18.62*
Health insurance type												
Workplace-insured	42.80	(41.08 – 44.51)	*18.06*	66.90	(64.95 – 68.85)	*20.05*	47.80	(47.22 – 48.39)	*14.39*	61.87	(61.13 – 62.61)	*18.43*
Regionally-insured	40.61	(39.16 – 42.06)	*16.08*	65.49	(63.73 – 67.24)	*18.58*	47.11	(46.37 – 47.85)	*16.00*	61.11	(60.11 – 62.10)	*21.14*
Medical aids	39.37	(38.69 – 40.05)	*14.83*	67.25	(66.50 – 68.00)	*16.24*	46.25	(45.76 – 46.73)	*14.06*	60.95	(60.36 – 61.55)	*17.20*

Appendix 19. (Continued)

Parameters	Patients with schizophrenia											
	Predicted value of the medication prescription											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Disability												
No	39.88	(39.26 – 40.50)	*14.31*	65.45	(63.86 – 67.04)	*19.19*	45.40	(45.06 – 45.74)	*13.53*	59.30	(58.65 – 59.95)	*19.16*
Yes	40.88	(39.40 – 42.36)	*19.26*	67.30	(66.58 – 68.02)	*16.71*	54.22	(53.27 – 55.17)	*17.40*	62.96	(62.40 – 63.52)	*17.95*
CCI scores												
0	40.70	(39.92 – 41.49)	*16.64*	66.38	(65.50 – 67.26)	*18.74*	47.81	(47.37 – 48.24)	*15.03*	61.75	(61.19 – 62.30)	*18.72*
1	39.58	(38.51 – 40.65)	*13.60*	68.18	(67.07 – 69.29)	*13.94*	45.91	(45.26 – 46.55)	*14.16*	60.65	(59.83 – 61.47)	*18.15*
2	37.99	(36.32 – 39.66)	*13.04*	68.03	(66.22 – 69.83)	*12.80*	44.27	(43.12 – 45.41)	*14.97*	60.45	(58.82 – 62.07)	*20.24*
3 or more	38.82	(36.20 – 41.44)	*15.09*	66.14	(62.90 – 69.39)	*16.60*	46.39	(45.28 – 47.50)	*10.12*	60.54	(58.93 – 62.14)	*16.67*
Prevalence period years												
1 year	39.30	(38.70 – 39.91)	*13.93*	61.83	(55.95 – 67.71)	*20.68*	44.29	(43.97 – 44.61)	*12.19*	59.17	(56.68 – 61.66)	*18.17*
2 year	45.73	(43.27 – 48.18)	*22.49*	72.22	(71.56 – 72.87)	*14.15*	60.39	(59.20 – 61.58)	*18.97*	65.16	(64.68 – 65.65)	*17.69*
3 years or more	39.69	(37.99 – 41.38)	*16.30*	54.99	(53.76 – 56.22)	*17.59*	48.67	(47.69 – 49.65)	*15.03*	51.89	(51.14 – 52.65)	*17.44*
Year												
2019	39.28	(38.68 – 39.88)	*13.42*	63.42	(62.06 – 64.78)	*11.29*	44.57	(44.25 – 44.90)	*12.22*	59.05	(58.04 – 60.06)	*17.04*
2020	43.38	(41.21 – 45.55)	*22.53*	73.04	(72.33 – 73.76)	*14.32*	57.51	(56.34 – 58.68)	*19.69*	65.80	(65.26 – 66.33)	*17.57*
2021	42.37	(40.51 – 44.24)	*16.91*	50.27	(49.00 – 51.54)	*15.06*	47.02	(45.99 – 48.05)	*14.13*	47.63	(46.81 – 48.44)	*15.35*
2022	33.47	(30.56 – 36.38)	*11.83*	68.31	(66.10 – 70.52)	*19.08*	56.34	(53.25 – 59.43)	*18.42*	64.97	(63.57 – 66.36)	*19.02*

Appendix 20. Predictive Value of Emergency Room Visits by Covariates in Patients with Schizophrenia

Parameters	Patients with schizophrenia											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Sex												
Male	1.11	(1.09 – 1.13)	*0.38*	1.32	(1.29 – 1.34)	*0.40*	1.28	(1.26 – 1.29)	*0.49*	1.34	(1.33 – 1.36)	*0.53*
Female	1.15	(1.13 – 1.17)	*0.40*	1.38	(1.36 – 1.40)	*0.44*	1.25	(1.24 – 1.27)	*0.48*	1.31	(1.30 – 1.33)	*0.51*
Age												
19 to 29	1.02	(0.92 – 1.12)	*0.49*	1.34	(1.21 – 1.47)	*0.61*	1.27	(1.23 – 1.32)	*0.38*	1.42	(1.37 – 1.48)	*0.46*
30 to 39	1.12	(1.06 – 1.18)	*0.41*	1.22	(1.16 – 1.27)	*0.34*	1.39	(1.34 – 1.44)	*0.57*	1.37	(1.32 – 1.41)	*0.52*
40 to 49	1.07	(1.04 – 1.11)	*0.41*	1.31	(1.27 – 1.36)	*0.53*	1.27	(1.24 – 1.29)	*0.49*	1.36	(1.33 – 1.38)	*0.53*
50 to 59	1.14	(1.12 – 1.16)	*0.35*	1.36	(1.33 – 1.38)	*0.38*	1.30	(1.28 – 1.32)	*0.50*	1.36	(1.33 – 1.38)	*0.56*
60 to 69	1.21	(1.17 – 1.24)	*0.41*	1.42	(1.40 – 1.45)	*0.39*	1.25	(1.23 – 1.27)	*0.44*	1.31	(1.29 – 1.33)	*0.47*
70 or more	1.10	(1.06 – 1.14)	*0.39*	1.32	(1.28 – 1.35)	*0.40*	1.16	(1.14 – 1.19)	*0.47*	1.22	(1.19 – 1.25)	*0.50*
Region												
Metropolis	1.13	(1.10 – 1.17)	*0.44*	1.37	(1.33 – 1.41)	*0.53*	1.28	(1.27 – 1.30)	*0.53*	1.34	(1.33 – 1.36)	*0.55*
Small cities and rural	1.13	(1.11 – 1.15)	*0.38*	1.35	(1.33 – 1.36)	*0.39*	1.25	(1.23 – 1.26)	*0.44*	1.31	(1.30 – 1.33)	*0.49*

Appendix 20. (Continued)

Parameters	Patients with schizophrenia											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Employment												
White collar	1.03	(0.93 – 1.12)	*0.51*	1.19	(1.07 – 1.31)	*0.61*	1.19	(1.14 – 1.23)	*0.53*	1.30	(1.26 – 1.35)	*0.56*
Service industry	0.90	(0.84 – 0.96)	*0.34*	1.18	(1.12 – 1.24)	*0.39*	1.17	(1.14 – 1.20)	*0.43*	1.22	(1.18 – 1.25)	*0.45*
Blue collar	0.83	(0.77 – 0.90)	*0.40*	1.15	(1.06 – 1.23)	*0.51*	1.26	(1.24 – 1.28)	*0.36*	1.29	(1.26 – 1.31)	*0.40*
Unemployed	1.17	(1.15 – 1.18)	*0.37*	1.39	(1.37 – 1.40)	*0.40*	1.28	(1.27 – 1.30)	*0.50*	1.35	(1.34 – 1.37)	*0.54*
Income level												
High	0.98	(0.95 – 1.02)	*0.36*	1.22	(1.18 – 1.27)	*0.45*	1.25	(1.23 – 1.27)	*0.46*	1.32	(1.29 – 1.34)	*0.50*
Medium	1.27	(1.19 – 1.34)	*0.50*	1.26	(1.17 – 1.34)	*0.58*	1.26	(1.23 – 1.29)	*0.50*	1.30	(1.27 – 1.33)	*0.52*
Low	1.15	(1.13 – 1.16)	*0.38*	1.38	(1.36 – 1.40)	*0.40*	1.27	(1.26 – 1.28)	*0.49*	1.34	(1.32 – 1.35)	*0.52*
Health insurance type												
Workplace-insured	0.94	(0.90 – 0.98)	*0.43*	1.17	(1.13 – 1.22)	*0.49*	1.22	(1.20 – 1.24)	*0.44*	1.28	(1.26 – 1.30)	*0.47*
Regionally-insured	1.20	(1.17 – 1.24)	*0.41*	1.37	(1.33 – 1.42)	*0.49*	1.26	(1.24 – 1.29)	*0.52*	1.30	(1.27 – 1.32)	*0.54*
Medical aids	1.15	(1.14 – 1.17)	*0.36*	1.39	(1.37 – 1.41)	*0.38*	1.30	(1.28 – 1.31)	*0.50*	1.37	(1.35 – 1.39)	*0.54*

Appendix 20. (Continued)

Parameters	Patients with schizophrenia											
	Predicted value of the emergency room visits											
	Group of telemedicine twice or more						In-person group					
	Before the index time			After the index time			Before the index time			After the index time		
	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD	Mean	95% CI	SD
Disability												
No	1.08	(1.06 – 1.09)	*0.34*	1.21	(1.17 – 1.25)	*0.53*	1.26	(1.25 – 1.28)	*0.49*	1.30	(1.28 – 1.31)	*0.52*
Yes	1.29	(1.25 – 1.33)	*0.49*	1.39	(1.38 – 1.41)	*0.38*	1.27	(1.24 – 1.29)	*0.46*	1.35	(1.34 – 1.37)	*0.51*
CCI scores												
0	1.11	(1.09 – 1.13)	*0.41*	1.32	(1.30 – 1.34)	*0.43*	1.24	(1.22 – 1.25)	*0.47*	1.28	(1.27 – 1.30)	*0.49*
1	1.14	(1.11 – 1.17)	*0.34*	1.36	(1.33 – 1.39)	*0.38*	1.29	(1.26 – 1.31)	*0.51*	1.37	(1.35 – 1.40)	*0.56*
2	1.25	(1.21 – 1.29)	*0.31*	1.53	(1.49 – 1.58)	*0.33*	1.34	(1.30 – 1.38)	*0.52*	1.43	(1.38 – 1.47)	*0.58*
3 or more	1.12	(1.03 – 1.20)	*0.50*	1.50	(1.39 – 1.61)	*0.56*	1.36	(1.31 – 1.41)	*0.46*	1.41	(1.36 – 1.46)	*0.50*
Prevalence period years												
1 year	1.07	(1.06 – 1.09)	*0.32*	1.21	(1.06 – 1.35)	*0.51*	1.27	(1.25 – 1.28)	*0.48*	1.36	(1.27 – 1.45)	*0.63*
2 year	0.98	(0.94 – 1.02)	*0.37*	1.34	(1.32 – 1.36)	*0.36*	1.26	(1.23 – 1.29)	*0.47*	1.37	(1.35 – 1.38)	*0.53*
3 years or more	1.60	(1.55 – 1.64)	*0.46*	1.39	(1.35 – 1.43)	*0.54*	1.26	(1.22 – 1.29)	*0.51*	1.22	(1.20 – 1.24)	*0.47*
Year												
2019	1.09	(1.08 – 1.11)	*0.32*	1.35	(1.28 – 1.41)	*0.53*	1.28	(1.26 – 1.29)	*0.49*	1.38	(1.35 – 1.41)	*0.51*
2020	0.92	(0.89 – 0.95)	*0.33*	1.36	(1.34 – 1.37)	*0.32*	1.20	(1.17 – 1.23)	*0.43*	1.38	(1.37 – 1.40)	*0.53*
2021	1.62	(1.57 – 1.67)	*0.48*	1.09	(1.06 – 1.12)	*0.35*	1.28	(1.24 – 1.32)	*0.52*	1.14	(1.12 – 1.16)	*0.43*
2022	1.27	(1.17 – 1.38)	*0.42*	1.81	(1.75 – 1.87)	*0.51*	1.18	(1.10 – 1.25)	*0.47*	1.28	(1.24 – 1.31)	*0.52*

Korean Abstract (국문 요약)

원격의료가 의료이용 및 건강결과에 미치는 영향

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서론: 정보통신기술의 발전으로 원격의료는 의료에 대한 혁신적인 접근 방식으로 주목받고 있으며, 이를 통해 상담, 치료, 모니터링과 같은 의료 서비스를 원격으로 제공할 수 있게 되었다. 한국에서는 2020 년 비대면 진료가 한시적으로 허용되면서 대중적으로 인식되기 시작했다. 그러나 한국에서 원격의료는 여전히 정책적 합의가 이루어지지 않은 논쟁적인 주제이며, 관련 법안이 계류 중인 상황이다. 원격의료는 치료 접근성을 개선하고 환자의 질환 관리에 기여할 것이라는 기대를 받는 한편, 기술적 한계로 인한 오진과 남용의 위험, 법적 책임 문제, 그리고 디지털 격차로 인한 의료 불평등에 대한 우려도 존재한다. 더욱이, 원격의료에 대한 연구는 충분하지 않은 실정이다. 이에, 본 연구는 원격의료가 효과적으로 활용될 수 있는 만성질환을 대상으로 원격의료가 의료 이용과 건강 결과에 미치는 영향을 확인하고자 하였다. 원격의료로 자주 활용되는 만성질환 중 지속적인 관리와 질병의 위험성, 원격의료에 따른 기대효과를 고려하여 신체적 만성질환으로는 당뇨를, 정신적 만성질환으로는 조현병을 선택하였다. 아울러, 한국이 직면한 정책적 과제이자 전통적인 의료전달체계에서 가장 기본적이고 직접적인 방법 중 하나인 진료을 통해 원격의료의 영향을 분석하고자 하였다. 본 연구는 비대면 상담을 중심으로 원격의료가 만성적인 당뇨와 조현병 환자들의 의료 이용과 건강 결과에 미치는 영향을 확인함으로써, 원격의료의 안전성과 효과성에 대한 정책적 근거를 제공하고자 한다.

연구방법: 연구 데이터는 한국 국민건강보험공단의 맞춤형 코호트를 사용하였다. 연구 대상은 2019 년 1 월 1 일부터 2022 년 12 월 31 일까지 만성 당뇨병 또는 만성적인 조현병을 가진 19 세 이상의 환자들로 설정되었다. 원격진료 그룹과 대면 진료 그룹은 위험 집합(risk-set) 매칭, 완전(exact) 매칭 및 성향 점수(propensity score) 매칭으로 1:3 매칭하였으며, 이후 계층화 및 랜덤 샘플링하였다. 혼합효과 모델(mixed-effects model)의 일반화 선형 혼합 모델(generalized linear mixed model)로 비교 단절적 시계열(comparative interrupted time series)분석을 수행하였다. 분석 모델에는 트위디(Tweedie), 일반화 포아송(generalized Poisson), 영과잉 포아송(zero-inflated Poisson), 영과잉 음이항(zero-inflated negative binomial) 분포와 자기회귀 모형(autoregressive model)이 반영되었다.

연구결과: 의료 이용과 건강 결과는 질병 유형과 원격 진료 이용 빈도에 따라 상이한 결과를 보였다. 만성 당뇨병 환자는 대면 진료군 대비 원격 진료 경험군에서 복약 순응도가 감소했으며, 원격 진료를 반복적으로 이용한 군에서 응급실 방문이 감소했다. 반면, 만성적인 조현병 환자는 원격 진료를 반복적으로 이용한 군에서 대면 진료군 대비 복약 순응도와 응급실 방문이 증가했다. 외래 방문, 약물 처방일, 약물 용량, 입원일, 당뇨병 합병증, 동반질환으로서의 우울증과 같은 지표들에서는 대면 진료와 원격 진료 간 유의미한 차이가 없었다. 원격진료를 이용한 환자 중 당뇨병 환자의 52.4%와 조현병 환자의 57.5%가 원격진료를 2 회 이상 이용하였다. 만성 당뇨병 환자의 월평균 복약 순응도는 시간이 지남에 따라 67.6%에서 60.0%로 감소하였으며, 이는 대면 진료 대비 약 4.2% 감소한 차이였다(Exp(β)=0.958, 95% CI: 0.927–0.991). 반면, 원격진료를 반복적으로 이용한 당뇨병 환자의 월평균 응급실 방문은 0.99 일에서 0.91 일로 감소하여 대면 진료 대비 약 2.9% 감소하였다(Exp(β)=0.971, 95% CI: 0.956–0.986). 조현병 환자의 복약순응도는 월평균 40.1%에서 66.9%로 증가하였으며, 이는 대면 진료 대비 약 7.4% 향상된 결과이다(Exp(β)=1.074, 95% CI: 1.028–

1.121). 그러나 원격진료를 반복적으로 이용한 조현병 환자들은 월평균 응급실 방문이 1.13 일에서 1.35 일로 증가하였으며, 이는 대면 진료 대비 약 2.1% 증가한 수치이다(Exp(β)=1.021, 95% CI: 1.005–1.038).

결론: 원격의료는 질환의 특성에 따라 적합성이 달라질 수 있다. 만성 당뇨병과 같이 복잡하고 빈번한 약물 조정이 필요한 경우에는 원격진료가 적합하지 않을 수 있다. 이는 의사와 환자 간의 정보 교환과 상호 작용이 제한되어 원격진료가 대면 진료보다 복약순응도에 부정적 영향을 미칠 수 있기 때문이다. 반면, 병식에 대한 이해 또는 자각이 부족하거나 사회적 낙인에 대한 두려움으로 대면 진료에 심리적 저항을 느낄 수 있는 조현병 환자의 경우, 원격진료는 환자와 환자 보호자의 의료 접근성을 개선하고 약물 복약과 같은 지속적인 관리에 기여할 수 있다. 그러나 원격진료는 의사와 환자 간의 라포 형성이나 심리적 치료가 부족할 가능성이 있다. 심리적 치료가 중요한 조현병과 같은 질환에서는 건강 악화로 응급실 방문이 증가할 위험이 존재한다. 또한 정신 질환이 급성 악화되어 통제하기 어려운 상황이 발생한 경우에도 원격진료를 통해 대처하기 어려워 응급실 방문으로 이어질 가능성이 있다. 그럼에도 불구하고, 반복적인 원격진료를 받은 만성 당뇨병 환자와 같이 원격진료에 익숙하고 자기관리 경험이 있는 경우, 원격진료는 긴급 상황에서 신속히 대응할 수 있는 수단으로 활용될 수 있으며, 이는 응급실 방문과 같은 부정적인 건강 결과 예방에도 기여할 수 있다. 따라서 원격진료가 질환의 특성과 환자의 상황을 종합적으로 고려하여 보완적 수단으로 적절히 활용된다면 안전하고 효과적인 의료 전달 수단으로 자리할 것이다.

핵심어 : 원격의료, 비대면 진료, 만성질환, 당뇨, 조현병, 의료이용, 건강결과, 혼합효과 모델, 비교 단절적 시계열 분석