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BMJ Open Evaluation of disparities in hospitalisation outcomes for deaf and hard of hearing patients with COVID-19: a multistate analysis of statewide inpatient databases from Florida, Maryland, New York and Washington

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ABSTRACT

Objective Investigate whether deaf or hard of hearing (D/HH) patients with COVID-19 exhibited different hospitalisation outcomes compared with hearing patients with COVID-19.

Design Cohort study

Setting Statewide Inpatient Databases for Florida, Maryland, New York and Washington, for the year 2020. **Participants** Records of patients aged 18–64 years with COVID-19

Primary outcomes and measures Differences in in-hospital death, 90-day readmission, length of stay, hospitalisation cost, hospitalisation cost per day, intensive care unit (ICU) or coronary care unit (CCU) utilisation and ventilation use were evaluated. Adjustment variables included patient basic characteristics, socioeconomic factors, and clinical factors.

Results The analyses included 347 D/HH patients and 72 882 non-D/HH patients. Multivariable log-transformed linear regression models found an association of patients' hearing loss status with longer length of stay (adjusted mean ratio (aMR) 1.15, 95% Cl 1.04 to 1.27, p<0.01), higher hospitalisation cost (aMR 0.96, 95% Cl 1.00 to 1.22, p=0.049) and lower hospitalisation cost per day (aMR 0.96, 95% Cl 0.92 to 1.00, p=0.04). We did not detect any significant relationships with other outcomes. **Conclusions** Our findings suggest that higher hospitalisation costs were attributed to prolonged stays rather than costly interventions, such as ICU care. Communication barriers between healthcare providers and D/HH patients, coupled with providers' cautious approach to discharging D/HH patients, may explain our findings.

INTRODUCTION

In the USA, approximately 15.5% of adults identify as d/Deaf or hard of hearing (D/HH).¹ Despite legal mandates requiring all healthcare settings to provide accessible

STRENGTHS AND LIMITATIONS OF THIS STUDY

- \Rightarrow The study focuses on the deaf or hard of hearing (D/HH) population, which is a vulnerable and underresearched group.
- \Rightarrow Use of Statewide Inpatient Databases from Florida, Maryland, New York and Washington allowed for the inclusion of a significant portion of the US population, approximately 16.7%, although the findings might not be generalisable to other parts of the country.
- ⇒ D/HH individuals were identified using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes, which lack detailed information such as the degree of hearing loss, communication preferences and the timing of hearing loss onset, but have been widely used in prior publications to identify D/HH patients.
- ⇒ Our analyses were based on data from 2020 during the early stages of the COVID-19 pandemic and may not be representative of later years, as factors such as vaccination roll out, diagnostic and therapeutic practices and access to health information in American Sign Language improved throughout the pandemic and could have influenced emergency department use and hospitalisation among D/HH patients.

communication methods for D/HH patients, some hospitals fail to provide interpreters.^{2–4} The communication barriers faced by D/HH patients in healthcare settings are well documented,^{5–6} leading to issues ranging from limited access of medical information to challenges in navigating the complex healthcare

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Rie Sakai-Bizmark; rsakaibizmark@lundquist.org system. These systematic barriers impact D/HH patient's healthcare utilisation and delivery.^{7–11}

The COVID-19 pandemic brought to the forefront existing disparities in health outcomes.^{12–19} The impact of the pandemic was disproportionately felt by vulnerable populations with limited health literacy, as understanding the importance of proper preventive measures and vaccination protocols, as well as navigating healthcare systems during the pandemic was a challenge for these individuals.^{20 21} Studies reported associations of higher health literacy skills and adoption of better protective behaviour against COVID.^{22–24}

The COVID-19 pandemic brought a unique set of challenges to the D/HH population, especially in accessing COVID-related health information and healthcare. The widespread use of face masks limiting lip reading and facial expressions as well as shifts to virtual platforms for healthcare services and information dissemination, which were sometimes affected by technical difficulties and poor audio/visual quality, made it particularly difficult for D/HH patients to navigate the healthcare system in the pandemic era. Additionally, the D/HH population is diverse, encompassing individuals with a wide range of abilities, communication preferences, life experiences and identities. The term D/HH encompasses those who are prelingually deaf (ie, deafness that occurred at birth or early in life, before speech and language development), those who are postlingually deaf (ie, deafness that occurred after speech and language development), as well as those with less severe levels of hearing loss. While some D/HH individuals primarily communicate through American Sign Language (ASL), others rely on oral communication and assistive listening technologies. These differences highlight the heterogeneity within the D/HH community and present unique challenges in healthcare settings, particularly during public health crises like the COVID-19 pandemic. Several studies found associations between D/HH identity and lower levels of COVID-related health literacy due to the limited availability of D/HH-accessible information online.^{25–27} These health information barriers may have contributed to health disparities by increasing the risk of COVID-19 for D/HH individuals.

Communication barriers in healthcare settings may lead to delayed or suboptimal care, impacting the progression of COVID-19 and complicating treatment.^{25–32} Moreover, social determinants of health, such as access to resources and health literacy, could further contribute to disparities in health outcomes between D/HH and hearing populations.^{33–36} These challenges highlight the importance of understanding how D/HH patients experience healthcare differently, particularly during public health emergencies, such as the COVID-19 pandemic.

The objective of this study is to examine whether D/ HH patients with COVID-19 exhibited different hospitalisation outcomes, such as length of stay (LOS) and hospitalisation cost, compared with hearing patients with COVID-19, using Statewide Inpatient Databases (SIDs) from Florida (FL), Maryland (MD), New York (NY) and Washington (WA). This study used International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes to identify D/HH patients. While ICD-10-CM codes have been used to identify D/HH patients in several prior publications,^{34–36–39} they inherently lack the granularity to capture detailed characteristics of each patient's diagnosis and experience. Consequently, this study includes individuals across the spectrum of D/HH identities, encompassing patients with varying degrees of hearing loss, varying types of hearing loss onset (eg, congenital, late-onset) and diverse communication preferences (eg, ASL, oral communication).

METHODS

The Institutional Review Board at The Lundquist Institute for Biomedical Innovation at Harbor-UCLA Medical Center approved the study under the 'exempt' category. Data analysis was performed from April 2024 to May 2024. This study followed the STrengthening and Reporting of OBservational studies in Epidemiology (STROBE) reporting guidelines for cohort studies.

Database

We used three data sets. The first data set was composed of Statewide Inpatient Databases (SIDs) for Florida (FL), Maryland (MD), New York (NY) and Washington (WA), compiled by the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ).⁴⁰ These four states were selected for the analyses to ensure geographic diversity, representing different regions of the USA (Northeast, South and West), which helps capture regional variations in healthcare systems and patient demographics. The SIDs capture all inpatient discharge data within those states. Therefore, we were able to include all eligible cases and track the same individuals, even if they utilised different healthcare facilities, throughout the year. The second and third data sets, which were used for the sensitivity analyses and the exploratory analyses, were the National (Nationwide) Inpatient Sample (NIS) and the Nationwide Emergency Department Sample (NEDS). The NIS and NEDS, which are also released from HCUP, are the most extensive publicly accessible databases for inpatient and emergency department (ED) visits, crafted to generate regional and national assessments of hospitalisations and ED visits in the USA, respectively.^{41 42} Data from 2020 were utilised for all data sets as it was the most recent data available at the time of this study. Additionally, SIDs for the year 2019 were used to calculate one of the adjustment variables (ie, case volume for each hospital), as outlined in the measurements section below.

Identification of patients

We identified patients aged 18–64 years with COVID-19 based on the ICD-10-CM code U07.1, for any of the first 34 ICD-10-CM diagnoses of a patient encounter. We

excluded older patients because these individuals may have experienced hearing loss due to ageing and are not necessarily representative of the D/HH population we aim to study. Patients who were discharged between April and September 2020 were included in the analyses for the following two reasons. First, the ICD-10 code for COVID-19 became available on 1 April 2020. Second, to evaluate the 90-day readmission after discharge from the index hospitalisation, which was defined as the first hospitalisation between April and September 2020, we only included the patients who were discharged before 30 September 2020 as to be able to capture readmissions during the final 90 days of the calendar year. As the ICD-10 code for confirmed COVID-19 was not available until April, we excluded patients who were hospitalised for any reason within 90-days prior to the index hospitalisation.

Measurements

All measurements used in the analyses are outlined in detail in table 1. Our outcomes of interest were in-hospital death, 90-day readmission, LOS, hospitalisation cost, hospitalisation cost per day, intensive care unit (ICU) or coronary care unit (CCU) utilisation and mechanical ventilation use among patients with COVID-19. ICU/ CCU utilisation was identified based on the revenue code shown in online supplemental table 2 and was defined as the use of a medical ICU/CCU bed. Patients with a COVID-19 diagnosis who were admitted to non-medical ICU (ie, the surgical ICU, psychiatric ICU, burn care, trauma care and heart transplant units) were not categorised as ICU/CCU users because their admittance to those specialised units may have been based on diagnoses separate from COVID-19. As revenue code was not available in the FL SID, the analyses for ICU/CCU utilisation only used the data from MD, NY and WA. The primary exposure variable was patient hearing loss status, which was identified with a diagnosis of D/HH, using ICD-10-CM codes H90 and/or H91.34 37 43 Other variables of interest included age, sex, insurance type, income quartile based on the residential zip code and the Elixhauser Comorbidity Index.⁴⁴ Hospitals were categorised into three groups (ie, high-, medium- and low-volume hospitals) based on the number of patients at each hospital in 2019 to ensure an equal number of patients in each category. This method has been used in several prior studies.⁴⁵⁻⁴⁸ Volume was based on the number of patients during the prepandemic period, as a significant number of hospitals experienced overloading due to COVID-19 and thus their case volume during the pandemic period did not reflect their case volume or resources during a typical period.

Analytic approach

Descriptive statistics were compared between D/HH and non-D/HH individuals. Chi-squared tests were used to compare proportions, and separate p values were calculated for each category within a variable. For example, within the race and ethnicity variable, individual p values were calculated for each category (eg, non-Hispanic

Table 1 Descriptive statistics					
	Participant group				
	D/HH (n=347)	Non-D/HH (n=72 882)	P value		
Individual characteristics					
Age group					
18–35	41 (11.82)	13870 (19.03)	<0.01		
36–46	38 (10.95)	14039 (19.26)	<0.01		
47–53	63 (18.16)	13648 (18.73)	0.79		
54–59	100 (28.82)	15965 (21.92)	0.02		
50–64	105 (30.26)	15360 (21.08)	<0.01		
Race and ethnicity					
Hispanic	90 (25.94)	24352 (33.41)	<0.01		
Non-Hispanic Black	72 (20.75)	21 099 (28.95)	<0.01		
Non-Hispanic White	132 (38.04)	18073 (24.80)	<0.01		
Other*	53 (15.27)	9358 (12.84)	0.18		
Sex					
Female	123 (33.45)	33602 (46.1)	<0.01		
Male	224 (64.55)	39280 (53.9)			
Insurance type					
Public	231 (66.57)	32 507 (43.98)	<0.01		
Private	93 (26.80)	32 469 (44.55)	<0.01		
Other	† (†)	4088 (5.61)	0.73		
Self-pay	≤10‡(†)	4268 (5.86)	<0.01		
Neighbourhood income quartile					
First (lowest)	114 (32.85)	22720 (31.17)	0.50		
Second	80 (23.05)	18894 (25.92)	0.22		
Third	80 (23.05)	17350 (23.81)	0.74		
Fourth (highest)	73 (21.04)	13918 (19.10)	0.36		
Hospital characteristics					
Hospital volume					
High	114 (32.85)	24293 (33.33)	0.85		
Medium	115 (33.14)	24625 (33.79)	0.80		
Low	118 (34.01)	23964 (32.88)	0.66		
Discharge quarter					
Quarter 2	213 (61.38)	42 539 (58.37)	0.26		
Quarter 3	134 (38.62)	30434 (41.63)			

*'Other' race category includes non-Hispanic American Indian or Alaskan Native, non-Hispanic Asian, non-Hispanic Native Hawaiian or other Pacific Islander and non-Hispanic other (unspecified) race.

†Value has been masked to prevent obtaining counts in neighbouring cells.

‡Cases ≤10 have been masked to protect patient privacy.

D/HH, d/Deaf or hard of hearing.

White, non-Hispanic Black and Hispanic) to identify significant differences between D/HH and non-D/HH individuals within each group. Multivariable logistic regression models were used to assess the association of D/HH with the outcomes outlined above. When evaluating the association with 90-day readmission, we only included individuals who were alive at discharge from the index hospitalisation. Multivariable log-transformed linear regression models were used to assess the association of patient hearing loss status with LOS, hospitalisation cost and hospitalisation cost per day. All regression

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models were adjusted for the other variables of interest listed above, with discharge quarter, state fixed effects and hospital random effect. Discharge quarter fixed effects adjust for factors that are common to all locations, but which change across time, such as seasonal differences in hospitalisations due to COVID-19. State fixed effects absorb all state-specific time-invariant effects. Hospital random effects were included to account for residual correlations across patients cared for at the same hospitals, as well as the effect on standard errors (SEs) of estimates and p values for clustering within hospitals.

Sensitivity analyses

First, to test whether the results using SIDs from four states are generalisable to a nationwide context, the NIS was used to evaluate the associations of hearing loss status with in-hospital death, ventilation use, LOS, hospitalisation cost and hospitalisation cost per day among patients with a diagnosis of COVID-19. The revenue codes to identify ICU/CCU utilisation are not available in NIS. Additionally, due to the study design of the NIS, it was impossible to evaluate readmission. Further details, including the adjustment variables included in the model, are provided in online supplemental text 1. Second, the main analyses defined ICU/CCU utilisation as the use of medical ICU beds. However, during the pandemic, some ICU beds not typically designated for medical care, such as surgical and trauma ICU beds, may have been utilised for COVID-19 patients due to overflow. Therefore, in the sensitivity analvsis, ICU/CCU utilisation was defined as the use of any ICU beds, including non-medical ICU, such as surgical ICU and psychiatric ICU. Third, individuals who utilised non-medical ICUs were excluded from the analyses.

Exploratory analyses

Some reports indicate that D/HH patients utilise the ED for less acute conditions compared with non-D/HH patients.⁹ We utilised NEDS to examine whether D/HH patients with a diagnosis of COVID-19 were less likely to be admitted to hospitals and more likely to visit the ED for non-acute conditions compared with non-D/HH patients with a diagnosis of COVID-19. Additionally, we tested for any differences in mortality at the ED due to COVID-19 between the two groups. Further details, including the adjustment variables included in the model, are provided in online supplemental text 2.

Patient and public involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

A total of 347 D/HH patients and 72 882 non-D/ HH patients were identified in the SIDs and included in the analyses. As shown in tables 1, D/HH patients had an older age distribution compared with non-D/ Table 2Results from regression analyses evaluating theassociation of patients' hearing status with each outcomeamong patients with a diagnosis of COVID-19

	aOR or aMR (95% Cl)	P value	
In-hospital mortality			
D/HH	0.85 (0.58 to 1.23)	0.39	
Non-D/HH	Reference		
90-day readmission			
D/HH	1.36 (0.98 to 1.90)	0.06	
Non-D/HH	Reference		
ICU/CCU utilisation			
D/HH	0.36 (0.05 to 2.90)	0.34	
Non-D/HH	Reference		
Ventilation use			
D/HH	1.00 (0.14 to 0.21)	0.99	
Non-D/HH	Reference		
Length of stay			
D/HH	1.15 (1.04 to 1.27)	<0.01	
Non-D/HH	Reference		
Hospitalisation cost			
D/HH	1.10 (1.00 to 1.22)	0.049	
Non-D/HH	Reference		
Hospitalisation cost per day			
D/HH	0.96 (0.92 to 1.00)	0.043	
Non-D/HH	Reference		
Models were adjusted for age group, sex, race and ethnicity,			

insurance type, median income quartile based on patients' residential zip code, hospital case volume and comorbidity index with state fixed effect and hospital random effect. aMR, adjusted mean ratio; aOR, adjusted odds ratio; CCU, coronary care unit; D/HH, d/Deaf or hard of hearing; ICU, intensive care unit.

HH patients. Specifically, a smaller proportion of D/ HH patients were aged 18-35 years (11.82% vs 19.03%, p<0.01) and 36-46 years (10.95% vs 19.26%, p<0.01). In contrast, a higher proportion of D/HH patients were aged 54-59 years (28.82% vs 21.92%, p=0.02) and 50-64 years (30.26% vs 21.08%, p<0.01). A higher proportion of D/HH patients were non-Hispanic White (38.04%) vs 24.80%, p<0.01) and a lower proportion were non-Hispanic Black (20.75% vs 28.95%, p<0.01) or Hispanic (25.94.% vs 33.41%, p<0.01). A higher proportion of D/ HH patients were male (64.55% vs 53.90%, p<0.01) and had public insurance (66.57% vs 43.98%, p<0.01). After adjusting for the variables listed previously, we found an association between patients' hearing status and longer LOS (adjusted mean ratio (aMR) 1.15, 95% CI 1.04 to 1.27, p<0.01), higher hospitalisation cost (aMR 1.10, 95% CI 1.00 to 1.22, p=0.049) and lower hospitalisation cost per day (aMR 0.96, 95%CI 0.92 to 1.00, p=0.043) (table 2). We did not detect any significant relationships
 Table 3
 Results from sensitivity analyses evaluating the association of patients' hearing status with ICU utilisation among patients with a diagnosis of COVID-19

	aOR or aMR (95% CI)	P value
Including all ICU cod	des	
D/HH	1.31 (0.41 to 4.16)	0.65
Non-D/HH	Reference	
Excluding records w etc	ith ICU codes for trauma, bu	ırn, surgery,
D/HH	1.67 (0.53 to 5.29)	0.39
Non-D/HH	Reference	
Models were adjusted insurance type, mediar residential zin code, bo	for age group, sex, race and eth n income quartile based on patie	inicity, ents' idity index

residential zip code, hospital case volume and comorbidity index with state fixed effect and hospital random effect. aMR, adjusted mean ratio; aOR, adjusted odds ratio; D/HH, d/Deaf or hard of hearing; ICU, intensive care unit.

with other outcomes. Sensitivity analyses using data from the SIDs and NIS revealed consistent trends that mirrored those observed in the main analyses (table 3 and online supplemental etable 3).

A total of 5408 D/HH patients and 2 262 854 non-D/ HH patients who visited the ED and received COVID-19 diagnoses were identified in the NEDS and included in the analyses. After adjusting for the variables listed previously, we did not detect any meaningful differences in ED mortality between D/HH and non-D/HH patients. We found that 78.4% of D/HH patients and 30.5% of non-D/HH patients were hospitalised after ED visits. After adjusting for the variables listed in online supplemental text 2, D/HH patients were more likely to be hospitalised after the ED visit compared with non-D/HH patients (adjusted OR (aOR) 6.23, 95% CI 4.76 to 8.17, p<0.001) (online supplemental etable 4)

DISCUSSION

We found that D/HH patients hospitalised with a COVID-19 diagnosis were likely to experience longer hospital stays and incur higher hospitalisation costs compared with non-D/HH patients. However, we also observed that D/HH patients were more likely to have a lower hospitalisation cost per day compared with their non-D/HH counterparts. These results suggest that the higher overall hospitalisation costs observed among D/HH patients were likely due to their extended LOS rather than costly interventions. In fact, our analysis did not detect any statistical differences between D/HH patients and non-D/HH patients for the adverse outcomes evaluated in this study (ie, in-hospital mortality, readmission, ICU/CCU utilisation and ventilation use).

One possible explanation for longer LOS, but lower hospitalisation cost per day, could stem from communication barriers between healthcare providers and D/ HH patients. D/HH patients exhibit lower health literacy compared with non-D/HH patients^{10 49} and have more limited access to consistent health education and healthpromoting resources.^{8 50} McKee *et al*^{δ 1} also noted a lack of provider training regarding effective communication with D/HH individuals. Thus, healthcare providers may not be confident in their understanding of the symptoms of D/HH patients, which could lead to delays in diagnosis, treatment or discharge planning. These factors could explain the longer hospital stays and increased costs we observed, as healthcare providers may need to spend more time addressing these communication barriers and ensuring proper care for D/HH patients. Additionally, the need for specialised accommodations or support services for D/HH patients during hospitalisation, such as sign language interpreters, might require additional time and prolong hospitalisation. James *et al*^{\tilde{p}^2} reported that inadequate communication, inability to discuss medical history with providers and lengthy wait times for on-site interpreters contribute to longer LOS in the ED.

For many D/HH individuals, English often functions as a second or third language, while ASL serves as their primary mode of communication. Despite legal mandates, challenges persist in providing ASL interpreters and other necessary communication accommodations within healthcare settings.²⁻⁴ In the absence of interpreters, D/ HH patients may rely on lip-reading, written notes or assistance from family members for communication, all of which are not only suboptimal but also time-consuming for many D/HH patients. For example, ASL does not directly correspond to English, and the average English reading comprehension level among D/HH individuals who use ASL is reported to be at or below the sixth-grade level.^{7 53 54} Therefore, relying on written explanations may prove difficult for D/HH patients, potentially leading to misunderstandings or prolonged interpretation times. In light of these findings, it is crucial for healthcare providers and policymakers to implement strategies aimed at improving communication access and ensuring equitable healthcare for D/HH patients. Improved communication access not only reduces unnecessary healthcare expenditures but also could shorten hospital stays, benefiting both patients and the healthcare system as resources could be allocated more efficiently to those in genuine need of medical attention.

Another possible explanation for our finding of longer LOS among D/HH patients compared with non-D/HH patients is a cautious approach by healthcare providers towards discharging D/HH patients. It has long been recognised that D/HH patients face challenges in accessing accurate health information, $^{55-57}$ especially during emergency situations. $^{58-60}$ Challenges in accessing information specifically during the COVID-19 pandemic have also been reported. $^{25-27}$ In addition to the communication challenges during hospitalisation, healthcare providers could be concerned with the challenges D/HH individuals face in navigating the healthcare system after discharge. These concerns could be influencing clinical decision-making, leading to extended hospitalisations

for D/HH patients. A cautious discharge management strategy, while well-intentioned, may inadvertently contribute to unnecessary healthcare expenditures and prolonged hospitalisations for D/HH patients. On the other hand, it has been documented that clinicians lack awareness regarding the unique needs of D/HH patients, ⁶¹ have discomfort in providing care to patients with disabilities, including D/HH individuals, and have difficulty in obtaining sufficient health history for D/HH patients. ^{62–64} Further investigation is warranted to gain insights into healthcare providers' decision-making processes regarding discharge planning for D/HH patients, as well as the potential challenges encountered in managing their care within the healthcare system.

We recognise the potential complexity of public insurance eligibility among D/HH patients. While public insurance is often associated with lower socioeconomic status (SES) in the general population, eligibility among D/HH individuals may also stem from disability-related criteria, which can vary across states and may not always be tied to SES. Despite these nuances, our models were adjusted for insurance type and state fixed effect. Regardless of insurance type and state of residence, D/ HH patients were more likely to have longer LOS and higher total hospitalisation costs. Importantly, D/HH patients were more likely to have lower total hospitalisation costs per day, suggesting that the higher total costs among D/HH patients are attributable to their longer hospital stays rather than more expensive treatments. This finding highlights the need for further investigation into other potential contributors to these differences, such as unmeasured socioeconomic or disability-related factors, including the role of individual-level income and disability-related accommodations in care delivery. With the analysis of nationwide ED visit data (ie, NEDS), we found that D/HH patients were more likely to be hospitalised compared with non-D/HH patients after ED visits. This finding contradicts existing evidence, which reports that D/HH patients were more likely to utilise ED visits for less acute conditions.⁸ One potential explanation for our findings is that the care-seeking behaviour of D/HH patients differs during emergencies. Due to limited health information accessibility, D/HH patients may delay their ED visits, resulting in presenting with more advanced diseases and higher likelihood of need for subsequent inpatient care. Another possible explanation for the higher hospitalisation rates is that healthcare providers may hesitate to discharge D/HH patients from the ED, recognising the challenges they may face in navigating the healthcare system post-ED discharge. There are data to support these concerns, as D/HH patients had higher rates of ED revisits than non-D/HH patients.^{65 66} Further investigation is needed to clarify the underlying reasons for the higher rate of admission that we observed.

While this study provides valuable insights into hospitalisation experiences due to COVID-19 among D/HH patients, it is important to acknowledge limitations to our investigation. First, our analyses utilised data from the

year 2020, representing the early stages of the COVID-19 pandemic when vaccination efforts had not yet been fully implemented. Therefore, our findings may differ from those patterns of care that occurred after vaccination was implemented or patterns of care affecting hospitalisation that evolved over the course of the pandemic, such as improved diagnostic testing and therapeutics. Additionally, during the early stages of the pandemic, accessible health information in ASL was limited. This gradually improved over time and may have influenced ED use, the timing of disease presentation and subsequent hospitalisation among D/HH patients. Second, the use of administrative claims data in our analysis limits our ability to account for potential unmeasured confounders. For example, information on patients' educational status-a key determinant of health literacy and informationseeking behaviours within the D/HH community³¹—is not available. However, we included zipcode-level median income as a proxy for SES, which is strongly correlated with education level.^{67–70} Furthermore, administrative data lack granularity on the extent of hearing impairment or primary communication methods, which may influence healthcare experiences and outcomes. The method we employed to identify D/HH patients using D/HH-related ICD-10-CM codes has not been formally validated. While this approach to identify D/HH patients using billing codes is commonly used,^{34 36-39} the lack of validation studies means that this method to identify D/ HH patients may introduce misclassification bias. This misclassification could impact the interpretation of our findings, potentially underestimating or overestimating differences between D/HH and non-D/HH patients. Despite these limitations, the use of administrative claims data remains crucial for studying health issues in vulnerable populations, such as the D/HH community, for whom traditional research methods often encounter significant barriers in recruitment and data collection.

Third, our study was based on data from four states, limiting the generalisability of our findings to other regions of the country. While we also utilised nationally representative databases (ie, NIS and NEDS) to supplement our state-level data, the outcomes assessed were limited and potential patient double-counting may have occurred due to the design of NIS and NEDS (ie, the patient identifiers in NIS and NEDS are at the record level, rather than the individual level).

CONCLUSIONS

Utilising statewide inpatient data from four states, we found that D/HH patients with COVID-19 experienced longer hospital stays and higher hospitalisation costs, while incurring lower costs per day, compared with non-D/HH patients. Our findings suggest that higher hospitalisation costs were attributed to prolonged stays rather than costly interventions such as ICU care. Communication barriers between healthcare providers and D/HH patients, coupled with providers' cautious approach to discharging

D/HH patients, may explain our findings. Addressing these disparities is crucial to ensure patient-centred care and optimise resource allocation within the healthcare system. Future research should examine the specific role of communication barriers in prolonging hospital stays among D/HH patients, particularly focusing on the effects of delayed medical decision-making and postdischarge planning. Investigations into the effectiveness of interpreters, accessible health technologies and culturally sensitive care models in improving health outcomes for D/HH patients are also warranted. From a policy perspective, implementing and enforcing standards for effective communication in healthcare, such as mandating access to qualified interpreters and visual aids, should be prioritised to enhance care quality and equity.

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Acknowledgements Database: this study utilised 2019–2020 data from the Florida, Maryland, New York and Washington Statewide Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. This study also utilised 2020 data from the National Inpatient Sample (NIS) and the Nationwide Emergency Department Sample (NEDS), HCUP, Agency for Healthcare Research and Quality. The authors would like to acknowledge the HCUP data partners: https://hcup-us.ahrq.gov/db/hcupdatapartners.jsp.

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