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ORIGINAL RESEARCH

Exploring the Interplay of Diabetes, Deaf Patient Reported Outcomes, and Cancer Screening in Deaf and Hard of Hearing Women

Emmanuel Perrodin-Njoku[1], Sowmya R Rao[2], Regina M Wang[3], Christopher J Moreland[4], Poorna Kushalnagar[1]

[1]Center for Deaf Health Equity, Gallaudet University, Washington, DC, USA; [2]Department of Global Health, Boston University School of Public Health, Boston, MA, USA; [3]Family Medicine and Public Health, University of California San Diego, San Diego, CA, USA; [4]Dell Medical School, University of Texas at Austin, Austin, TX, USA

Correspondence: Poorna Kushalnagar, Gallaudet University, 800 Florida Avenue NE, Hall Memorial Building, Washington, DC, 20002, USA, Email poorna.kushalnagar@gallaudet.edu

Purpose: Some deaf and hard-of-hearing (DHH) individuals face health information barriers, increasing their risk of diabetes mellitus (DM) and subsequent cancer development. This study examines if health-related quality of life (HRQoL) and deaf patient-reported outcomes (DHH-QoL) mediate the relationship between DM diagnosis and cancer screening adherence among DHH individuals.

Patients and Methods: In a cross-sectional study, US DHH adults assigned female at birth answered questions on cervical and breast cancer screenings from the ASL-English bilingual Health Information National Trends Survey (HINTS-ASL) and the PROMIS (Patient Reported Outcome Measurement Information System) Deaf Profile measure's Communication Health and Global Health domains. Odds ratios (OR) and 95% confidence intervals (CI) were obtained from multivariable logistic and linear regression models, examining the association between DM, DHH-QoL, and cancer screening adherence, adjusting for other covariates and HRQoL. A Baron and Kenny causal mediation analysis was used. A two-sided $p < 0.05$ indicated significance.

Results: Most respondents were White (66.4%), heterosexual (66.2%), did not have DM (83.9%), had health insurance (95.5%), and adhered to pap smears (75.7%) and mammograms (76.9%). The average (standard deviation) DHH-QoL score was 50.9 (8.6). Those with DM had lower HRQoL scores (46.2 (9.5) vs 50.2 (8.8); $p < 0.0001$) than those without. Non-significant multivariable models indicate that those with DM were more adherent to pap testing (OR: 1.48; 95% CI: 0.72, 3.03; $p = 0.285$) and mammograms (2.18; 95% CI: 0.81, 5.88; $p = 0.122$), with DHH-QoL scores slightly increasing them to 1.53 (0.74, 3.16; $p = 0.250$) for pap testing and 2.55 (0.91, 7.13; $p = 0.076$) for mammograms. DHH-QoL was significantly associated with mammograms ($p = 0.027$), with 6% increased adherence per unit increase in the score. Overall, HRQoL and DHH-QoL were not significant mediators.

Conclusion: While HRQoL/DHH-QoL in DHH individuals with DM does not mediate cancer screening adherence, higher DHH-QoL scores are associated with it. DHH-focused health literacy and communication training can improve cancer-related outcomes.

Keywords: deaf, cancer screening, sign language, hearing loss, diabetes

Introduction

In the United States, diabetes mellitus (DM) is a significant public health concern, affecting 11.3% of the US population (37.3 million people), including both diagnosed and undiagnosed individuals.[1] Individuals with DM are at increased risk for comorbidities, leading to higher health care costs, lower quality of life, and increased mortality risk. Rates of DM are rising concurrently with rates of some cancers, supporting the long-standing hypothesis about a direct relationship between DM and cancer.[2] Several studies suggest that DM in particular, uncontrolled DM, may be causally associated with colorectal cancer, and potentially with other cancer types.[3–7] Also, several studies have quantified DM control as a predictor of cancer screening rates. Specifically, patients with high hemoglobin A1C measurements were less likely to have been screened for colorectal cancer, and women with DM are less likely to have received guideline-concordant

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breast or cervical cancer screenings.[8–12] Since people with uncontrolled DM are less likely to undergo recommended cancer screenings, increasing cancer screening rates should be a priority in caring for patients with DM.

Even though the association between DM and cancer screening is not consistent after adjusting for factors known to be associated with diabetes and healthcare access, it is important for individuals with DM to adhere to recommended cancer screenings.[3,13,14] Furthermore, people with DM may face other barriers to managing their health, including health literacy, beliefs, financial resources, social support, culture, and language.[15,16]

For American Sign Language-using (ASL) deaf and hard-of-hearing (DHH) community members who are diagnosed with diabetes, access to incidental information plays a significant role in shaping health beliefs and health literacy.[17] Being well-informed increases the effectiveness of DM self-management. In addition, perceived health-related quality of life in general and specific to being DHH (HRQoL and DHH-QoL) can be distinct in people with intersecting identities.[18] Generic health measures for quality of life typically assess global, physical, social and emotional dimensions of health. On the other hand, deaf- or disease-specific measures are sensitive and can capture subtle changes that are specific to being DHH. For example, a DHH person may perceive their generic HRQoL as good, however this person may simultaneously perceive their DHH-specific QoL to be low, impacting DM self-management. Multiple studies have shown a higher incidence of DM among DHH people compared to the general population.[19–23] Of particular importance, some subsets within the DHH community have been found to have increased likelihood of being diagnosed with diabetes compared to counterparts: Black DHH adults compared to hearing Black adults; DHH adults who report high frequency of experiencing language deprivation as a form of an adverse childhood communication experience (ACCE) while growing up compared to DHH adults who did not often experience ACCEs; and mid-to-older DHH adults identifying as members of the LGBTQ+ (lesbian, gay, bisexual, transgender, and queer) community compared to DHH adults who self-identify as straight.[19,24,25]

Literature identifies people who are African American/Black, Hispanic, American Indian/Alaska Native, and some Asian Americans/Pacific Islanders as having a greater risk of developing type 2 diabetes mellitus, as well as an increased risk of obesity and hypertension. For instance, a Black DHH individual might be at a greater risk than a white hearing person of being diagnosed with both hypertension and diabetes.[19,26] Within the DHH community, the intersection of their lived experience with hearing loss, in the context of other identities, places DHH people at higher risk for DM and other chronic conditions.

To better understand the effect of decreased cancer screening rates among DHH people at risk for health care disparities, patient reported outcomes specific to being DHH should also be assessed. Some DHH people experience repeated information deprivation due to living in societal contexts that prioritize English- and sound-based access to health-related information. As described by Kushalnagar et al (2020), language deprivation occurs when a DHH person lacks consistent access to direct communication (such as from parents or primary caregivers). Even if the DHH person has consistent access to direct communication with a parent or caregiver, the same DHH person may be repeatedly deprived of access to incidental information (such as hearing family members discussing healthcare issues with one another) and experience ACCEs as a result.[24] Severe ACCEs further perpetuate a DHH person's barriers to attaining high health literacy, which is essential for effective self-risk analysis and self-management of one's health care.[27]

Increased access to health information, including incidental/indirect information in ASL, has often been recommended as an approach to help DHH people improve their overall health knowledge and reduce disparities in cancer screening.[19,27–34] While there is a known association between DM and cancer screening rates, the relationships among DM diagnosis, cancer screening adherence, quality of life and patient reported outcomes specific to being DHH have not yet been explored.

In this study, we explored whether the DHH-QoL and HRQoL scores from the PROMIS-Deaf Communication Health and Global Health domains mediated the relationship between DM diagnosis and cancer screening adherence. We hypothesized that low perceived DHH-QoL scores (mediator) may mediate the relationship between DM (predictor) and cancer screening adherence (outcome) after adjusting for HRQoL. If a person with DM perceives both their health-related quality of life and their DHH-specific quality of life to be high, then this person may demonstrate increased cancer screening adherent behaviors.

Materials and Methods

Study Design and Survey Questionnaire

The institutional review board at Gallaudet University approved this study, which complies with the principles set forth in the Declaration of Helsinki regarding human subjects involved in medical research. In a cross-sectional study, DHH adults in the United States answered a set of demographic, health-indicator, cancer perception/knowledge, lifetime diabetes diagnosis, and cancer screening questions that were drawn from an American Sign Language (ASL)-English bilingual version of National Cancer Institute's Health Information National Trends Survey (https://hints.cancer.gov/; HINTS-ASL – see Kushalnagar et al, 2017, for more information).[35]

Participants' perceived quality of life specific to being DHH were assessed using the Communication Health domain of the Patient Reported Outcomes Measurement Information System (PROMIS) Deaf Profile measure (see Kushalnagar et al 2020, for details on translation and standardization for DHH-QoL).[18] PROMIS Global Health domain was used to assess a person's perceived general health-related quality of life (see Kushalnagar et al, 2014 for HRQoL).[36]

Recruitment Procedure

After the Gallaudet University Institutional Review Board approved the study procedures, between 2015 and 2023, research staff recruited through national channels, targeting DHH community adults (ages 18 and older) who use ASL. Several approaches were used for recruiting DHH signers across the USA, including Hawaii and Alaska: personal networks, distributing flyers, and advertising on deaf-centered organization websites and e-newsletters. Communication between the research staff and participants occurred through email, social media, and videophone communication.

Research staff provided prospective participants with an information flyer, discussed the study purpose and procedures, reviewed inclusion and exclusion criteria, and answered any questions they might have had to determine eligibility and interest. Individuals who self-reported that they used ASL as their primary language were included in the study.

Individuals who were 17 years old or younger, as well as those who had unilateral hearing loss, were excluded. Participants provided signed informed consent before entering the study. The survey took up to one hour to complete. No names or identifying information were collected as part of this online survey. Each participant received a cash gratuity for participating in the study.

Statistical Analyses

All analyses with complete data were conducted in SAS 9.4 (SAS Institute, Cary, NC, USA) and a two-sided $p < 0.05$ was considered significant.

Data from respondents in the HINTS-ASL primary dataset from 10/21/2015 to 12/19/2019 were used in this analysis. Summary statistics (proportions, means, standard deviations (SD)) were obtained for all characteristics by cancer screening adherence (Yes/No), defined as whether they received cancer screening according to the United States Preventive Services Task Force guidelines for breast and cervical cancer or not when they took the survey.[37] Significance of the differences in the distributions of the characteristics between the groups were tested with chi-square or Fisher's exact test (categorical variables) or the *t*-test (continuous variables). Analysis of the association of characteristics and DM with cancer screening was restricted to those assigned as females at birth.

Adjusted odds ratios (OR) and 95% confidence intervals (CI) were obtained from separate multivariable logistic regression models assessing the relationship of DM with breast or cervical cancer screening adherence adjusting for other covariates with and without HRQoL and DHH-QoL scores. Additionally, separate general linear regression models were applied to assess the relationship of DM with DHH-QoL score and HRQoL score adjusting for other covariates.

Further, the percentage mediated by DHH-QoL and the percentage mediated due to the interaction between DM and DHH-QoL was obtained from a Baron and Kenny causal mediation analysis to assess whether DHH-QoL is a mediator of the relationship between DM and cancer screening adherence, and other covariates. Bootstrap confidence intervals were obtained for the effects. Regressions adjusted for race (White, Non-White), age (continuous), education (high school, some college, college graduate), BMI (Underweight/Normal, Overweight/Obese), and regular clinician/provider (No, Yes). A similar analysis was conducted to test whether HRQoL was a mediator.

Sensitivity Analysis

There was <9% missing data for the covariates. However, 36% and 48% of age-eligible women were missing information on Pap and Mammograms. So, we conducted a sensitivity analysis by creating 30 datasets with multiply imputing for the missing data using PROC MI and conducted the multivariable logistic regressions described above on each of the 30 datasets. We combined the results from these 30 regressions using PROC MIANALYZE. The p-values were obtained from the data sets by pooling the chi-square statistics from the 30 imputed datasets using the procedure described in Li et al (1991).[38]

Results

Table 1 shows the majority of respondents were female (58.5%), White (66.4%), heterosexual (66.2%), overweight or obese [63.2%; mean (SD) BMI: 27.9 (6.5)], had a regular clinician provider (60.5%) and health insurance (95.5%), and did not have diabetes (83.9%). More than half (63.5%) of the respondents were less than 50 years of age [mean (SD): 43.6 (17.5)]. Most female respondents were adherent to age-eligible pap testing within 3 years (75.7%) and mammograms within 2 years (76.9%). The average (SD) Communication Health Score (CHS) was 50.9 (8.6).

Results of the bivariate analysis of characteristics with DM status shown in Table 2 indicate that sex at birth, race and health insurance status were not significantly associated with diabetes diagnosis. Lower education (HS: 23.8% vs Non-HS: 14.0%; p =

Table 1 Distribution of the Characteristics of 810 Female Respondents[a]

Characteristics	N (Col%)
Age	
18–34	292 (36.0)
35–49	211 (26.0)
50–64	181 (22.3)
65–74	85 (10.5)
75+	41 (5.1)
Race	
White	535 (66.0)
African-America/Black	74 (9.1)
Asian/Other	88 (10.9)
Hispanic	107 (13.2)
Missing	6 (0.7)
Education	
HS	161 (19.9)
Some college	158 (19.5)
College graduate	491 (60.6)
Sexual orientation	
Straight	530 (65.4)
LGBTQA+	254 (31.4)
Missing	26 (3.2)

(*Continued*)

Table 1 (Continued).

Characteristics	N (Col%)
BMI	
Underweight/Normal	305 (37.7)
Overweight/Obese	497 (61.4)
Missing	8 (1.0)
Have regular provider	
No	279 (34.4)
Yes	462 (57.0)
Missing	69 (8.5)
Have health insurance	
No	21 (2.6)
Yes	787 (97.2)
Missing	2 (0.2)
Diabetes	
No	672 (83.0)
Yes	138 (17.0)
Age-eligible PAP test within 3 years[b]	
Not adherent	103 (15.6)
Adherent	321 (48.7)
Missing	235 (35.7)
Age-eligible mammogram within 2 years[b]	
Not adherent	40 (12.0)
Adherent	133 (39.8)
Missing	161 (48.2)
	N[a]; **Mean (SD**[c])
Age in years	810; 44.2 (17.3)
BMI	802; 28.3 (7.1)
DHH-QoL Score	
PROMIS-Deaf Profile Communication Health	810; 51.0 (8.6)
PROMIS-Deaf Global Health	801; 48.8 (8.6)

Notes: [a]Do not add up to the total due to missing observations. [b]Distribution among those assigned as females at birth with information on cancer screening. [c]Standard Deviation.
Abbreviations: DHH-QoL, Deaf and Hard of Hearing Quality of Life; PROMIS, Patient Reported Outcome Measurement System.

0.013), LGBTQA+ identity (12.6% vs Straight: 17.4%; p = 0.023), higher BMI (20.6% vs lower BMI: 8.5%; P < 0.0001), and having a regular clinician (16.3% vs lack of a regular provider: 11.0%; p < 0.01) are all significantly associated with having DM. Additionally, on average (SD) higher age [DM: 52.3 (16.5) vs No DM: 41.7 (17.0); p < 0.0001], higher BMI [31.7 (8.00 vs 27.2

Table 2 Distribution of Characteristics by Diabetes Status Among 810 Female[a] Respondents

Characteristics	Diabetes		
	No (N=672)	Yes (N=138)	P Value[b]
	N (Row%)		
Race			0.667
White	441 (82.4)	94 (17.6)	
Non-White	225 (83.6)	44 (16.4)	
Missing	6 (100.0)	0 (0.0)	
Education			<0.0001
HS/Some college	242 (75.9)	77 (24.1)	
College graduate	430 (87.6)	61 (12.4)	
Sexual orientation			<0.01
Straight	426 (80.4)	104 (19.6)	
LGBTQA+	226 (89.0)	28 (11.0)	
Missing	20 (76.9)	6 (23.1)	
BMI			<0.0001
Underweight/Normal	279 (91.5)	26 (8.5)	
Overweight/Obese	385 (77.5)	112 (22.5)	
Have regular provider			0.084
No	245 (87.8)	34 (12.2)	
Yes	384 (83.1)	78 (16.9)	
Missing	43 (62.3)	26 (37.7)	
Have health insurance			0.351
No	19 (90.5)	2 (9.5)	
Yes	651 (82.7)	136 (17.3)	
Missing	2 (100.0)	0 (0.0)	
	N[a]; Mean (Standard Deviation)		
Age in years	672; 42.3 (16.8)	138; 53.6 (16.3)	<0.0001
BMI	664; 27.5 (6.4)	138; 32.2 (8.6)	<0.0001
DHH-QoL Score			
PROMIS-Deaf Profile Communication Health	672; 51.3 (8.5)	138; 49.1 (8.7)	<0.01
PROMIS-Deaf Global Health	667; 49.4 (8.5)	134; 45.7 (8.4)	<0.0001

Notes: [a]Do not add up to the total due to missing observations. [b]Based on a two-sided Chi-Square test (categorical variables) or *T*-test (continuous variables). Excludes missing values in the calculations.
Abbreviations: DHH-QoL: Deaf and Hard of Hearing Quality of Life; PROMIS: Patient Reported Outcome Measurement System.

(5.9); p < 0.0001], lower PROMIS Communication Health T-scores [49.4 (9.0) vs 51.2 (8.4); p < 0.01] and lower PROMIS Global Health scores [46.2 (9.5) vs 50.2 (8.8); p < 0.0001] are significantly associated.

Results of the bivariate analysis shown in Table 3 indicate that only sexual orientation (Straight: 81.4% vs LGBTQA+: 68.8%; p < 0.01) was associated with pap testing. The magnitude of the difference in pap testing among the categories of other characteristics was not large enough to be statistically significant. Possibly due to small sample sizes, none of the characteristics were associated with having a mammogram, although there was some difference in the proportion across the categories of the various characteristics.

Table 4 displays the odds ratios and 95% confidence intervals from multivariable logistic regressions evaluating the association of DM with age-eligible cancer screenings adjusting for other variables. Two regressions for each cancer screening were performed with and without DHH-QoL in the model. Those with DM had non-significantly higher odds of adherence to age-eligible pap testing (1.48; 95% CI: 0.72,3.03; p = 0.285) and mammogram testing (2.18; 95% CI:

Table 3 Distribution of Characteristics by Age-Eligible Screenings Among 810 Female Respondents[a]

Characteristics	Age-eligible PAP test within 3 years (N=424)			Age-eligible Mammogram within 2 years (N=173)		
	Not adherent (N=103)	Adherent (N=321)	P Value[b]	Not adherent (N=40)	Adherent (N=133)	P Value[b]
	N[a] (Row%)			N[a] (Row%)		
Race			0.907			0.156
White	65 (24.8)	197 (75.2)		33 (26.2)	93 (73.8)	
Nonwhite	38 (23.9)	121 (76.1)		7 (15.2)	39 (84.8)	
Missing	0 (0.0)	3 (100.0)		0 (0.0)	1 (100.0)	
Education			0.461			0.577
HS/Some college	35 (26.9)	95 (73.1)		13 (20.3)	51 (79.7)	
College graduate	68 (23.1)	226 (76.9)		27 (24.8)	82 (75.2)	
Sexual orientation			<0.01			0.165
Straight	43 (18.6)	188 (81.4)		25 (20.3)	98 (79.7)	
LGBTQA+	60 (31.3)	132 (68.8)		15 (30.6)	34 (69.4)	
Missing	0 (0.0)	1 (100.0)		0 (0.0)	1 (100.0)	
BMI			0.298			0.326
Underweight/Normal	36 (21.6)	131 (78.4)		9 (17.6)	42 (82.4)	
Overweight/Obese	67 (26.3)	188 (73.7)		30 (25.0)	90 (75.0)	
Missing	0 (0.0)	2 (100.0)		1 (50.0)	1 (50.0)	
Have regular provider			0.174			0.855
No	54 (27.4)	143 (72.6)		15 (22.1)	53 (77.9)	
Yes	49 (21.6)	178 (78.4)		25 (23.8)	80 (76.2)	
Have health insurance			0.079			1.000
No	6 (50.0)	6 (50.0)		1 (16.7)	5 (83.3)	
Yes	97 (23.5)	315 (76.5)		39 (23.4)	128 (76.6)	

(*Continued*)

Table 3 (Continued).

Characteristics	Age-eligible PAP test within 3 years (N=424)			Age-eligible Mammogram within 2 years (N=173)		
	Not adherent (N=103)	Adherent (N=321)	P Value[b]	Not adherent (N=40)	Adherent (N=133)	P Value[b]
	N[a] (Row%)			N[a] (Row%)		
Diabetes			0.328			0.068
No	92 (25.2)	273 (74.8)		34 (26.8)	93 (73.2)	
Yes	11 (18.6)	48 (81.4)		6 (13.0)	40 (87.0)	
	N[a]; Mean (SD)			N[a]; Mean (SD)		
Age in years	102; 37.1 (13.0)	319; 38.7 (11.9)	0.252	40; 54.5 (7.0)	131; 56.8 (7.9)	0.102
BMI	102; 28.4 (7.6)	317; 28.0 (7.3)	0.643	39; 30.8 (8.0)	130; 28.7 (6.3)	0.098
DHH-QoL Score						
PROMIS-Deaf Profile Communication Health	102; 50.7 (8.4)	319; 51.4 (8.1)	0.430	40; 48.5 (7.3)	131; 51.2 (8.9)	0.074
PROMIS-Deaf Global Health	101; 48.8 (8.1)	318; 48.9 (8.7)	0.874	39; 48.1 (7.8)	131; 48.2 (8.4)	0.939

Notes: [a]Only among females who reported information on the cancer screenings. [b]Based on a two-sided Fishers Exact test or *T*-test. Excludes missing values in the calculations.

Abbreviations: DHH-QoL: Deaf and Hard of Hearing Quality of Life; PROMIS: Patient Reported Outcome Measurement System.

Table 4 Odds Ratios (OR) and 95% Confidence Intervals (CI) from Multivariable Logistic Regressions Evaluating the Association of DM with Age-Eligible Cancer Screening Adherence Adjusting for Other Characteristics[a]

Characteristics	PAP Test Within 3 Years (N=417)		Mammogram Within 2 Years (N=169)	
	Model 1[b]	Model 2[b]	Model 1[b]	Model 2[b]
	OR (95% CI)			
Diabetes (P value)	**0.285**	**0.250**	**0.122**	**0.076**
No	Ref.	Ref.	Ref.	Ref.
Yes	1.48 (0.72,3.03)	1.53 (0.74, 3.16)	2.18 (0.81, 5.88)	2.55 (0.91, 7.13)
Race (P value)	**0.475**	**0.431**	**0.126**	**0.127**
White	Ref.	Ref.	Ref.	Ref.
Non-white	1.19 (0.74, 1.92)	1.21 (0.75, 1.96)	2.11 (0.81, 5.49)	2.14 (0.81, 5.69)
Education (P value)	**0.381**	**0.496**	**0.859**	**0.658**
HS/Some college	Ref.	Ref.	Ref.	Ref.
College graduate	1.24 (0.76, 2.03)	1.19 (0.72, 1.97)	0.93 (0.41, 2.10)	0.83 (0.36, 1.92)
BMI (P value)	**0.188**	**0.238**	**0.131**	**0.175**
Underweight/Normal	Ref.	Ref.	Ref.	Ref.
Overweight/Obese	0.73 (0.45, 1.17)	0.75 (0.46, 1.21)	0.51 (0.22, 1.22)	0.54 (0.22,1.32)

(*Continued*)

Table 4 (Continued).

Characteristics	PAP Test Within 3 Years (N=417)		Mammogram Within 2 Years (N=169)	
	Model 1[b]	Model 2 [b]	Model 1 [b]	Model 2 [b]
	OR (95% CI)			
Have regular provider (P value)	**0.322**	**0.320**	**0.704**	**0.759**
No	Ref.	Ref.	Ref.	Ref.
Yes	1.26 (0.80, 1.98)	1.26 (0.80, 1.99)	0.86 (0.39, 1.88)	0.88 (0.39,1.99)
Age (P value)	**0.345**	**0.322**	**0.046**	**0.100**
Age	1.01 (0.99, 1.03)	1.01 (0.99,1.03)	1.06 (1.00, 1.11)	1.05 (0.99,1.11)
PROMIS-Deaf Profile Communication Health **(P value)**		**0.371**		**0.027**
PROMIS-Deaf Profile Communication Health		1.01 (0.98,1.04)		1.06 (1.01,1.11)
PROMIS-Deaf Profile Global Health (**P value**)		**0.988**		**0.588**
PROMIS-Deaf Profile Global Health		1.00 (0.97, 1.03)		0.99 (0.94, 1.04)

Notes: [a]Only among females who reported information on the cancer screenings. [b]Model 1 does not include the QoL scores; Model 2 includes both the QoL scores.
Abbreviations: DHH-QoL: Deaf and Hard of Hearing Quality of Life; PROMIS: Patient Reported Outcome Measurement System.

0.81,5.88; p = 0.122) with DHH-QoL increasing them slightly to 1.53 (0.74,3.16) (p = 0.250) for PAP testing and 2.55 (0.91,7.13) (p = 0.076) for mammograms.

PROMIS-Deaf Profile Communication Health T-scores (DHH-QoL) were only significantly associated with mammograms (p = 0.027), with every unit increase in the score increasing the likelihood of being adherent to mammogram testing by 6%. PROMIS Global Health scores were not significantly associated with either of the cancer screenings.

The results of the sensitivity analysis in Supplemental Table 1 are similar to that based on the complete cases except that the effect of DM was attenuated and the association of DHH-QoL with mammogram was no longer significant although the magnitude of the estimates was similar.

Table 5 displays the beta estimates and 95% confidence intervals from the multivariable linear regression model used to assess the relationship of DM with DHH-QoL and HRQoL scores adjusting for other covariates.

Table 5 Results from Linear Regressions to Assess the Relationship of Diabetes with DHH-QoL and HRQoL Scores Among Females Who Reported Information on the Cancer Screenings

Characteristics	Age-Eligible PAP Test Within 3 Years (N=417)		Age-Eligible Mammogram Within 2 Years (N=169)	
	Beta (95% CI)			
	DHH-QoL Scores	HRQoL Scores	DHH-QoL Scores	HRQoL Scores
Intercept	52.35 (49.33,55.36)	49.77 (46.61,52.94)	43.50 (33.55,53.44)	45.68 (36.46,54.89)
Diabetes (P value)	**0.034**	**0.035**	**<0.01**	**0.032**
No	Ref.		Ref.	Ref.
Yes	−2.40 (−4.62,-0.18)	−2.51 (−4.84,-0.18)	−4.06 (−7.01,-1.10)	−3.01 (−5.74,-0.27)
Race (P value)	**0.124**	**0.964**	**0.505**	**0.152**
White	Ref.		Ref.	Ref.
Non-white	−1.24 (−2.82,0.34)	−0.04 (−1.70,1.62)	−1.01 (−3.99,1.98)	−2.01 (−4.78,0.75)

(*Continued*)

Table 5 (Continued).

Characteristics	Age-Eligible PAP Test Within 3 Years (N=417)		Age-Eligible Mammogram Within 2 Years (N=169)	
	Beta (95% CI)			
Education (P value)	**<0.001**	**<0.01**	**0.050**	**0.361**
HS/Some college	Ref.		Ref.	Ref.
College graduate	3.17 (1.51,4.83)	2.55 (0.81,4.30)	2.72 (−0.00,5.45)	1.17 (−1.35,3.70)
BMI (P value)	**0.013**	**<0.0001**	**0.135**	**<0.01**
Underweight/Normal	Ref.		Ref.	Ref.
Overweight/Obese	−1.98 (−3.55,-0.41)	−3.57 (−5.21,-1.92)	−2.14 (−4.94,0.67)	−4.28 (−6.88,-1.68)
Have regular Provider (P value)	**0.769**	**0.059**	**0.468**	**0.016**
No	Ref.		Ref.	Ref.
Yes	−0.23 (−1.75,1.30)	−1.54 (−3.14,0.06)	−0.96 (−3.58,1.65)	−2.99 (−5.41,-0.56)
Age (P value)	**0.319**	**0.581**	**0.063**	**0.071**
Age	−0.03 (−0.09,0.03)	0.02 (−0.05,0.08)	0.16 (−0.01,0.33)	0.14 (−0.01,0.30)

Compared to respondents without DM, those with DM had lower DHH QoL scores despite adhering to the PAP test [beta (95% CI): −2.49 (−4.71, −0.26); p = 0.029] and mammogram [−4.08 (−7.02,-1.15); p < 0.01] had lower DHH-QoL scores. Results were similar for the global health scores.

On average, those with DM had lower HRQoL scores among those who responded to the PAP test [beta (95% CI): −2.51 (−4.84, −0.18); p = 0.035] and those who responded to the mammogram [−3.01 (−5.74,-0.27); p = 0.032] than those without DM.

Table 6 displays the percentage mediated which is the percent of the DM effect that is attributed to the mediation factors, DHH-QoL and HRQoL, and the percentage mediated due to the interaction, which is the percent of the total DM effect that is due to the interaction between DM and DHH-QoL. None of these are statistically significant, suggesting that in our study, neither DHH-QoL nor HRQoL mediate the relationship between DM and adherence to pap testing or mammograms.

Table 6 Results from the Mediation Analysis of DHH-QoL and HRQoL Scores

Effect	Age-Eligible PAP Test Within 3 Years		Age-Eligible Mammogram Within 2 Years	
	Estimate (95% CI[a])	P value	Estimate (95% CI[a])	P value
DHH-QoL Scores				
Percentage Mediated	−17.70 (−311.01,38.98)	0.523	−60.06 (−273.70,658.14)	0.195
Percentage Due to Interaction	−5.91 (−1380.21,14.69)	0.507	−1.08 (−86.70,93.16)	0.961
HRQoL Scores				
Percentage Mediated	−0.52 (−98.12,103.88)	0.984	−26.74 (−207.63,18.95)	0.421
Percentage Due to Interaction	1.00 (−205.96,83.84)	0.965	−7.49 (−3123.33,26.39)	0.634

Notes: [a]CI: Bootstrap confidence intervals.

Abbreviations: DHH, deaf and hard of hearing; ASL, American Sign Language; DM, diabetes mellitus; QoL, quality of life; HR, health-related; ACCEs, Adverse Childhood Communication Experiences; SD, standard deviation; CI, confidence interval, OR, odds ratio; BMI, body-mass index; PROMIS, Patient Reported Outcome Measurement Information System; HINTS, Health Information National Trends Survey; DHH-QoL, Deaf and Hard of Hearing Quality of Life; HRQoL, Health-Related Quality of Life.

Discussion

Results show that neither perceived quality of life specific to being deaf or hard of hearing nor overall health-related quality of life appears to play a significant mediating role in whether a person with a diabetes diagnosis will be more or less likely to be adherent to age-eligible breast or cervical cancer screening guidelines. However, DHH-specific QoL does play a role in a DHH individual reporting a diabetes diagnosis.

Participants with a diabetes diagnosis may already have a clinician, and the likelihood of receiving reminders for cancer screening is partially dependent on how well the provider communicates with the participant. This can be reflected in patient-centered communication scores, where the extent to which the patient engages in shared decision-making and has access to information can be measured. If a DHH individual feels involved in discussions with their doctor about their healthcare, they are more likely to have opportunities to be asked about being screened for cancer and understand the importance of the screenings. This patient- and provider-level factor might help elucidate the role of cancer screening disparities among women with DM.[11]

The significant association of DHH-specific QoL with mammogram testing in the regression model might be due to the ubiquity of breast cancer awareness campaigns, which could make DHH individuals more amenable to breast cancer screenings. They might perceive breast cancer screening as part of a healthy lifestyle, one that can help maintain their quality of life. Breast cancer awareness is prevalent within the DHH community, from personal experiences with the cancer to knowledge of support groups for DHH people with breast cancer. The level of access to discourse surrounding breast cancer and its diagnosis, treatment, and awareness could explain why those participants with DM who have higher perceived DHH-specific QoL, which includes access to information, are more likely to receive mammogram testing. This association might provide further context to the finding in a previous study that DHH women experienced only a slight disparity in mammogram adherence, compared to hearing women.[30]

Pap testing is only significantly associated with LGBTQ+ identity among our DHH participants, with those identifying as LGBTQ+ having lower rates of pap testing compared to heterosexual participants. This finding parallels with previous research suggesting that members of the DHH LGBTQ+ community often do not disclose their sexual orientation and gender identity to their clinicians, owing to anti-LGBTQ+ stigma and limited cultural and linguistic competency.[39] To elicit disclosure of sexual and gender identities to aid with tailored health care, LGBTQ+ patients could benefit from more frequent, comprehensive, or uniquely tailored health care services. This reinforces the need to improve communication between clinicians and DHH LGBTQ+ populations. For example, those who have a cervix in the DHH LGBTQ+ community should be encouraged by their clinicians to follow-up for their pap smear when due.

Future Directions

The findings in this paper raise important questions that deserve further investigations with a larger, education-diverse sample. The potential relationships between communication-related quality of life and health correlates (eg, health literacy and coping behaviors), adjusting for education, can inform future program development and implementation for DHH people who are at risk for not adhering to recommended cancer screenings. Studies have shown higher rates of depression/anxiety that impact health-related outcomes among DHH adult populations, and more so in historically marginalized subgroups such as the LGBTQ+ community.[25,39] Given the relationship between the communication neglect construct of adverse childhood communication experiences (ACCEs) and adulthood depression/anxiety diagnoses, there might be other mediating factors to consider and this needs to be studied.[24] This is in addition to the contributory role of language deprivation in low health literacy, which can tie to a host of poor health outcomes and behaviors. All are topics that deserve exploration in future studies looking into pathway mechanisms for the role of perceived DHH-specific quality of life in driving health behavior and decision-making processes.

Conclusion

Our study results indicate that as the DHH-specific QoL scores increase, the probability of breast cancer screening adherence increases. Contrary to our hypothesis, DHH-QoL did not mediate breast or cervical cancer screening adherence among DHH women with DM. The lack of mediating effect is likely to be tempered by a study limitation in which highly educated respondents also had high adherence to their screenings, along with lower rates of DM and a regular provider. Having high DHH-specific QoL allows for more positive engagement from DHH people with the

health care system.[40] In order to increase health outcomes, it is important to ensure improved communication access for DHH people in the health care system, as well as increase the availability of health information in ASL, promote health literacy in this community, grow a DHH culturally competent physician pool, and train community health workers or navigators who can empower DHH people to make informed choices about their health.[41,42]

A study limitation that may explain the lack of association between perceived DHH-specific QoL and health-related QoL (predictors) and cancer screening adherence (outcome) is the higher proportion of adherent respondents who are also college educated, have lower rates of DM, and report having a provider that they see regularly. Future studies that include a higher number of individuals without a college degree in the study sample may shed new light on the relationship between the variables of interest.

Our study has other limitations. Our self-selected sample is limited to DHH participants who had access to the internet or cellular service that supported video conference interviews and taking online surveys; the sample did not include DHH individuals without such resources (eg, unhoused, uninsured) who are likely at even greater risk for inequitable access to health care. Our sample is also limited to DHH participants who have sufficient ability to independently utilize technology and comprehend the questions asked in the survey.

However, the study also has strengths, in the nation-wide scale of the recruitment and response from DHH community members, as well as the varied modalities of engagement (videophone interviews, online surveys, face-to-face interviews). The bilingual, bimodal nature of the survey also strengthened its reach in the DHH community.

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Disclosure

The authors report no conflicts of interest in this work.

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