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Sudden Hearing Loss before, during, and after the Pandemic: Investigating COVID-19 Illness and Vaccine-Related Symptoms

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Keywords
Sudden sensorineural hearing loss · Tinnitus · SARS-CoV-2 · COVID-19 · Hearing loss

Abstract
Introduction: Accumulating reports suggest an increase in sudden sensorineural hearing loss during the COVID-19 pandemic and vaccination periods. However, clear evidence is lacking. The goal of this study was to determine if sudden sensorineural hearing loss is associated with COVID-19 illness or its vaccine. ***Methods:*** Retrospective chart review of 50 randomly selected patients from three, 6-month time periods: "pre-pandemic," "early pandemic," and "late pandemic." Group comparisons were performed for demographics, comorbid conditions, audiologic history, audiometric data, speech reception thresholds, and word recognition. ***Results:*** One hundred 50 patients were included in this study. A mean difference was observed in that the relative percentage of sensorineural hearing loss (SNHL) cases increased over time, corresponding to a relative decrease in conductive hearing loss cases. However, this change was not explained by proportional changes in sudden SNHL. Patients in the early pandemic time period were more likely to report tinnitus. Otherwise, the patient groups did not differ on demographic variables, hearing health history, hearing loss presentation, pure tone averages, speech reception thresholds, or word recognition performance. ***Conclusions:*** Proportion of patients with sudden sensorineural hearing loss did not change over time from the pre-pandemic period to the early or late pandemic phases. Despite a randomized sample, these findings do not support the hypothesis that COVID-19 illness or vaccine is associated with sudden sensorineural hearing loss.

Introduction

Sudden sensorineural hearing loss (SSNHL) is defined as at least three consecutive frequency losses of 30 dB or more occurring over the course of 72 h [1, 2]. The annual incidence of SSNHL varies between 5 and 27 cases per 100,000 persons [3, 4]. A number of possible etiologies have been proposed, including viral infections, vascular dysfunction, autoimmune disease, inner-ear pathology, and defects of the central nervous system [5, 6]. SSNHL is considered idiopathic when there is no discernable cause.

To date, a handful of case reports suggest the SARS-CoV-2 (i.e., COVID-19) virus may trigger SSNHL. For example, patients diagnosed with COVID-19 endorsed hearing loss within days [7] to weeks [8] of their first symptoms. For many of these reports, symptoms developed suddenly [9] and could not be attributed to a known cause [10].

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Despite evidence suggestive of a link between COVID-19 and SSNHL, large-scale investigations have been inconsistent and occasionally contradictory. For example, a prospective study by van Rijssen et al. [11] included patients seeking treatment for idiopathic sensorineural hearing loss (ISSNHL) between November 2020 and March 2021. No patient tested positive for COVID-19 during the assessment; however, 2 patients (8%) had previously tested positive for COVID-19; one testing positive 3 months prior and the other 8 months prior to first noting hearing symptoms [11].

In addition to COVID-19 illness, conflicting evidence exists on whether COVID-19 vaccination is linked to hearing changes. Fisher et al. [12] performed a retrospective review comparing individuals diagnosed with ISSNHL in 2021 to those who presented between 2018 and 2020. Results revealed an increasing incidence of ISSNHL from 2018 to 2021, with approximately 25% of patients presenting in 2021 receiving the COVID-19 vaccine within 30 days of their diagnosis [12]. In contrast, Damkier et al. [13] evaluated the likelihood of SSNHL in patients who had received their first, second, or third dose of the COVID-19 vaccines compared to unvaccinated individuals. Results indicate no evidence of an elevated risk of SSNHL following COVID-19 vaccination [13]. Lin and Selleck [14] investigated a connection between tinnitus and COVID-19 vaccination and found a trending increase in patients presenting during the pandemic relative to pre-pandemic time periods, yet results were not statistically significant [14].

Taken together, whether COVID-19 infection, vaccination, or seasonal fluctuations are responsible for SSNHL remains unknown. This study aimed to characterize the demographic, clinical, and audiological traits of patients before the pandemic, early pandemic, and during the vaccine release (i.e., late pandemic) through a randomized sample of patients with hearing loss in order to identify potential associations between COVID-19 and SSNHL. We hypothesized that exposure to COVID-19 (illness or vaccine) is associated with SSNHL, and aimed to test this hypothesis by comparing the frequency of SSNHL cases before and during the COVID-19 pandemic.

Methods

Study Design

This is a retrospective analysis of data from electronic medical records of patients seen by Otolaryngology providers at Emory University. As a Quality Improvement project, Institutional Review Board (IRB) exemption was granted by the Emory IRB. Inclusion criteria included adults with hearing loss seen between July 2019 and June 2021. Patients were identified using International Classification of Diseases (ICD)-9 and -10 codes for sudden idiopathic hearing loss, conductive hearing loss, and sensorineural hearing loss (H91.20, H91.2, H91.22, H91.23, H90.11, H90.12, H90.2, H90.3).

Comparison groups were created by first isolating three 6 month time periods: July–December 2019 “pre-pandemic,” January–June 2020 “early pandemic,” and January–June 2021 “late pandemic” shown in Figure 1. These periods were chosen based on calendar year and in light of the COVID-19 pandemic with medical office closures, stay-at-home mandates, and vaccination rollouts. Once the time periods were identified, a query was performed to identify all patients seen during that interval with the aforementioned ICD-10 codes. Then, using a random number generator, 50 patients were randomly selected in each time period to constitute the comparison groups. Patient appointments could be classified as new or follow up. Patients seen more than one time in the 6-month period were included as a single individual in each time-period based on the earliest visit.

Data Collection and Definitions

Demographic information, hearing loss presentation, hearing health history, past medical history, and audiologic evaluation was obtained for all patients through retrospective review of electronic medical records. Statistical analyses were performed using SPSS 27 (SPSS, Inc., Chicago, IL, USA). χ^2 and independent *t* tests were used for group comparisons.

Symptom onset was created based on patient report of symptoms occurring within 1 month (acute), 3 months (subacute), or greater than 3 months (chronic). Pure tone averages (PTAs) were calculated based on standardized guidelines per Gurgel et al. [15] in which 0.5-, 1-, 2-, and 3-kHz air conduction thresholds were averaged together. If the 3 kHz threshold was missing, an interpolated threshold was created by averaging thresholds at 2 and 4 kHz. Speech reception thresholds (SRTs) were defined as the minimum hearing level for speech at which 50% of speech material was recognized. Patients with missing audiometric data were excluded from audiologic analyses (i.e., PTA, SRT, and word recognition performance comparisons).

Results

Demographics and Health Comorbidities

The final cohort included 150 patients. The groups did not differ with respect to age, sex, race, ethnicity, body mass index, smoking history, or comorbid health conditions (i.e., hypertension, diabetes, chronic kidney disease, sickle cell anemia, vascular disease, autoimmune disease, or malignancy; Table 1). Most patients were female in their sixth decade of life, overweight or obese, never smokers, and nondrinkers. Approximately half of patients in each group had hypertension.

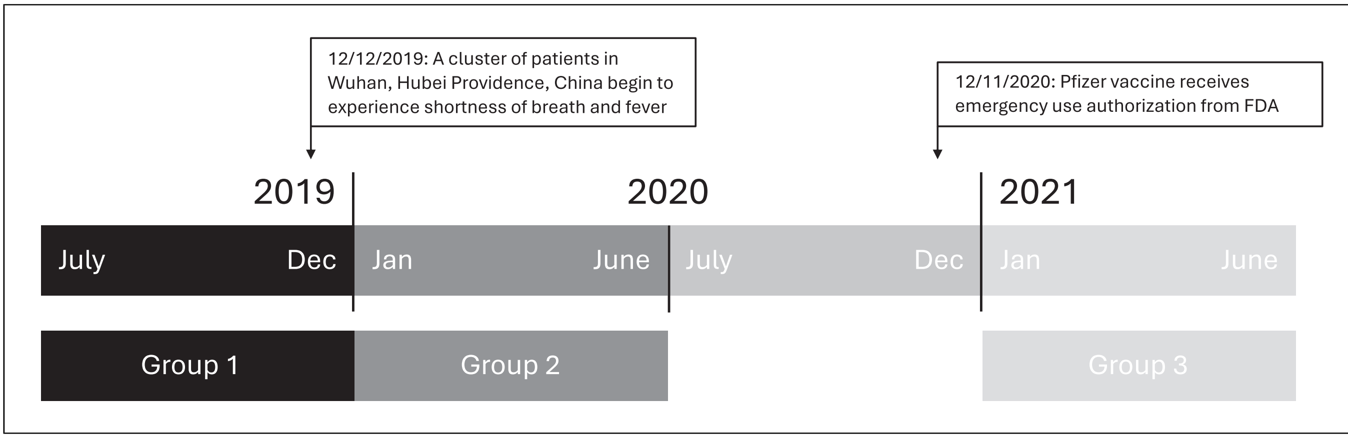

Fig. 1. Pre-, during-, and late-pandemic comparison groups. Three 6-month time periods of interest were identified for data analyses: July–December 2019 (group 1 or “pre-pandemic”), January–June 2020 (group 2 or “early pandemic”), and January–June 2021 (group 3 or “late pandemic”).

Hearing Loss Presentation

There was no significant difference between the three groups with respect to conductive versus sensorineural hearing loss (Table 2). However, a greater proportion of patients presented with SNHL in the late pandemic time-period relative to pre-pandemic, or early pandemic phases. This was associated with a corresponding decrease in CHL: pre-pandemic (CHL n = 8 vs. SNHL n = 42), early pandemic (CHL n = 11 vs. SNHL = 39), late pandemic (CHL n = 5 vs. SNHL n = 45). Of note, this trend was not statistically significant.

The 3 patient groups did not differ in laterality of hearing loss nor symptom onset (acute vs. subacute vs. chronic). A greater proportion of patients reported tinnitus during the early pandemic (n = 27, 54%) relative to pre-pandemic (n = 15, 30%) or late pandemic (n = 12, 24%) time-periods (p = 0.004). The groups did not differ on report of vertigo. Furthermore, groups did not differ on self-reported history of hearing loss, amplification, noise exposure, ototoxic exposure, or preceding upper respiratory infection symptoms (Table 3).

Audiologic Evaluation

Pure tone averages, SRT, or word recognition scores did not differ between the three groups. See Table 4 for details.

Vaccination History

See Table 5 for descriptive statistics regarding vaccination history of patients in the late pandemic group. Most patients were vaccinated (45 out of 50 vaccinated), with 70% vaccinated prior to the first encounter. Of this subgroup, 23% of patients were vaccinated within 30 days of the encounter, whereas 77% were vaccinated greater than 30 days prior to their first encounter.

Discussion

In this study, we randomly selected 150 patients with diagnosed hearing loss from three time points relative to the COVID-19 pandemic to evaluate associations between hearing loss and COVID-19 illness or vaccination. Results reveal patients were more likely to report tinnitus during the early pandemic compared to pre-pandemic or late pandemic periods. Otherwise, no associations were observed with respect to hearing loss presentation, type, or audiologic performance. Furthermore, groups did not differ on demographic characteristics or comorbid health conditions.

Altogether, this study does not support a correlation between SSNHL and COVID-19 illness or vaccination, which aligns with previous research using various methodologies. For example, Parrino et al. [16] retrospectively analyzed records of all patients (n = 42) with acute cochleo-vestibular impairment of unknown cause who were seen between March 2020 and February 2021. No appreciable variations were observed in the total number of cases during the pandemic compared to pre-pandemic. Patients with SSNHL seen during the pandemic had worse pure-tone averages and higher rates of vestibular complaints, yet these results were not

Table 1. Comparison of demographics and health comorbidities between randomly selected groups from three time points shows no significant differences

	Pre-pandemic		Early pandemic		Late pandemic		Test	*p* value
	July–December 2019		January–June 2020		January–June 2021			
	n	%	*n*	%	*n*	%		
Randomly selected	50	100	50	100	50	100		
Age (average)	64.15		60.82		67.84		1.798	0.169
Female	24	48	26	52	32	64	2.798	0.247
Race								
African American	13	26	15	30	20	40	7.150	0.521
Asian	3	6	2	4	0	0		
Caucasian	30	60	28	56	25	50		
NA/PI	1	2	1	2	0	0		
Unknown	3	6	4	8	5	10		
Ethnicity								
Not Hispanic or Latino	41	82	40	80	44	88	3.108	0.540
Hispanic or Latino	2	4	3	6	0	0		
Unknown	7	14	7	14	6	12		
BMI	26.77		29.14		27.85		1.943	0.147
Smoking								
Never	34	68	33	66	39	78	6.268	0.180
Current	8	16	6	12	1	2		
Former	8	16	11	22	10	20		
Alcohol use								
Denies	35	70	35	70	39	78	1.074	0.584
Endorses	15	30	15	30	11	22		
Hypertension								
Yes	20	40	25	50	24	48	1.127	0.569
No	30	60	25	50	26	52		
Diabetes								
Yes	9	18	9	18	10	20	0.088	0.957
No	41	82	41	82	40	80		
Chronic kidney disease								
Yes	4	8	4	8	2	4	0	1
No	46	92	46	92	48	96		
Sickle cell								
Yes	0	0	0	0	1	2	2.013	0.365
No	50	100	50	100	49	98		
Vascular disease (CVD, MI, CVA, HLD)								
Yes	16	32	13	26	14	28	0.456	0.796
No	34	68	37	74	36	72		
Autoimmune disease (RA, SLE, sarcoid, Cohan, GCA)								
Yes	0	0	1	2	1	2	1.014	0.602
No	50	100	49	98	49	98		
Malignancy								
Yes	9	18	8	16	10	20	0.271	0.873
No	41	82	42	84	40	80		

NA/PI, Native American/Pacific Islander; CVD, cardiovascular disease; MI, myocardial infarction; CVA, stroke; HLD, hyperlipidemia; RA, rheumatoid arthritis; SLE, systemic lupus erythematous; GCA, giant cell arteritis; BMI, body mass index.

Table 2. Comparison of hearing loss presentation between three randomly selected groups shows a greater proportion of patients reported tinnitus in the early pandemic group relative to pre- or late-pandemic groups

	Pre-pandemic		Early pandemic		Late pandemic		Test	*p* value
	July–December 2019		January–June 2020		January–June 2021			
	n	%	*n*	%	*n*	%		
Hearing loss type								
CHL	8	16.0	11	22	5	10	3.900	0.420
SNHL	41	82.0	36	72	43	86		
SSNHL	1	2.0	3	6	2	4		
Laterality								
Bilateral	41	82.0	39	78	42	84	0.615	0.735
Unilateral	9	18.0	11	22	8	16		
Onset								
Acute	0	0	7	14	3	6	10.277	0.113
Subacute	3	6	2	4	4	8		
Chronic	45	90	38	76	38	76		
Unknown	2	4	3	6	5	10		
Associated symptoms								
Tinnitus	15	30.0	27	54	12	24	10.938	0.004
Vertigo	4	8.0	8	16	8	16	1.846	0.397
Both	0	0.0	4	8	2	4	4.167	0.125

No differences were observed for hearing loss chronicity.

statistically significant [16]. Kandakure et al. [17] conducted a prospective study of laboratory-confirmed COVID-19 patients seen over the course of 6 months, documenting the prevalence of SSNHL was 1.07% (n = 3) among 280 patients, and that SSNHL with tinnitus was noted in 2.14% (n = 6). Formeister et al. [18] examined the Vaccine Adverse Events Reporting System (VAERS) data using a group of patients who reported SSNHL after receiving the COVID-19 vaccine and found no evidence to suggest the COVID-19 vaccine was associated with a higher incidence of hearing loss relative to the general population.

Several explanations exist for the lack of correlation between SSNHL and COVID-19. The first is that COVID-19 illness or vaccine does not affect cochlear or vestibular function. While possible, the more plausible explanation is that there is a relationship that occurs in a select group of individuals, and as such is not easily captured through large-scale investigations. Indeed, small-scale studies do show evidence that COVID-19 and hearing loss may be related [7, 8, 10]. Maharaj et al. [9], for example, performed a systematic review and found seven studies (5 case reports, 2 case series) of patients with suspected COVID-related hearing loss. All patients (n = 28) had hearing loss when they were first seen, and 3 patients reported concomitant vertigo, otalgia, and tinnitus. While these authors concluded that SARS-CoV-2 can cause SNHL and middle ear infections, likely through viral propagation to the middle ear [9], others have speculated SSNHL may be due to COVID-19-associated coagulopathy, which in turn causes intralabyrinthine hemorrhage [19].

Another explanation for the lack of correlation is that overall fewer patients were seen during the COVID-19 pandemic. A reduced number of visits to healthcare facilities such as community physicians and emergency rooms has been documented for other serious illnesses during the COVID-19 pandemic [11, 16, 20]. The considerable decline in viral respiratory illnesses during the COVID-19 pandemic, likely brought on by social isolation, lockdown procedures, and the widespread usage of masks, may help explain the lack of anticipated increased SSNHL cases seen by clinicians [20].

In the present study, tinnitus was more common during the early pandemic relative to pre- or late pandemic periods. This corroborates previous literature

Table 3. Comparison of hearing-health history between three randomly selected patient groups shows no difference with respect to history of previous hearing loss, amplification, noise exposure, ototoxic exposure, or preceding upper respiratory infection (URI)

	Pre-pandemic		Early pandemic		Late pandemic		Test	*p* value
	July–December 2019		January–June 2020		January–June 2021			
	n	%	*n*	%	*n*	%		
Randomly selected	50	100	50	100	50	100		
H/o hearing loss								
Yes	26	52.0	25	50	21	42	1.122	0.571
No	24	48.0	25	50	29	58		
H/o amplification								
Yes	12	24.0	14	28	10	20	0.877	0.645
No	38	76.0	36	72	40	80		
H/o noise exposure								
Yes	14	28.0	11	22	10	20	0.969	0.616
No	36	72.0	39	78	40	80		
H/o ototoxic exposure								
Yes	4	8.0	4	8	7	14	1.333	0.513
No	46	92.0	46	92	43	86		
H/o preceding URI								
Yes	0	0.0	4	8	1	2	4.167	0.125
No	50	100.0	46	92	49	98		

Table 4. Comparison of audiometric data between three randomly selected patient groups pre-, during-, and post-pandemic shows no significant difference across audiologic variables

	Pre-pandemic		Early pandemic		Late pandemic		Test	*p* value
	July–December 2019		January–June 2020		January–June 2021			
	mean	standard deviation	mean	standard deviation	mean	standard deviation		
Right								
PTA	39.06	17.1	40.09	19.79	35.88	23.66	0.527	0.592
SRT	34.76	21.95	34.47	15.01	34.42	16.70	0.005	0.995
Word Rec (%)	84.35	27.30	87.04	22.29	79.30	28.29	1.007	0.368
Word Rec (dB HL)	71.63	16.43	72.56	13.76	75.69	14.79	0.854	0.428
Left								
PTA	36.84	21.29	39.04	21.41	40.29	27.73	0.251	0.779
SRT	35.72	29.78	34.38	21.40	36.59	18.13	0.104	0.901
Word Rec (%)	82.32	30.25	86.85	24.59	84.59	27.21	0.313	0.732
Word Rec (dB HL)	73.07	26.77	70.65	15.41	74.19	16.07	0.363	0.696

examining audiovestibular symptoms following COVID-19 infection. Almufarrij Munro [21] reviewed 56 studies demonstrating a connection between COVID-19 and hearing loss, tinnitus, and vertigo and found tinnitus was the most commonly reported symptom, with an estimated prevalence of 14.8%. Of the 56 investigations, tinnitus was mentioned in 26 (46%) studies. Of note, most of these findings were from case reports and retrospective questionnaires, which can be skewed by recall and publication bias.

Table 5. Most patients in the late pandemic group were vaccinated

	Late pandemic		Test	*p* value
	January–June 2021			
	n	%		
Vaccinated?				
No	5	10.0	11.913	0.003
Yes	45	90.0		
Type of vaccine				
Moderna	18	36	17.34	0.027
Pfizer	26	52		
Moderna and Pfizer	0	0		
J&J	1	2		
N/a	5	10		
Vaccine doses				
One	45	–		
Two	44	–		
Three	16	–		
Before first encounter	35	70		
After first encounter	10	20		
N/a	5	10		

A majority of these patients were vaccinated prior to their first encounter.

Our findings indicate tinnitus was not more common in the late pandemic phase (i.e., early vaccination rollout). Previous research regarding COVID-19 vaccination and tinnitus is similarly mixed, with some reports showing no correlation [14], and others indicating a relationship does exist [22–24]. For instance, Wichova et al. [25] examined 30 patients with postvaccination otologic symptoms and found hearing loss was the most common manifestation (83.3%), followed by tinnitus (50%) and dizziness (26.7%). Elmoursy et al. [26] conducted an observational cross-sectional study at two institutions and found tinnitus was the motivating symptom for all patients seeking medical advice.

Since the start of the COVID-19 pandemic, there has been an increase in chronic subjective tinnitus among the general population, which has been ascribed to the heightened stress and sadness brought about by isolation and lockdown [24, 27]. COVID-19 pandemic-related stress, sadness, and personal problems have likewise increased the prevalence of temporomandibular disorders and bruxism. This is in line with other research suggesting that psychological variables are linked to both illnesses, and could explain findings independent of infection or vaccination [28].

Limitations

This study has limitations worth discussing. First is the small sample size of our cohort. A major goal of the present study was to investigate a randomized sample to examine possible associations between SSNHL and COVID-19 illness and/or vaccination. As such, by nature of the study design, the sample size was kept small. It is possible that the small number of participants in our study did not accurately represent the variability found in larger communities. One point worth mentioning is that the patients in this study are likely to represent the surrounding community based on recent research investigating racial inclusivity [29]. Nonetheless, larger sample sizes inherently allow for greater variability and representation across a broad spectrum and should be considered for future investigations. A second limitation is the inherent subjectivity in retrospective chart review, which relies on documentation that may not be accurate or comprehensive. Additionally, data derived via chart review may not always offer precise or in-depth insights into the features of the research variables. These limitations should be considered when interpreting the findings and extrapolating them to larger groups. Future research using more diverse sample sizes and thorough data collection techniques, including direct observation or prospective data collection, may offer a more complete understanding of the subject at hand.

Statement of Ethics

This study protocol was reviewed by the Emory University Institutional Review Board who determined ethics approval was not required. The Emory University Institutional Review Board determined this project did not require written informed consent because it is not considered "research with human subjects," nor is it a "clinical investigation" as defined in federal regulations.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Elaine C. Thompson: experimental design, data collection, data analysis, preparation and writing of the manuscript; Khaled Altartoor: data collection and writing the manuscript; Esther X. Vivas: experimental design, oversight of methods and data collection, drafting/editing of manuscript, and approval of submitted manuscript version.

Data Availability Statement

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants but are available from the corresponding author E.X.V. upon reasonable request.

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