Antenatal Emergency Department and Inpatient Use Among Massachusetts Deaf and Hard of Hearing Women: A Retrospective Cohort Study

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Abstract

Background

Hearing loss is increasingly prevalent among younger adults and significantly impacts health and health care use. Deaf and hard of hearing (DHH) women have a significantly higher risk of chronic diseases, pregnancy complications and adverse birth outcomes compared to hearing women. The mechanisms, including health care utilization patterns during the perinatal period, remains not well understood.

Methods

We conducted a retrospective cohort study design to analyze 2002–2013 Massachusetts Pregnancy to Early Life Longitudinal data to compare antenatal inpatient and emergency department use between DHH (N=925) and hearing (N=2895) women with singleton deliveries. Matching was done based on delivery year, age at delivery and birth parity in 1:3 case-control ratio. Demographic, socioeconomic, clinical and hospital characteristics were first compared for DHH mothers and the matched control group using chi-squared tests and t-tests. Multivariable models were adjusted for socio-demographic and clinical characteristics.

Results

Among DHH women (N=925), 49% had at least one emergency department visit, 19% had an observational stay, and 14% had a non-delivery hospital stay compared to 26%, 14%, and 6%, respectively among hearing women (N=2895) during the antenatal period (all $p < 0.001$). The risk of non-delivery emergency department visits (RR 1.58; $p < 0.001$) and inpatient stays (RR 1.89; $p < 0.001$) remained higher among DHH women compared to hearing women even after adjustment for relevant variables. Having four or more emergency department visits (7% vs. 2%), two or more observational stays (7% vs. 3%) and two or more non-delivery hospital stays (4% vs. 0.4%) prior to delivery were more common among pregnant DHH women compared to their controls (all $P < 0.001$).

Conclusion(s):

The study findings demonstrate that DHH women during the use emergency departments and inpatient services at a significantly higher rate than their hearing controls during the antenatal period. A systematic investigation of the mechanisms for these findings, including healthcare, patient- and provider-based factors, are needed. Health care providers should be aware of potentially heightened risk for pregnancy and birth complications among DHH women which are in part due to persistent social and healthcare barriers, including communication and language.

Introduction

Hearing loss is common, affecting approximately 15-17% of Americans, most of whom have mild to moderately severe hearing loss [1–3]. While the majority of these individuals are older, younger individuals are still at risk. Hearing loss is increasingly prevalent in younger adults, with 8.5% of individuals ages 20 to 29 years and 17% of those ages 30 to 39 years having some degree of high-frequency hearing loss [1].

Having hearing loss is associated with social isolation [4], lower socioeconomic status, including reduced income and educational attainment [5] along with impacts on psychological, cognitive and physical health [6, 7]. Additionally, deaf and hard of hearing (DHH) women have been found to be at a heightened risk for chronic conditions, pregnancy-related complications, and adverse birth outcomes [6, 7]. Little is known on why DHH women experienced higher risks for a variety of adverse events and outcomes but social and healthcare barriers, including communication and language, have been hypothesized to play a role. For example, treatment adherence, hospital readmission rates and preventive care receipts can be impacted if communication and language are not accessible [8–15]. DHH individuals also utilize emergency departments and hospitals more often [16, 17]. DHH individuals, even those with milder forms of hearing loss have higher hospitalization rates (16% and 21% higher, respectively for mild and moderate hearing loss) when compared to their hearing peers [18]. DHH generate \$22,000 greater health care costs over 10 years in respect to those who are hearing, even after adjusting for health and sociodemographic factors [16, 17]. DHH individuals are also at higher risk for readmission, in part due to communication challenges. A retrospective analysis of the *2010-2013 Medicare Current Beneficiary Survey* found that older DHH patients who had “trouble communicating” with clinicians [8] had 32% greater readmissions rate compared to their peers.

An emerging body of literature suggests that DHH women are at risk for pregnancy complications and adverse birth outcomes [6, 7, 19]. Two recent studies by Mitra and colleagues using national and state-level data found that DHH women were significantly more likely than their hearing peers to have preterm birth and low birth weight infants, and at increased risk of chronic medical conditions and pregnancy complications, including pre-existing and gestational diabetes, pre-eclampsia and eclampsia, and placental abruption [7, 19]. Deliveries to DHH

women were significantly associated with pre-term birth and low and very low birth weight infants, and infants with low Apgar scores [7]. There is a lack of data, however, on the antenatal health care utilization patterns and risk factors among DHH women. The paper's objective is to examine differences in antenatal emergency department and inpatient utilization, and the primary indication for the utilization, among DHH and non-DHH women.

Materials And Methods

Study setting

We conducted a population-based retrospective matched case-control study in Massachusetts. Our study included all hospital-based deliveries in Massachusetts that occurred during the 2003-2013 period. The study was approved and deemed exempt under exemption category 4 by the Brandeis University IRB, protocol number 17135R-E. The original approval was issued on June 22, 2017. It was considered exempt under Category 4 of the federal regulations since the study involves analysis of secondary data and the research was conducted in a manner that the resulting dataset does not include identifiable information. Additionally, as per guidance with the use of PELL data user agreement, we did not display any frequencies less than 12 to further ensure confidentiality. All ethical guidelines according to the Declarations of Helsinki were otherwise followed.

Data

We used the Pregnancy to Early Life Longitudinal (PELL) data system, a longitudinal, population-based, reproductive health data set. PELL data links to all Massachusetts birth certificates, fetal death reports, and delivery and non-delivery (inpatient visits, observational stays, and emergency department visits) related hospital discharge records for all infants and their mothers [20, 21]. The PELL data set includes >100 clinical and nonclinical data elements for each delivery, including primary and secondary diagnoses and procedures. This rich dataset allows for the ability to examine both delivery and non-delivery health care use patterns, including emergency department (ED) visits, observational- and hospital-based stays. Detailed information on the design of the PELL data set is available elsewhere [7, 21–23].

Study Cohort

The PELL data include unique decoded patient identifiers; thus, the unit of analysis is any delivery to Massachusetts women who gave birth between January 1, 2002 and December 31, 2013. This time period allowed us to include all antenatal visits for women who delivered in 2003 and had antenatal visits during 2002. Additionally, we restricted deliveries to women with at least 720 days gap between two consecutive deliveries to avoid the complexity of the time overlapping between the postpartum period from one delivery and antenatal period from a subsequent delivery. Deliveries to DHH women (n=925) or case subjects were identified by analyzing the primary and secondary diagnoses of any hospital admissions (not just those associated with deliveries), ED visit, or observational stay up to the time of delivery [7]. If any of the DHH-related diagnoses from the *International Classification of Diseases and Related Health Problems 9th Revision (ICD-9 CM)* codes (389.0, 389.1, 389.2, 389.7, 389.8, and 389.9) were present on the hospital discharge record, the woman was considered to have DHH [7]. The control group with no record of DHH status (n=2,895) similar to previous research [24] was matched on delivery year, age at delivery and birth parity in 1:3 case-control ratio.

Measures

Dependent variables. The main dependent variables were 1) any ED visit, and 2) any hospitalization (an in-patient stay and/or observational stay). Observational stays were aggregated with inpatient stays due to their relatively low frequency in the target population. Any hospitalizations and ED visits during the antenatal period were identified in the PELL data set using linked birth certificate, inpatient discharge, outpatient observation, and ED data. The antenatal period was calculated from the beginning of pregnancy (defined as the week of gestation at birth/fetal death subtracted from the date of birth/fetal death) through the date of birth/fetal death. The primary reasons for antenatal hospital admission and ED visits were classified based on the 18 condition categories of the Clinical Classification Software (CCS) [25].

Covariates. Model covariates included maternal sociodemographic and clinical characteristics. Maternal socio-demographic characteristics at the time of delivery were derived from the birth certificate and included maternal age (<20, 20-29, 30-39, 40+ years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Other), language (English, other, unknown), education (<high school, high school, some or more college), marital status (single or married), health insurance (private or public), and father named on the birth certificate (yes/no) [26]. Clinical characteristics were also derived from the birth certificate and included smoking during pregnancy and Adequacy of Prenatal Care Utilization (APNCU) Index [27]. APNCU or Kotelchuck index was categorized as: adequate plus – received 110% of expected visits; adequate – 80-109%; intermediate – 50-79%; and inadequate – <50% of expected visits [27]. Diabetes during pregnancy—including both gestational and chronic—and hypertension during pregnancy (yes/no)—including both pregnancy-related and chronic (yes/no) were also obtained from birth certificate data [28].

Analysis

Demographic, socioeconomic, clinical and hospital characteristics were compared for DHH mothers and the matched control group. Differences across categorical variables and continuous variables between the two clinical populations were evaluated using chi-squared tests and t-tests, respectively.

We used Generalized Estimating Equations (GEEs) to estimate the unadjusted and adjusted relative risk for hospital utilization and ED visits between DHH women and the matched control group. The unadjusted and adjusted risk ratio (RR) for selected medical conditions for hospital utilization and ED visits between DHH women and the matched control group were estimated. We used GEEs to account for repeated measurements (multiple deliveries to the same woman). Primary reasons for antenatal hospital admission and ED visits, based on CCS [25] were assessed and compared between DHH and non-DHH mothers. We used RR or odds ratio (OR) for different measures because when an outcome is common (>10% in the unexposed group), the OR will exaggerate the RR [29]. Unadjusted models were adjusted for delivery year, age at delivery and birth parity because the case-control matching was based on delivery year, age at delivery and birth parity. Multivariable models were adjusted for socio-demographic (maternal age, education, race/ethnicity, marital status, health insurance, and father named on the birth certificate) and clinical characteristics (smoking, Kotelchuck index, chronic diabetes and chronic hypertension). A p-value of <0.05 was considered significant. All analyses were performed using statistical software SAS, version 9.3 (SAS Institute Inc., Cary NC). This study was approved by the authors' respective institutional review boards.

Results

Maternal Characteristics

A description of the sample comparing DHH women with the matched control group are presented in Table 1. Compared to the matched control group, DHH women were more likely to be non-Hispanic Black or Hispanic ($p<0.001$) and more likely to communicate in other or unknown languages (e.g. American Sign Language) ($p=0.004$), and less likely to be married ($p<0.001$) (Table 1). They were also more likely to have a lower education level ($p<0.001$), more likely to receive public health insurance ($p<0.001$), and more likely to receive “adequate plus” prenatal care based on the Kotelchuck index ($p<0.001$) (Table 1). DHH women were also more likely to have smoked during pregnancy ($p=0.003$) and have gestational diabetes and hypertension (all $p=0.003$), along with chronic diabetes (0.003) and hypertension ($p=0.011$) (Table 1).

Table 1: Maternal Characteristics, by Deaf and Hard of Hearing (DHH) Status, 2002-2013 Massachusetts Pregnancy to Early Life Longitudinal Data System

Characteristics	DHH		NonDHH		test statistic	
	N	925	N	2,895		
	n	%	n	%	χ^2	P-value
Age					0.14	0.986
age<20	54	5.84	168	5.80		
20<=age<30	420	45.41	1,332	46.01		
30<=age<40	402	43.46	1,248	43.11		
age>=40	49	5.30	147	5.08		
Education					14.37	0.001
Less than high school	341	36.94	1,005	34.86		
High school graduate	221	23.94	562	19.49		
Some or more college	361	39.11	1,316	45.65		
Maternal Race/Ethnicity					18.17	<0.001
Hispanic	164	17.73	447	15.44		
Non-Hispanic white	624	67.46	1,950	67.36		
Non-Hispanic black	95	10.27	254	8.77		
Other	42	4.54	244	8.43		
Language					11.27	0.004
English	569	61.51	1,903	65.73		
Others	111	12.00	246	8.50		
Unknown	245	26.49	746	25.77		
Marital Status (%Married)	463	50.16	1,810	62.83	46.61	<.0001
Public Health Insurance	345	50.74	831	38.72	30.67	<.0001
Other Characteristics						
Father named on birth certificate	802	90.21	2,595	91.50	1.40	0.237
Smoking during pregnancy	102	14.25	225	10.18	9.00	0.003
Prenatal care 1th trimester	724	79.74	2,243	79.79	0.00	0.970
Prenatal care utilization index						
Missing	28	3.03	109	3.77	19.54	<0.001
Inadequate	87	9.41	253	8.74		
Intermediate	68	7.35	181	6.25		
Adequate	335	36.22	1,265	43.70		
Adequate Plus	407	44.00	1,087	37.55		
Pregnancy complications						
Gestational Diabetes	17	1.84	21	0.73	8.81	0.003
Gestational Hypertension	47	5.08	87	3.01	8.93	0.003
Other pregnancy complications	592	64.00	1,598	55.20	22.20	<.0001
Emergency department visit						
Any, n (%)	453	48.97	743	25.66	177.08	<.0001
Distribution of visits						

0	472	51.03	2152	74.34	202.60	<.0001
1	224	24.22	432	14.92		
2-3	160	17.30	255	8.81		
4+	69	7.46	56	1.93		
Observational stay						
Any, n (%)	180	19.46	350	12.09	31.86	<.0001
Distribution of visits						
0	745	80.54	2545	87.91	41.73	<.0001
1	114	12.32	263	9.08		
2+	66	7.14	87	3.01		
Non-delivery Inpatient stay						
Any, n (%)	129	13.95	182	6.29	54.99	<.0001
Distribution of visits						
0	796	86.05	2713	93.71	85.94	<.0001
1	95	10.27	170	5.87		
2+	34	3.68	12	0.41		
Length of stay						
Average	5.92	14.61	3.23	4.54	t=-2.34	0.02
Median	3		2		Z=3.459	<0.001

Source: Pregnancy to Early Life Longitudinal (PELL) Data, 2002-2013

Abbreviations: DHH—Deaf or hard of hearing.

Antenatal ED visits

Table 2 presents unadjusted and adjusted RR for ED and non-delivery hospital visits. After adjusting for socio-demographic, and clinical characteristics, DHH women had a 58% higher risk of having an ED visit during pregnancy (RR=1.58; 95% CI, 1.44, 1.73) compared to non-DHH women. Likewise, the DHH women experienced an 89% higher risk of non-delivery based inpatient stays (RR=1.89; 95% CI, 1.58, 2.27) compared to their non-DHH peers. DHH women also had significantly longer duration of hospital stays in terms of average days during hospitalizations (5.92 days vs 3.23; p=0.044).

Table 2: Emergency Department and Hospital Utilization by Deaf and Hard of Hearing (DHH) Status

			Unadjusted		Adjusted ^a		p-value
	DHH	Non-DHH	RR	95%CI	RR	95%CI	
Number of deliveries, n(%)	925 (100)	2,895 (100)					
Number ^a of total ED visits, n(%)	1,061(100)	1,341(100)					
Pregnancies with at least an ED visit, n (%)	453 (48.97)	743(25.66)	1.92	1.75-2.10	1.58	1.44-1.73	<0.001
Number ^a of total non-delivery inpatient/obs stay , n(%)	548 (100)	691 (100)					
Pregnancies with non-delivery inpatient/obs stay, n (%)	309 (33.40)	532 (18.4)	1.71	1.49-1.94	1.89	1.58-2.27	<0.001
Length of stay (average days; SD)	5.92 (14.61)	3.23 (4.54)					0.044

Source: Pregnancy to Early Life Longitudinal (PELL) Data, 2002-2013

Abbreviations: DHH–Deaf or hard of hearing.

^a Adjusted model included the following covariates: maternal age (<20, 20-29, 30-39, 40+ years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Other), language (English, other, unknown), education (<high school, high school, some or more college), marital status (married or married), health insurance (private or public), and father named on the birth certificate (yes/no). Clinical characteristics were also derived from the birth certificate and included smoking during pregnancy, chronic diabetes and chronic hypertension and Adequacy of Prenatal Care Utilization (APNCU) Index. APNCU or Kotelchuck index was categorized as adequate plus – received 110% of expected visits; adequate – 80-109%, intermediate – 50-79%, and inadequate – <50% of expected visits.

Patterns of risk for select health condition categories among those who utilized the ED and inpatient stays during the antenatal period were also examined. The leading diagnoses categories for ED for DHH were complications of pregnancy and childbirths, and diseases of the nervous system and sense organs. For the non-DHH women, the leading diagnoses included complications of pregnancy and childbirths as the top condition, and injury and poisoning (see Table 3). The leading diagnoses categories for inpatient stays for both DHH and non-DHH were complications of pregnancy and childbirths, and mental illness (see Table 4).

Table 3: Top Clinical Classifications Listed by ED Visit by Deaf and Hard of Hearing (DHH) Status

Top 10 Clinical Classifications Listed by ED Visit		N	%
DHH	Complications of pregnancy; childbirth; and the puerperium	556	52.40
	Diseases of the nervous system and sense organs	111	10.46
	Symptoms; signs; and ill-defined conditions and factors influencing health status	67	6.31
	Diseases of the respiratory system	65	6.13
	Injury and poisoning	65	6.13
	Mental illness	39	3.68
	Diseases of the digestive system	37	3.49
	Diseases of the genitourinary system	28	2.64
	Diseases of the musculoskeletal system and connective tissue	26	2.45
	Diseases of the circulatory system	17	1.60
Non-DHH	Complications of pregnancy; childbirth; and the puerperium	775	57.79
	Injury and poisoning	113	8.43
	Symptoms; signs; and ill-defined conditions and factors influencing health status	97	7.23
	Diseases of the respiratory system	87	6.49
	Diseases of the digestive system	53	3.95
	Diseases of the genitourinary system	50	3.73
	Diseases of the nervous system and sense organs	49	3.65
	Diseases of the musculoskeletal system and connective tissue	27	2.01
	Diseases of the circulatory system	21	1.57
	Diseases of the skin and subcutaneous tissue	21	1.57

Source: Pregnancy to Early Life Longitudinal (PELL) Data, 2002-2013

Abbreviations: DHH–Deaf or hard of hearing.

Table 4: Top 5 Clinical Classifications by Hospital/Observational Stay by Deaf and Hard of Hearing (DHH) Status

Top 5 CCS in Hospital/Observational room stay		N	%
DHH	Complications of pregnancy; childbirth; and the puerperium (CCS11)	489	89.23
	Mental illness (CCS5)	18	3.28
	Injury and poisoning (CCS16)	<11	NR
	Diseases of the respiratory system (CCS8)	<11	NR
	Diseases of the blood and blood-forming organs (CCS17)	<11	NR
Non-DHH	Complications of pregnancy; childbirth; and the puerperium (CCS11)	659	95.37
	Mental illness (CCS5)	12	1.74
	Injury and poisoning (CCS16)	<11	NR
	Symptoms; signs; and ill-defined conditions and factors influencing health status (CCS17)	<11	NR
	Diseases of the digestive system (CCS9)	<11	NR

Source: Pregnancy to Early Life Longitudinal (PELL) Data, 2002-2013

Abbreviations: DHH—Deaf or hard of hearing.

Discussion

Principal Findings

This study offers the first examination of antenatal ED and hospital use among DHH women in the U.S. using population-based, longitudinally linked, administrative data. As hypothesized, DHH women were significantly more likely to experience higher rates of antenatal non-delivery-based ED and inpatient visits compared to non-DHH women. The results are consistent with multiple DHH related healthcare utilization studies among the general population of DHH using both claims and non-claims based [17,18,30]. DHH women in this study were more racially and ethnically diverse and with lower social economic status than their non-DHH matched peers. Even after controlling for prenatal care utilization, DHH women were at an increased risk for antenatal ED visits and hospital stays. Similar to what has been shown for women with other types of disabilities [26,31], the Kotelchuck index, based on the quantity and the timing of prenatal care visits, may fail to capture the adequacy of the prenatal visits for DHH women. For example, the Kotelchuck index does not account for the components, comprehensiveness, accessibility, nor quality of the prenatal care. The index likely doesn't reflect the communication needs of DHH women, and whether they were met during the prenatal care appointments, or the quality of their interaction, which may have significant effects on their compliance with treatment, health and wellbeing, and hospital use.

Breakdowns in language and healthcare communication may drive higher rates of ED use and inpatient hospital utilization. This may also reflect issues with communication accessibility and provider-patient relationship quality. DHH women in the study were less likely to report English as a native language. While it is unknown which language was primarily used, it is likely that some of these women communicated primarily in sign language. Communication accessibility unfortunately remains infrequent and inconsistent in healthcare despite the passage of the Americans with Disabilities Act over 30 years ago. One study highlighted that among Deaf signers, only 17% of their primary care appointments were attended by a sign language interpreter [32]. This resulted in both lower willingness of Deaf signers to see their primary care providers and higher rates of medication errors. In contrast, ED are viewed as a location in which obtaining a sign language interpreter is easier and more reliable [30].

Even for DHH individuals who communicate in English, communication breakdowns often occur in the hospital setting and this has resulted in higher rates of hospital and ED visits as well as associated readmissions [8]. Health care providers rarely screen patients for hearing loss and if positive, often lack training on how to effectively communicate with DHH patients. This is combined with the fact that DHH individuals are at higher risk for inadequate health literacy, including poor navigational literacy [30,33]. DHH individuals struggle with reduced fund of knowledge across a variety of health topics [30,34-38]. This knowledge gap may reduce the ability for DHH women to appropriately understand signs of false labor, complications of pregnancy and how to effectively seek care.

Health burdens, including the presence of diabetes and hypertension, along with risky behavior such as tobacco use during pregnancy, were higher among DHH women [7]. This parallels other work that demonstrated higher health burdens among older DHH adults [18,39-45]. The mechanism remains unclear. Due to the younger age of this cohort, it is less likely that hearing loss is simply secondary to metabolic and

microvascular pathophysiology that damages the hearing apparatus. There may be other bio-behavioral factors driving the increased need for inpatient and emergency department services. For example, it is likely that a high proportion of the DHH women in this study likely have congenital or early age onset of hearing loss. The etiology of congenital hearing loss shifted largely from an infectious cause to genetic and prematurity related sequelae [46,47] yet little is known how these affect their clinical correlates or phenotypes. DHH individuals also have demonstrated higher risk for tobacco and substance use disorders [48,49], possibly due to inaccessible public service announcements on the dangers of these substances, lower overall self-esteem, and higher rates of mental health disorders [49-51]. These risk factors exert powerful adverse influences on pregnancy and birth health.

There may be other drivers such as long-standing stressors and higher rates of mental health disorders that may influence their inpatient and ED use. Mental health conditions were associated with a significantly higher proportion of DHH women's ED visits in contrast to non-DHH women. Secondary analysis using the above data demonstrated that DHH women were 2 times more likely than their non-DHH peers to have mental health listed as a leading diagnosis for ED (OR 2.10; 95% CI 1.02-4.32). For hospital stays, this was not significant despite a similar trend (OR 2.00; 95% CI 0.72-5.60). DHH individuals, similar to people with other types of disabilities, experience higher rates of stress, depression, anxiety, and interpersonal violence, factors that may impact pregnancy outcomes [51-54]. These factors, along with poor mental health, significantly elevate the risk of low birth weight and preterm birth along with their need for inpatient services [55]. Additionally, DHH women were less likely to have a spouse, which can lead to reduced social and interpersonal support for them during their pregnancy [56-61].

Strengths and Limitations

To our knowledge, this is the first study of antenatal hospital utilization among DHH women. While the use of a longitudinal, linked, population-based dataset to identify DHH women is a notable strength, several limitations remain. First, there was no process of clinical and audiometric corroboration of the DHH codes. Most health care providers default to "Hearing Loss, Not Otherwise Specified (NOS)" (nearly 76% of women who were classified as such in the DHH sample) rather than select specific hearing loss codes. This may simply be reflective of health care providers noting the presence of the hearing loss that were sufficient to make a general diagnosis, but unsure of a specific hearing loss diagnosis, including its etiology or laterality. Coding rules specify that only diagnoses actively managed or treated (including those that affect health care delivery or communication) should be listed, it is possible that not all DHH women were identified and is likely an underestimate. Secondly, there was no way to ascertain the hearing loss severity and their communication preferences (e.g. ASL) based on the ICD-9 codes. However, multiple studies have also used similar ICD-9-CM codes to identify DHH status [7,17,62]. Thirdly, the dataset lacks the ability to determine the quality or how healthcare communication took place. Lastly, the dataset is representative for the women in Massachusetts, it may not be generalizable to women residing in other states.

Conclusions

The study findings demonstrate that DHH women during the antenatal period use the ED and inpatient services significantly more often than their hearing peers. This underscores the need for a systematic investigation of the mechanisms for this, including healthcare-, patient- and provider-based factors. The health care disparities also highlight the need to ensure effective and accessible health care communication as well as find novel ways to provide clinical support during the antenatal period for DHH women. Due to significantly higher health care use and documented risk for adverse pregnancy and birth outcomes, clinicians should closely monitor DHH women to identify addressable risk factors in an effort to help reduce their disparities. Further work is needed to help develop effective and evidence-based clinical and policy interventions to improve DHH women's pregnancy and birth outcomes as well as reduce reliance on ED and hospital services for non-delivery related causes.

Abbreviations

DHH: deaf and hard of hearing

ED: emergency department

CCS: Clinical Classification Software

OR: odds ratio

RR: risk ratio

GEEs: Generalized Estimating Equations

APNCU: Adequacy of Prenatal Care Utilization

ICD-9 CM: International Classification of Diseases and Related Health Problems 9th Revision

Declarations

Ethics approval and consent to participate

The study was approved and deemed exempt under exemption category 4 by the Brandeis University IRB, protocol number 17135R-E. The original approval was issued on June 22, 2017. It was considered exempt under Category 4 of the federal regulations since the study involves analysis of secondary data and the research was conducted in a manner that the resulting dataset does not include identifiable information. Additionally, as per guidance with the use of PELL data user agreement, we did not display any frequencies less than 12 to further ensure confidentiality. All ethical guidelines according to the Declarations of Helsinki were otherwise followed.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MMM and MM provided the study conceptualization. MMM, MM, JZ, KM and IA analyzed and interpreted the data. MMM was a major contributor in writing the manuscript. All authors interpreted the findings and contributed to writing the manuscript, as well as reading and approving the final manuscript.

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