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ORIGINAL RESEARCH

Effects of COVID-19 on Sleep Services Use and Its Recovery

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Purpose: The COVID-19 pandemic affected the utilization of various healthcare services differentially. Sleep testing services utilization (STU), including Home Sleep Apnea Testing (HSAT) and Polysomnography (PSG), were uniquely affected. We assessed the effects of the pandemic on STU and its recovery using the Veterans Health Administration (VHA) data.

Patients and Methods: A retrospective cohort study from the VHA between 01/2019 and 10/2023 of veterans with age ≥ 50. We extracted STU data using Current Procedural Terminology codes for five periods based on STU and vaccination status: pre-pandemic (Pre-Pan), pandemic sleep test moratorium (Pan-Mor), and pandemic pre-vaccination (Pan-Pre-Vax), vaccination (Pan-Vax), and postvaccination (Pan-Post-Vax). We compared STU between intervals (Pre-Pan as the reference).

Results: Among 261,371 veterans (63.7±9.6 years, BMI 31.9±6.0 kg/m², 80% male), PSG utilization decreased significantly during Pan-Mor (−56%), Pan-Pre-Vax (−61%), Pan-Vax (−42%), and Pan-Post-Vax (−36%) periods all compared to Pre-Pan. HSAT utilization decreased significantly during the Pan-Mor (−59%) and Pan-Pre-Vax (−9%) phases compared to the Pre-Pan and subsequently increased during Pan-Vax (+6%) and Pan-Post-Vax (−1%) periods. Over 70% of STU transitioned to HSAT, and its usage surged five months after the vaccine Introduction.

Conclusion: Sleep testing services utilization recovered differentially during the pandemic (PSG vs HSAT), including a surge in HSAT utilization post-vaccination.

Keywords: home sleep apnea testing, polysomnography, COVID-19, pandemic, current procedural terminology

Introduction

The COVID-19 pandemic had detrimental effects on healthcare access, and healthcare providers struggled to address diverse and rapidly changing medical challenges. Social distancing measures and limitations on in-person healthcare appointments throughout the COVID-19 pandemic restricted in-person delivery of care. Despite the extensive restrictions, limited knowledge exists regarding their impact on the delivery of specialized health care services like sleep medicine.[1,2] The adaptations in sleep medicine during the COVID-19 era may extend beyond transient changes, potentially indicating a significant shift in healthcare delivery. This study's examination of the evolving use of HSAT and PSG, essential tools in diagnosing and managing obstructive sleep apnea, is pivotal. It highlights how sleep medicine services have adapted to ensure continuity and quality of care during such crisis situations. The insights gained are vital for shaping future healthcare policies and refining patient care practices in sleep medicine, particularly in preparing for and addressing the long-term implications of sleep medicine in the face of global health emergencies.

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There are some reports of the COVID-19 pandemic's impact on the utilization of sleep testing services.[3–7] However, the studies reported the pre-post pandemic effect and did not address the adaptation during the pandemic (peri-pandemic) as vaccinations became available. HSAT is an unattended, portable, self-administrated diagnostic test designed to evaluate and diagnose obstructive sleep apnea at a patient's home. HSAT devices can be mailed and, thus, do not require patients in-person contract with the healthcare facility and providers. PSG is a comprehensive sleep study conducted in a specialized sleep laboratory attended by a sleep technologist to diagnose various sleep disorders. This scientific analysis aims to comprehensively investigate the impact of the COVID-19 pandemic on healthcare accessibility of the home sleep apnea test (HSAT) and in-lab polysomnography (PSG) in veterans. We investigated the change in sleep testing services over several peri-pandemic intervals. To address this gap in knowledge, we surveyed Veterans Health Administration (VHA) sleep-testing services at multiple peri-pandemic intervals. We investigated the pattern of sleep-testing services usage along with telehealth visits. The findings of this study regarding the usage of HSAT and PSG amid the pandemic have the potential to shape upcoming healthcare strategies and enhance methodologies in sleep medicine, emphasizing the importance of adaptable, patient-focused approaches in addressing worldwide health crises.

Materials and Methods

This study has undergone review by the Institutional Review Board (IRB) of Baylor college of Medicine and has been approved under IRB number H-47595.

Study Design and Cohort

This retrospective cohort study used the national VHA electronic medical records (EMR). VHA EMR is a relational database that aggregates patient data from all VHA facilities from 1999 to present. It has all patients encounters (inpatient and outpatients) including diaganosis, medication, labs, vital signs, physician impression notes, vaccination, and etc.[8] To extract COVID-19 related information, we used the COVID-19 shared data resource (CSDR).[9] CSDR encompasses a wide range of information of SARS-CoV-2 tested patients (eg, timing and nature of test results, pharmacological and nonpharmacological interventions, patient outcomes, and pre-existing conditions and medication). Considering the majority of veterans are older adults, we included those veterans who aged ≥50 years by 10/15/2022. The study covered sleep related service encounters from 01/01/2019 to 10/01/2023 (Supplement Figure 1). These intervals were determined based on the start date of the pandemic, the moratorium date, the period of nonessential health services discontinuation except COVID-19-related services, the start date of vaccination, and the date when vaccination plateaued but the vaccine was still offered (Supplement Table 1).

Variables

Outcome Variables

The outcomes of interest were HSAT and in-lab PSG utilization (exposure variables). We used Current Procedural Terminology (CPT) codes to calculate HSAT ("0203T", "0204T", "95782", "95800", "95801", "95806", "G0398", "G0399", "G0400") and in-lab PSG usage ("95782", "95783", "95808", "95810", "95811"). The CPT code helps doctors and health care professionals with a uniform language for coding medical services and procedures to streamline reporting, increase accuracy and efficiency.[10] According to the intervals when sleep-testing services were performed, We defined five distinct time intervals to analyze sleep-testing service utilization: 1) Pre-pandemic (pre-pan): January 2019 to February 2020, covering 14 months. 2) Pandemic Moratorium (pa-mor): March 2020 to June 2020, lasting 4 months. 3) Pandemic Pre-vaccination (pan-pre-vax): July 2020 to December 2020, lasting 6 months. 4) Pandemic Vaccination (pan-vax): January 2021 to June 2021, lasting 6 months. 5) Pandemic Post-vaccination (pan-post-vax): July 2021 to September 2022, lasting 15 months.

Other Variables

We curated the age, gender, race, ethnicity, and COVID-19 status from VHA electronic medical records, and extracted the number of positive COVID-19 cases and ever-vaccinated veterans from the COVID-19 Shared Data Resource. We

also collected the telehealth encounters for patients who used sleep-testing services. The telehealth encounters were extracted using VA specific telehealth Stop Codes including telephonic and video visits.[11]

Statistical Analysis

The study aimed to compare the average utilization of sleep tests, using univariate analysis across different sequential time intervals. Continuous variables are presented as mean, standard deviation, and categorical variables as numbers and percentages, to characterize the cohort. For categorical variables, we used Chi-squared test to compare between groups. For continuous variables, we used the unpaired *t*-test to compare between groups. We considered the pre-pandemic interval as the reference. The significance level was p-value < 0.05. All analyses were performed using R Statistical Software (v4.1.2; R Core Team 2021) (tidyverse, lubridate, tseries).[12]

Results

General

A total of 261,371 unique patients (80% male) who underwent sleep testing between 01/01/2019 and 10/01/2022 were identified. Of these patients, 167,395 (64%) underwent HSAT, while 93,974 (36%) underwent PSG, Figure 1. The average age of all patients was 63.7±9.6 years, and the average body mass index (BMI) was 31.9±6.0 Kg/m^2. Of the participants, 98,374 (38%) were ≥65 years, and 139,604 (53.4%) had a BMI ≥ 30, Table 1. Vaccination started in 12/2020, and the cumulative number of ever-vaccinated veterans reached saturation point by 04/2021, Figure 1. Additionally, we observed that the number of new cases of COVID-19 had two distinct peaks, one at 12/2020 (Delta variant) and another at 01/2022 (Omicron variant[13]), Figure 1.

Different Pandemic Phases

The average number of sleep tests during the Pre-Pan phase was 8564/M (PSG, 4723/M; HSAT, 3841/M). Compared to the Pre-Pan, the PSG utilization diminished in Pan-Mor (−56%), Pan-Pre-Vax (−61%), Pan-Vax (−42%), and Pan-Post-Vax (−36%). The PSG use during these intervals was significantly lower than Pre-Pan (p-values < 0.001) with large effect sizes. We observed the same trend of decline in HSAT utilization in Pan-Mor (−59%) and Pan-Pre-Vax (−9%), but

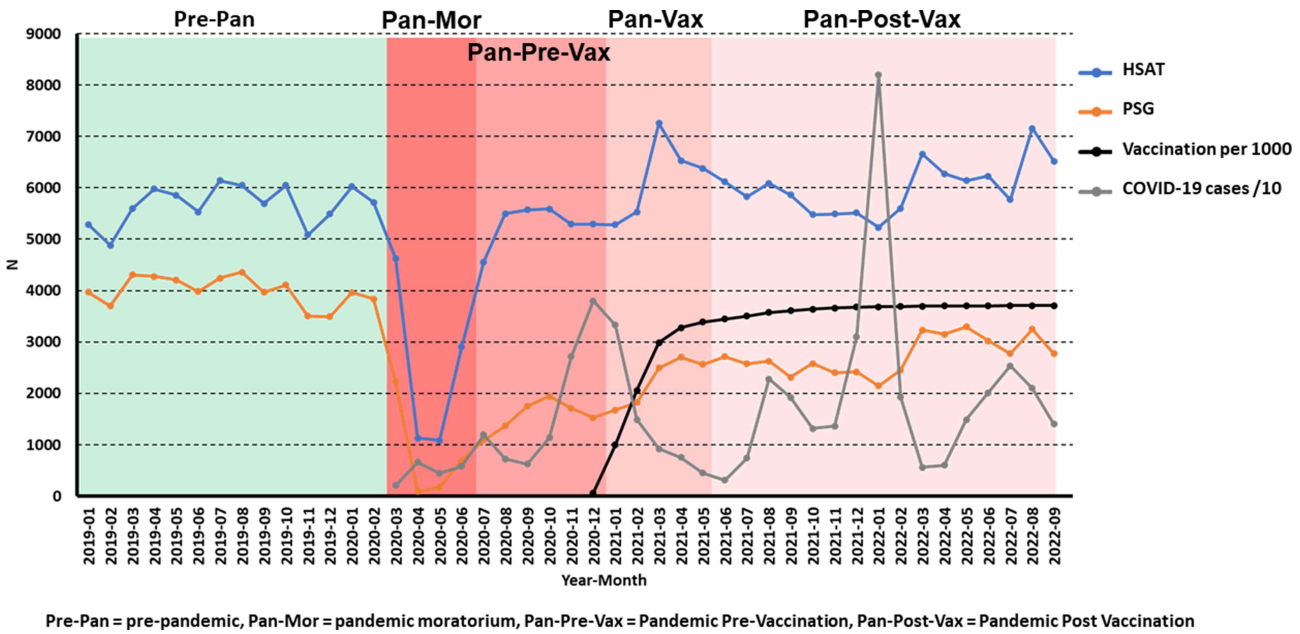

Figure 1 The time series of sleep testing service utilization (Home Sleep Apnea Test [HSAT] and Polysomnography [PSG]), the cumulative number of vaccinated veterans per 1000 cases, and the number of positive COVID-19 cases divided by 10. Five intervals defined: 1) PRE-Pandemic (01/2019 to 02/2021, 14 months), 2) Pandemic-Moratorium (03/2020 to 06/2020, 4 months), 3) Pandemic-Pre-Vaccination opening (07/2020 to 12/2020, 6 months), 4) Pandemic Vaccination (01/2021 to 06/2021, 06 months), and 5) Pandemic Post-Vaccination (07/2021 to 09/2022, 15 months).

Table 1 Veterans' Characteristics Who Used Sleep Testing Services (HSAT and PSG) During the Study Period

Labels	All	Pre-Pan	Pan-Mor	Pan-Pre-Vax	Pan-Vax	Pan-PostVax
n	261,369	100,105	8888	28,660	35,317	88,399
HSAT, N (%)	167,395(64.0)	55,266(55.2)	6392(71.9)	21,468(74.9)	25,063(71.0)	59,206(67.0)
PSG, N (%)	93,974(36.0)	44,839(44.8)	2496(28.1)	7192(25.1)	10,254(29.0)	29,193(33.0)
H/P Ratio	1.8	1.2	2.6	3.0	2.4	2.0
Age, M(SD)	63.7(9.7)	63.1(9.7)	62.8(9.6)	62.8(9.6)	63.9(9.6)	64.8(9.5)
Age ≥ 65, N (%)	107,087(41)	42,462(42.5)	3500(35)	11,295(39.4)	14,237(40.3)	35,593(40.3)
Sex, Male, N (%)	212,061(81.1)	87,559.0(87.5)	7602.0(85.5)	24,009.0(83.8)	27,919.0(79.1)	64,972.0(73.5)
Race						
White, N (%)	157,325(60)	63,918.0(63)	5640.0(63)	17,990.0(62)	20,917.0(60)	48,860.0(55)
Black, N (%)	55,048(21)	23,145.0(23)	1916.0(22)	6126.0(21)	7257.0(20)	16,604.0(19)
Others, N (%)	48,996(19)	13,042(14)	1332(15)	4544(17)	7143(20)	22,935(26)
Ethnicity, Hispanic, N(%)	17,306(6.6)	6878.0(6.9)	643.0(7.2)	1900.0(6.6)	2225.0(6.3)	5660.0(6.4)
BMI, M(SD)	32(6.0)	32.3(6.1)	32.1(6.0)	31.9(6.0)	31.7(6.0)	31.7(5.9)
BMI ≥ 30, N(%)	139,604(53.4)	58,720.0(58.7)	5056.0(56.9)	15,792.0(55.1)	18,017.0(51.0)	42,019.0(47.5)
Telehealth, n per month	249,659	150,741	352,143	348,274	315,174	249,003
Telehealth /person/month, n	1.0	1.5	39.6	12.2	8.9	2.8

Notes: Pre-Pan = pre-pandemic (01/2019 to 02/2021, 14 months), Pan-Mor = pandemic-moratorium (03/2020 to 06/2020, 4 months), Pan-Pre-Vax = pandemic-pre-vaccination opening (07/2020 to 12/2020, 6 months), Pan-Vax = pandemic vaccination (01/2021 to 06/2021, 06 months), and Pan-Post-Vax = pandemic post-vaccination (07/2021 to 09/2022, 15 months).
Abbrevation: M(SD) = Mean and standard deviation.

Table 2 Comparing the HSAT and PSG Between Pre-Pandemic and Different Peri-Pandemic Intervals

	Pre-Pan	Pan-Mor	Pan-Pre-Vax	Pan-Vax	Pan-Post-Vax
HSAT, N per Month	4723	1944	4316	5020	4663
Difference, %	Reference	−59	−9	6.29	−1.25
p-value (cohen's *d*)	Reference	<0.001 (3.84)	0.0191 (1.32)	0.1297 (0.69)	0.6195 (0.19)
PSG, N per Month	3841	1671	1491	2203	2469
Difference, %	Reference	−56	−61	−42.63	−35.72
p-value (cohen's *d*)	Reference	<0.001 (5.69)	<0.001 (9.07)	<0.001 (5.06)	<0.001 (5.13)

Notes: Pre-Pan = pre-pandemic (01/2019 to 02/2021, 14 months), Pan-Mor = pandemic-moratorium (03/2020 to 06/2020, 4 months), Pan-Pre-Vax = pandemic-pre-vaccination opening (07/2020 to 12/2020, 6 months), Pan-Vax = pandemic vaccination (01/2021 to 06/2021, 06 months), and Pan-Post-Vax = pandemic post-vaccination (07/2021 to 09/2022, 15 months).

an increase in HSAT use during Pan-Vax (+6%). During Pan-Post-Vax, we observed about the same level of HSAT use (−1%), Table 2.

During Pre-Pan phase, 55.2% of sleep tests were HSAT, and 44.8% were PSG. After the pandemic, the proportion of HSAT to PSG increased during the Pan-Mor (71.9%), Pan-Pre-Vax (71.0%), Pan-Vax (71.0%), and Pan-post-Vax (67.0%).

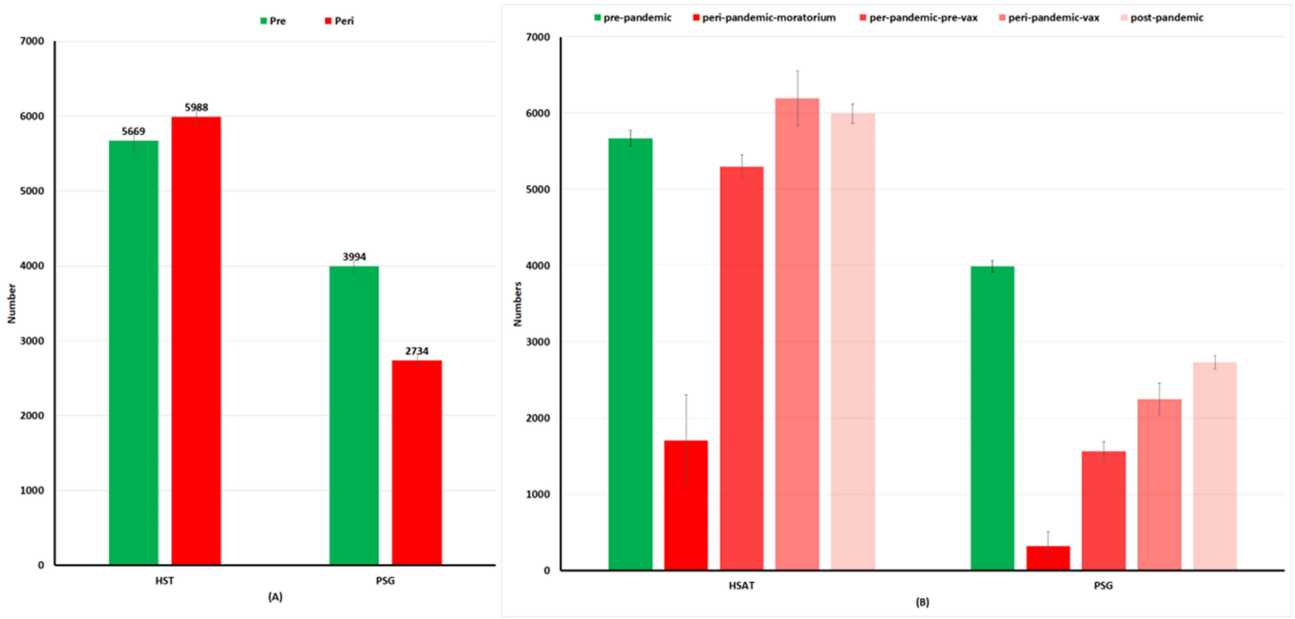

Figure 2 Comparing the sleep testing service utilizations, ie, Home Sleep Apnea Test (HSAT) and Polysomnography (PSG). (**A**) between pre-pandemic and peri-pandemic; (**B**) between five intervals defined: 1) PRE-Pandemic (01/2019 to 02/2021, 14 months), 2) Pandemic-Moratorium (03/2020 to 06/2020, 4 months), 3) Pandemic-Pre-Vaccination opening (07/2020 to 12/2020, 6 months), 4) Pandemic Vaccination (01/2021 to 06/2021, 06 months), and 5) Pandemic Post-Vaccination (07/2021 to 09/2022, 15 months).

The average ages were similar during Pre-Pan (63.1±9.7 yr), Pan-Mor (62.8±9.6 yr), Pan-Pre-Vax (62.8±9.6 yr), Pan-Vax (63.9±9.6 yr), and Pan-Post-Vax (64.8±9.5 yr). The percentage of older adults aged ≥65 years was 42.5% Pre-Pan and was reduced during Pan-Mor (35.0%), Pan-Pre-Vax (39.4%), Pan-Vax (40.3%), and Pan-Post-Vax (40.3%). The number of telehealth encounters per month in Pre-Pan was 150,741. The telehealth encounters increased during Pan-Mor (1.34 times), Pan-Pre-Vax (1.31 times), Pan-Vax (1.09 times), and Pan-Post-Vax (65%) compared to Pre-Pan. We observed a gradual reduction in the use of telehealth as we distanced from the COVID-19 pandemic index date, Figure 2.

Discussion

We studied the utilization of sleep testing services before and during the COVID-19 pandemic. We identified several key findings based on the large, national, longitudinal cohort of patients. First, the use of total sleep testing services drastically declined with the onset of the pandemic. Secondly, PSG utilization following the onset of the COVID-19 pandemic decreased considerably and reached zero use. Thirdly, we observed that HSAT decreased markedly initially. Finally, the utilization of sleep testing services recovered differentially, with more robust HSAT compared to PSG recoveries. We observed a surge in the use of HSAT when the veterans' vaccinations reached the plateau point and returned to pre-pandemic levels 1.5 to 2 years after the onset of the pandemic. In contrast, PSG use did not reach the pre-pandemic level of use during the study period. Understanding the significance of these observed shifts in sleep testing services is central. The decline in PSG use and the increased reliance on HSAT have important implications for patient care and clinical outcomes. Particularly for patients with undiagnosed or untreated sleep disorders, these changes could mean differences in the accuracy of diagnosis, the timeliness of treatment initiation, and the overall quality of care. Moreover, the shift towards HSAT might indicate a broader trend in patient preference for remote and convenient healthcare services, which could persist beyond the pandemic. Recognizing these implications is essential for healthcare providers and policymakers to adapt strategies that ensure the continued effectiveness and accessibility of sleep disorder diagnostics and treatment.

As previously reported, we observed a significant decrease in polysomnography (PSG) utilization, attributable to various factors. These include lockdown measures, fear of exposure to COVID-19 in medical facilities (given that PSG is an in-person test), and restrictions on elective medical procedures.[1] Our experiences within various VA hospitals showed that many of the professional staffs were reallocated to deliver COVID-19 related acute care services during pandemic. Consequently, many individuals may have postponed or canceled their PSG appointments, resulting in fewer studies being conducted during this

period.[14,15] However, previous reports did not account for the adaptation phases of the COVID-19 pandemic [1]. Our study indicates a continuous decline in PSG utilization, potentially impacting the detection of sleep disorders that require comprehensive in-lab PSG.

HSAT was initially reduced due to logistical challenges, disrupted healthcare services, and shifting priorities towards COVID-19 management. HSAT is a more convenient and accessible alternative to PSG, allowing patients to perform sleep studies in the comfort of their own homes.[10] The shift towards HSAT and reduced use of PSG has elicited varied responses from both patients and healthcare providers. Patients often favor HSAT for its convenience and comfort, reducing the stress associated with in-lab studies. Healthcare providers, however, might have concerns regarding the accuracy and comprehensiveness of HSAT compared to PSG. Understanding these differing perspectives is crucial for evaluating the sustainability and acceptability of these changes in sleep testing practices.[16,17] As the pandemic progressed and when the situation improved, HSAT utilization regained momentum and surpassed the pre-pandemic level. This surge might be attributed to increased awareness about HSAT as a viable option, better availability of home-testing kits, and a preference for remote medical services even after pandemic restrictions eased.[14,15] A considerable increase (more than 52%) in the use of HSAT during the pandemic was reported, and here we show that this increase continued after the pandemic, with the usage of HSAT expected to continue in the future. Additionally, we observed that three-quarters of sleep testing services shifted toward HSAT. While our study provides valuable insights into the utilization of sleep testing services within the VHA healthcare system, a comparison with international data could further elucidate whether these trends are unique or part of a global shift in sleep medicine during the pandemic. Studies from other countries could offer perspectives on how different healthcare systems and policies have influenced the adoption of HSAT and the decline in PSG usage, providing a more comprehensive understanding of the pandemic's impact on sleep medicine globally. HSAT is supported by telehealth visits, and the increases in HSAT may also be explained by increased telehealth use. The integration of telehealth with HSAT during the pandemic highlighted the potential for lasting changes in sleep medicine. This synergy, reducing the need for in-person visits, has not only addressed immediate COVID-19 concerns but also set the stage for enduring transformations in diagnosing and managing sleep disorders. The ongoing advancement of telehealth could further enhance the accessibility and efficiency of sleep medicine, shaping a more patient-centered future in healthcare.

The study found a notable surge in the use of HSAT in the post-pandemic period, corresponding to the plateau in vaccination efforts. As the risk of COVID-19 decreased due to increased vaccination, individuals might have felt more comfortable seeking medical services, including sleep studies. Additionally, healthcare providers could have adapted their practices to accommodate higher HSAT demand, leading to increased availability and promotion of home sleep testing.[18,19]

We recognized several limitations in this study. It is important to consider the potential impact of focusing exclusively on VHA healthcare system data in our study. By concentrating on this specific system, our findings might not encompass the broader spectrum of sleep testing service utilization patterns across different healthcare settings. This focus could limit the Generalizability of our Results to other populations and healthcare systems. As such, while our findings are highly relevant to the VHA context, they may not fully reflect the trends and challenges in sleep testing services encountered in non-VHA or private healthcare environments. We did not correct the data to reflect data from the Medicare database to consider sleep-testing services utilization outside the VHA healthcare system. We also did not report changes in the sleep-disorders trend between the pre-pandemic and peri-pandemic phases. Further study is warranted to investigate the effects of the pandemic on the diagnosis of sleep disorders. Additional studies are needed to evaluate the potential differential recovery in sleep testing services utilization peri-pandemic in various age and race categories. We also did not include locations as a possible factor that may affect sleep testing service utilization. Although we acknowledge that there may be confounding factors influencing sleep testing utilization (STU), our primary focus in this study was to examine the effects of the pandemic on STU and subsequent recovery. Our team is actively working to acquire additional data to conduct further analysis, taking into account other variables that may impact STU during and post-pandemic periods.

A unique aspect of our study is detail evaluation of an outpatient sub specialized services' recovery during and after the vaccination within a healthcare system with no or limited access issues for the eligible participants. The study found a notable surge in the use of HSAT in the post-pandemic period, corresponding to the plateau in vaccination efforts. As the risk of COVID-19 decreased due to increased vaccination, individuals might have felt more comfortable seeking

medical services, including sleep studies. Additionally, healthcare providers could have adapted their practices to accommodate higher HSAT demand, leading to increased availability and promotion of home sleep testing.

Conclusion

The COVID-19 pandemic significantly impacted the utilization of sleep testing services in veterans. While HSAT was resilient and increased during the pandemic, the increase did not offset the shift away from PSG. In light of our findings, future research should focus on several key areas. Detailed studies are needed to explore the long-term effects of the pandemic on the diagnosis and management of sleep disorders, particularly in populations not covered by the VHA system. Additionally, research should investigate the impact of increased HSAT use on the accuracy and effectiveness of sleep disorder diagnoses. Further, examining patient and provider preferences in the choice between HSAT and PSG, in both pandemic and post-pandemic settings, would provide valuable insights. Finally, a comparative analysis of sleep testing service utilization across different healthcare systems and regions could offer a more comprehensive understanding of these trends. Overall, the findings indicate that the pandemic had a significant impact on sleep study utilization, with PSG experiencing a notable drop and HSAT initially facing a decline but eventually recovering to an even higher level than the pre-pandemic level. The surge in HSAT use following the plateau in vaccination rates suggests a potential link between improved pandemic conditions, higher vaccination rates, and increased confidence in seeking medical care, including sleep-related services. The surge may also stem from guidelines from various sleep societies, including recovery plans from VHA. Future research is needed to understand better the reasons for this change in clinical practice, such as professional staff availability, equipment resources, provider and patient preferences, and the effect of local, regional, and national directives and guidelines related to various health services during the pandemic. These insights could help inform healthcare policies and practices during future health crises and might also shed light on the acceptance and adoption of remote healthcare services. However, it is essential to conduct further research and analyses to fully understand the underlying reasons for these trends and their implications on public health and healthcare delivery. To improve the generalizability of our findings, addition of international databases is warranted in the future investigations.

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Disclosure

The authors report no conflicts of interest in this work.

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