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Authors

Feier, Joel S
Lin, Matthew E
Awad, Matthew
[et al.](#)

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Social Media Perspectives on Over-The-Counter Hearing Aids: Sentiment and Thematic Analysis of Twitter (X) Data

Joel S. Feier¹  | Matthew E. Lin²  | Matthew Awad³ | Aman M. Patel⁴  | Cindy Vu¹ | John C. Parsons⁵ | Margaret Wallhagen⁶ | Janet S. Choi⁵

¹Department of Otolaryngology-Head & Neck Surgery, University of California, Irvine, Orange, California, USA | ²Department of Head and Neck Surgery, University of California, Los Angeles, Los Angeles, California, USA | ³University of Minnesota Medical School, University of Minnesota Twin-Cities, Minneapolis, Minnesota, USA | ⁴Rutgers New Jersey Medical School, Newark, New Jersey, USA | ⁵Caruso Department of Otolaryngology-Head and Neck Surgery, Keck School of Medicine of the University of Southern California, Los Angeles, California, USA | ⁶University of California, San Francisco School of Nursing, San Francisco, California, USA

Correspondence: Janet S. Choi (janet.choi@med.usc.edu)

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ABSTRACT

Objective: To assess public perspective on over-the-counter (OTC) hearing aids through social media data.

Methods: Twitter (X)'s Application Program Interface was utilized to collect English-language tweets mentioning OTC hearing aids between January 2019 and October 2022. Sentiment analysis was conducted using the Valence Aware Dictionary and Sentiment Reasoner, categorizing tweets as positive, neutral, or negative. Main outcomes and measures were average compound sentiment scores. Joinpoint analysis was used to evaluate changes in sentiment scores over time. Two independent raters categorized account type and tweets into categories determined by thematic analysis.

Results: A total of 8912 tweets were included. The tweets were categorized as Economy, Political, Logistics, Information, and Other based on thematic analysis. Overall mean (SD) compound sentiment score (range: -1 to +1) was weakly positive at 0.15 (0.40). The total number of tweets increased significantly after August 2022, with 331 tweets in Q2 of 2022 and 2110 tweets in Q3 of 2022. There were no significant changes in sentiment scores over the study period. Economy received the highest average compound sentiment score of 0.21 (0.39), followed by Political 0.18 (0.46), Logistics 0.16 (0.41), Other 0.14 (0.39), and lastly Information 0.13 (0.36).

Conclusion: This study demonstrated an increase in public awareness regarding OTC hearing aids in social media; although the sentiment toward them remained unchanged, reflecting mixed opinions on their benefits and challenges. Our findings highlight the need for more transparent and educational information, particularly given the increasing confusion accompanying the growing awareness.

1 | Introduction

Hearing loss is often referred to as a “silent epidemic” in the U.S. due to its insidious onset and high prevalence, with around 40 million (15% of the U.S. adults) impacted [1]. The prevalence of hearing loss increases exponentially with aging, affecting two-thirds of those older than 70 in the U.S. [2].

The high prevalence of hearing loss is especially concerning considering its negative impact on social, mental, physical, and cognitive health. Hearing loss, with its profound effects on communication, can lead to increased feelings of loneliness and social isolation [3]. Numerous previous studies have shown a significant association of hearing loss with depression, cognitive decline, and dementia [4–6]. Furthermore, the

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repercussions of hearing loss on health and quality of life have been connected with global economic burdens nearing one trillion dollars annually [7, 8]. As such, addressing hearing loss is crucial to mitigate negative health consequences and the global burden it imposes.

Hearing aids are a first-line intervention for the majority of the individuals impacted by hearing loss, and their use has improved perceived handicaps and quality of life [9]. Although nearly 30 million Americans could benefit from hearing aids, the rate of hearing aid use remains low in the U.S., ranging from 7% to 37% [10–12]. Reasons for the low rates of hearing aid use are multifactorial, including high cost, complexity of navigating the hearing healthcare system, technical limitations, lack of awareness of treatment options, and stigma. One commonly cited reason for low hearing aid adoption is the prohibitively high cost of seeing a physician, an audiologist, and purchasing a set of hearing aids [13, 14].

Expansion of over-the-counter (OTC) hearing aids has been suggested as a promising strategy to address some of these barriers, providing high-quality, low-cost sound amplification. The U.S. Food and Drug Administration (FDA) proposed a rule to establish a new category of OTC hearing aids, aimed at ensuring their safety and effectiveness by incorporating specific indications and regulations in October 2021 [15]. The final rule was established in August 2022, and took effect in October 2022 [16]. However, professional and public opinion about OTC hearing aids remained varied, with praises of increased accessibility mixed into concerns about the need for medical exams and unresolved social stigma that may hinder the new rule's clinical benefit [17–20].

A wide range of these opinions were expressed on Twitter (X), a popular social media platform that previously has been used to gauge public sentiment on several health-related topics. None, however, have examined public sentiment about OTC hearing aids and their changes over time [21–23]. As such, we sought to perform a thematic and sentiment-based analysis of all tweets about OTC hearing aids from 2019 to 2022 prior to and following the FDA's OTC rule to understand public perceptions of OTC hearing aids and the FDA ruling.

2 | Methods

We obtained access to Twitter (X)'s Application Program Interface for academic research, and a custom Python script was developed to gather all study-relevant tweets. According to the policy-defining activities that constitute research at the University of Southern California, this work met the criteria for operational improvement activities exempt from Institutional Review Board review. All English-language original tweets posted between January 2019 and October 2022 that contained the phrase “Over the counter hearing aid” or “OTC hearing aid” within the body of the tweet were collected. The author ID, account name, number of followers, number of tweets associated with each account, account description, self-reported author location, account creation date, body of the tweet, date of the tweet, geotag, timestamp, number of retweets, replies, likes, and quotes were collected.

None of the collected tweets were excluded from analysis, as the purpose of the present paper was to broadly survey public opinion on OTC hearing aids. Sentiment analysis was performed using the “Valence Aware Dictionary and Sentiment Reasoner” (VADER), a Python package which is part of the Natural Language Toolkit [24]. VADER calculates a compound sentiment score for each tweet by identifying words which have previously been rated for inherent positivity and negativity by humans. Then, in conjunction with equations that consider punctuation, capitalization, emoticons, and word modulators, a sentiment score between -1 and $+1$ is calculated. Prior to analysis by VADER, punctuation and emoticons were removed from the tweet as part of text preprocessing. Per convention outlined in VADER's documentation, positive tweets were defined as those with compound sentiment scores $\geq +0.05$, neutral tweets were those with scores < 0.05 and > -0.05 , and negative tweets had scores ≤ -0.05 [24].

Upon collecting sentiment scores for all tweets, two independent raters (ML and MA) categorized both author type and tweet category into categories determined by thematic analysis based in grounded theory [25, 26]. Percent agreement and Cohen's kappa were calculated to determine inter-rater reliability, and for those tweets for which a thematic category was not agreed upon by the two raters, a third rater (JF or JC) cast a tie-breaking vote. Percent agreement provides a calculation of the proportion of times two raters agree, without considering chance. Cohen's kappa adjusts the observed agreement by accounting for expected agreement due to chance, providing a more robust measure of true agreement between raters. Cohen's kappa is therefore not directly proportional to percent agreement. The goal of the thematic analysis was to understand themes of conversation around OTC hearing aids, and whether certain themes were associated with more positive or negative sentiment. Author type was only included if the original raters (ML and MA) agreed—no tie-breaking votes were cast. Mean and SD of sentiment scores were calculated overall and per category based on the thematic analysis results. Sentiment scores were calculated by each quarter. Trend analysis was then performed using Joinpoint software [27]. Exclusively for Joinpoint analysis, all sentiment scores were adjusted upwards by a value of 1 to ensure no negative values.

3 | Results

A total of 8912 tweets were identified mentioning OTC hearing aids during the study period between 2019 and 2022. The tweets were assigned a category determined by the study team. Tweets fit into the following thematic categories: Economy, Political, Logistics, Information, and Other. Table 1 summarizes inter-rater reliability for each tweet category and author type.

The category with the largest number of tweets was Information, followed by Political, Logistics, Economy, and Other (Figure 1A). The most common author type was tweets from the media news (Figure 1B). The total number of tweets in the study timeframe dramatically increased in the third and fourth quarters of 2022, while the average sentiment score appears to have hit its maximum in the third quarter of 2020 (Figure 1C); though Joinpoint

TABLE 1 | Inter-rater reliability for tweet category and author type.

	Percent agreement (%)	Cohen's K	Level of agreement
Tweet category			
Economy	85.6	0.527	Moderate
Political	91.8	0.700	Substantial
Logistics	88.6	0.511	Moderate
Information	72.3	0.441	Moderate
Other	91.5	0.315	Fair
Author type			
Patients	96.9	0.312	Fair
Physicians	99.0	0.620	Substantial
Audiologists	99.0	0.714	Substantial
Other healthcare worker	97.6	0.289	Fair
Political commentator	85.4	0.418	Moderate
Media/news	88.6	0.639	Substantial
Stock investor	94.8	0.706	Substantial
Hearing advocate	88.4	0.184	None/slight
Companies	91.7	0.660	Substantial
Other unknown	72.1	0.372	Fair

analysis did not find significant trends in average aggregate and category sentiment scores (Figure S1).

Table 2 summarizes average compound sentiment score by tweet category. The overall mean (SD) sentiment score (range: -1 to +1) was 0.15 (0.40). Sentiment scores by category were 0.21 (0.39) for Economy, 0.18 (0.46) for Political, 0.16 (0.41) for Logistics, 0.13 (0.36) for Information, and 0.14 (0.39) for Other.

Table 3 summarizes representative quotes from each category based on the thematic analysis. Tweets about Economy focused on consumer costs of OTC hearing aids, with positive tweets centering around the perceived affordability of OTC hearing aids. One user wrote, “hearing aids can be the third largest life [expense], behind a house and a car, the [OTC] hearing aid law that takes place in August could change that”. Additional positive sentiment within this category expressed hope that lower costs would allow for greater access to hearing aids, and ultimately more widely treated hearing loss. Economy tweets with negative sentiment voiced concern over how the availability of OTC hearing aids could decrease insurance coverage, leading to an increase in consumer cost. Neutral Economy tweets discussed how the FDA announcement might change market dynamics and investment opportunities.

Tweets in the Political category included tweets about the president's actions and influence, partisan perspectives/policy debates, and advocacy. Positive Political tweets praised the bipartisan effort that took place to pass the bill. Negative tweets expressed concern over the lack of regulation, the administration's lack of clarity in who may benefit from OTC hearing aids, and delays in passing legislation. Neutral political tweets questioned if the legislation had gone far enough to delineate insurance coverage and safe clinical practice around patient selection for OTC hearing aids.

Tweets within the Logistics category focused on accessibility, insurance coverage, the role of hearing health professionals, indications, safety, and regulations. Positive tweets expressed excitement over how different healthcare professionals could play a role in getting OTC hearing aids to consumers: “Pharmacists, let's show how we can champion safe and effective use of OTC hearing aids...” Negative tweets expressed concern over hearing professionals' role in OTC hearing aids, especially as it pertained to patients foregoing proper audiologic evaluation. Many warned that professional advice is wise when fitting hearing aids, even if over the counter: “Both the quality of the hearing aids and the appropriate fitting and adjusting of...hearing aids are critical...” One user expressed concern over potential risks, writing, “my father lost his hearing as a child and suffered from hearing loss for most of his life while I celebrate access to OTC hearing aids, I am concerned that proposed FDA safety standards are not aligned with those of hearing care professionals.” Other negative tweets in the logistics category warned that insurance coverage for this new category of devices may be incomplete: “Unless you have an advantage plan, Medicare won't cover anything OTC so when hearing aids become OTC, it will be a loophole that they no longer have to pay for.”

Information tweets focused on education, declaration of news, awareness of brands, models, indications, and research findings. One user wrote, “You're right, it is confusing! The good news is that the Eargo, Tweak, Jabra all are likely to be re-classified as OTC hearing aids.” Other users commented that OTC hearing aids were available prior to the new FDA regulation, writing, “Hearing aids have always been over the counter. They've been sold on Amazon, Costco, and any hearing aid center throughout the state. Programmable hearing aids are the ones that need prescription.” Positive tweets in this category communicated information about how the legislation would make hearing aids more widely available. Negative tweets predicted disappointment with the devices and posited questions about the quality of the devices.

4 | Discussion

The current study examines public perspective on OTC hearing aids using sentiment and thematic analysis of Twitter (X) posts from a 3-year period before and after the FDA implemented a new category of OTC hearing aid. The sentiment of OTC hearing aids on Twitter (X) was overall neutral to positive, with 47% being positive, 33% being neutral, and 20% being negative. While the number of Tweets has significantly increased over time, overall sentiment scores toward OTC hearing aids did not change. These findings suggest that while the legislation for

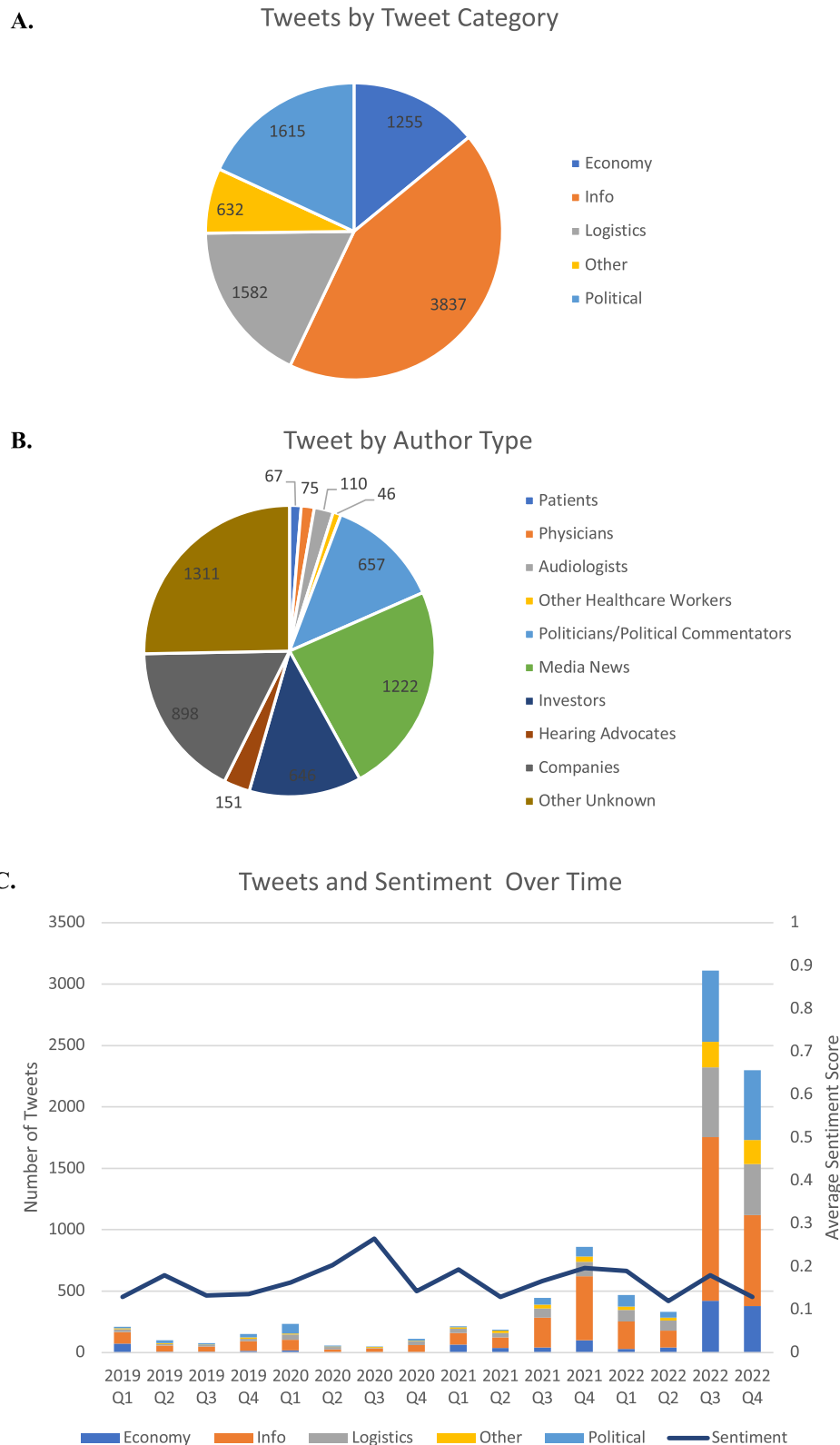


FIGURE 1 | Summary of tweet characteristics. (A) Pie chart by tweet category. (B) Pie chart by author type. (C) Number of total tweets by quarter.

OTC hearing aids stimulated conversation about OTC hearing aids, many questions remain before public opinion may change. By polling public commentary on social media, we can identify perspectives that may not be readily apparent in a clinical setting.

To our knowledge, this is the first study to broadly assess public attitude toward OTC hearing aids and its changes over time. Prior studies have shown that consumers are uncomfortable pursuing OTC hearing aids in a direct-to-consumer pathway and prefer doing so in-person [28]. Other studies

TABLE 2 | Average compound sentiment score by tweet category.

Tweet category	Count (%) <i>n</i> = 8912	Average compound sentiment score (SD) 0.15 (0.40)	Proportion sentiment category		
			Pos	Neg	Neu
Economy	1255 (14.1)	0.21 (0.39)	0.51	0.15	0.34
Political	1615 (18.1)	0.18 (0.46)	0.57	0.27	0.15
Logistics	1582 (17.8)	0.16 (0.41)	0.48	0.20	0.32
Information	3837 (43.1)	0.13 (0.36)	0.41	0.18	0.41
Other	623 (7.0)	0.14 (0.39)	0.43	0.20	0.38

Note: Sentiment scores range from −1 (most negative), 0 (neutral), to +1 (most positive).

have found that healthcare professionals have significant concerns around the quality of devices, appropriate medical evaluation, and the roles/requisite knowledge that audiologists/pharmacists might need to counsel patients [29–31]. Our study found similar themes of consumers and professionals desiring proper guidance. However, our study builds upon prior literature by exploring the changing perspectives of the broader public.

In this study, we explored perspectives on OTC hearing aids from a diverse audience utilizing Twitter (X). We employed a validated sentiment analysis algorithm to quantify tweets over a 3-year period. Additionally, we used thematic analysis to understand the various opinions and experiences surrounding OTC hearing aids. Our mixed methods approach offers valuable insights into public attitudes toward OTC hearing aids and offers clinicians the opportunity to engage in more targeted counseling.

The mean (SD) sentiment score for all tweets within the dataset was 0.15 (0.46), indicating a weakly positive overall sentiment. Roughly half of the tweets on OTC hearing aids were found to have positive sentiments. The aggregate sentiment score is comparable to the mean sentiment score for tweets related to cochlear implants, 0.21 (0.46) [32]. A study examining pregnant women's feelings of support during COVID-19 yielded an average sentiment score of −0.05 [33]. Lastly, VADER sentiment scores ranged from −0.66 to 0.40 when analyzing tweets about cannabidiol [34].

In addition to sentiment analysis, we utilized thematic analysis to provide additional understanding of the attitudes toward OTC hearing aids. Among the five major themes, the largest thematic category within the tweets was related to Information, which included primarily neutral (41%) and positive (41%) tweets. Many of these tweets were declaring news, sharing research findings, or spreading awareness about OTC hearing aids. One writer shared research findings that “hearing loss is linked to depression, cognitive decline, and greater risk of falls currently, only certain FDA-regulated medical devices can be sold as hearing aids. That might change later this year.” Yet, the Information category had the lowest average compound sentiment score,

possibly due to a high number of neutral tweets within the category. The total number of tweets within this category, however, increased over time, suggesting increased public awareness stemming from the legislative changes.

Among the five major themes, the economy category had the highest sentiment score. This is likely related to many positive comments highlighting the affordability of OTC hearing aids. Numerous tweets revolved around the high cost of traditional hearing aids, citing the costs of visiting an audiologist as particularly prohibitive. One user tweeted, “If it's OTC I'd rock that...in a heartbeat hearing aid(s) are so...expensive!!” Users expressed their delight at the availability of hearing aids in pharmacies, given that prior studies have found that hearing aids were financially out of reach for 75% of Americans with hearing loss, citing average costs of \$2500 [35]. The positive attitudes toward the affordability of OTC hearing aids were mixed with concerns about quality and proper clinical evaluation.

Lastly, several controversies around hearing aids were voiced within our dataset. While some users celebrated the ease of access of OTC hearing aids, others were concerned that they only benefit those with mild to moderate hearing loss. The concern was largely centered around potential delays in proper clinical evaluation and missed diagnoses of more serious etiologies of hearing loss. Additionally, concerns have been raised about the potential loss of insurance coverage for hearing aids with the new legislation. There was misinformation regarding Medicare coverage, which was feared to be potentially lost with the advent of OTC hearing aids. Currently, Medicare only covers diagnostic appointments, and only certain advantage plans or secondary policies cover hearing aids. Many individuals within our dataset expressed misunderstanding about the difference between Personal Sound Amplification Products, headphones, and OTC hearing aids: “hearing aids are (typically) medical devices...Airpods Pro are cheaper, and have far superior tech. Now, Airpods can be used to assist hearing impaired.” The discussion on social media underscores the intricate and evolving nature of public perceptions of OTC hearing aids. These findings emphasize the importance of providing more transparent and educational information about OTC hearing aids and insurance coverage given the rising confusion that accompanies growing awareness. Physicians represented a small percentage of those tweeting about OTC hearing aids, and thus there is an untapped opportunity to steer public discourse about which patients may benefit from OTC hearing aids.

There are several limitations to this study. We exclusively examined discussions on Twitter (X), and the distribution of positive and negative tweets might differ across various social media platforms. Additionally, emoticons were removed in the preprocessing of tweets prior to the calculation of sentiment score. Therefore, VADER may have missed subtleties in tone conveyed by emoticons. VADER may be limited in evaluating health-care related topics as certain illness-related terms (such as pain, stress, and cancer), and the method of preprocessing can impact overall sentiment [33, 36]. Despite these limitations, VADER is still among the most reliable sentiment analysis algorithms for social media posts [37]. Another limitation of our study is the level of agreement between raters for tweet category and author type given that both are free text fields, subjecting our data to

TABLE 3 | Representative quotes from thematic analysis of positive, neutral and negative tweets.

Category	Tweet quote	Sentiment score
Economy		
Positive	“Omg OTC hearing aids? That’s awesome! Maybe that can spark more innovation in the industry, though I fear it might just drive the presence of scammers—hopefully it can lower prices though as hearing aids have often been priced out for a lot of people, especially quality ones”	0.7569
	“As someone with a hearing disability and wary of the costs of hearing aids, this makes me happy although I do wonder how it will affect the price per: FDA moves to allow hearing aids to be sold over the counter”	0.6808
Neutral	“Prescription hearing aids are expensive. Are over-the-counter models an option?”	0
	“CVS closes hearing centers as FDA readies rules for over-the-counter sales of hearing aids”	0
Negative	“At first, I was excited—but now I’m concerned. Hearing aids are expensive and hard to get covered as is. If they’re considered OTC, many insurances will not cover them—so will customers end up having to pay more in the end?”	−0.1280
	“Making hearing aids available OTC means insurance will not cover them another high dollar out of pocket expense, idiot”	−0.5106
Politics		
Positive	“She sponsored a bill to try to increase hearing aid accessibility to more Americans in a rare show of bipartisan support, it passed”	0.6124
	“Just amazing that the president got OTC hearing aids for the all the people”	0.5859
Neutral	“One thing she has done quite recently, got a bipartisan bill passed through congress that makes hearing aids available OTC which will vastly reduce their cost while increasing their accessibility”	0
	“Senators call on FDA to issue over-the-counter hearing aid regulations by November”	0
Negative	“I’m not against OTC hearing aids. I just think the regulation (or lack thereof) is totally ridiculous”	−0.624
	“Your administration has done nothing of the kind. Allowing generic hearing aids to be purchased OTC without examination or prescription doesn’t help anyone. It costs them more money because that shit is worthless eventually, they’ll have to go back for the real thing”	−0.8241
Logistics		
Positive	“Today is the day for OTC hearing aids! Pharmacists, let’s show how we can champion safe and effective use of OTC hearing aids by collaborating with audiologists”	0.8805
	“Well said!!! I am an audiologist, and your concerns and thoughts were spot on. I actually just took a continuing ed. course on how to adapt to the changing industry. Most of our top hearing aid manufacturers are going to offer over the counter (OTC) aids”	0.6174
Neutral	“I couldn’t find a newsletter from major retail stores to announce OTC hearing aids. You think it’ll happen sometimes next month?”	0
	“You may get hearing aids OTC in the US, but do not buy one without consulting your ENT first”	0
Negative	“No, not really. Like it or not hearing aids need to be adjusted by professional audiologists for each patient. [Cheap amplifiers] will do more damage than good, guaranteed”	−0.5935
	“As an audiologist, both the quality of the hearing aids and the appropriate fitting and adjusting of those hearing aids is critical. These OTC hearing aids may work for a select few, but you are telling people that there is no need for audiological services. That is wrong”	−0.8225

(Continues)

TABLE 3 | (Continued)

Category	Tweet quote	Sentiment score
Information		
Positive	“In order to ensure that FDA has consumer protections as a top consideration in OTC regulations, the hearing industries association has researched key areas for them to consider as they deal with state preemption laws hearing loss hear about hearing”	0.5267
	“The FDA finalized regulations to make available hearing aids to millions of Americans without them requiring to see a doctor. It is hoped that having hearing aids available OTC will help lower prices through increased retail competition”	0.6369
Neutral	“Have you heard the news? A big change is coming: hearing aids will soon be available without a prescription”	0
	“If anyone has watched TV in the last five years, they absolutely know you have been able to buy OTC hearing aids for a long time. I can almost recite those ads by heart!!!!”	0
Negative	“Opinion: first generation of OTC hearing aids will struggle to meet expectations via hearing loss”	−0.3182
	“Unpopular opinion: OTC hearing aids are a terrible and dangerous idea that is not the solution to the problem of access to hearing aids for people who need them. What will fix the problem? All inclusive universal health care for all at no cost to the individuals/family”	−0.8901
Others		
Positive	“We are reviewing all the fine-print in the OTC announcement (all pages worth), but we certainly support additional options and access to help people hear better. We are always available for help and support, whether hearing aids are purchased at our office or elsewhere”	0.9688
	“Best Christmas gifts—OTC hearing aids”	0.6369
Neutral	“I know the FDA is busy, but I’m getting really antsy waiting for the OTC hearing aid regulations”	0
	“OTC hearing aids that connect to your wireless devices and all your digital home items”	0
Negative	“OTC hearing aids are a start, but the industry structure is really the deeper problem”	−0.6054
	“Just wait until the FDA finishes the guidelines for OTC hearing aids. It will be more confusing”	−0.2944

both reporting bias and the individual biases of the study team. Our data were initially collected immediately after the OTC ruling went into effect in October 2022. Shortly thereafter, access to Twitter (X)’s academic database was discontinued by the company’s new ownership, limiting our ability to gather additional data on consumer insights, and how sentiment may affect OTC hearing aid sales. Lastly, the external validity of our study is limited given that only English-language tweets were analyzed, and most tweets originated from users in the United States.

5 | Conclusions

This study sought to use a sentiment analysis algorithm to understand public sentiment about OTC hearing aids, and how public sentiment may have changed in the period around the FDA’s announcement of a new OTC category of hearing aids. While there were no significant trends in the average compound sentiment score over the study’s timeframe, the number of tweets increased significantly in the period immediately preceding and following the FDA’s announcement. The most salient

themes that arose from our study were questions about the true affordability of OTC hearing aids, the role of different clinicians in connecting consumers with devices, and the logistic and legislative future of ensuring proper clinical evaluation. Our findings highlight the importance of counseling patients about the different devices on the market, and who may or may not be a good candidate for OTC hearing aids. While there were no significant trends in public sentiment toward OTC hearing aids in our study, we believe that with clarification of the above concerns, OTC hearing aids will help a larger proportion of individuals impacted by hearing loss, and eventually public perception of OTC hearing aids will improve.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** Joinpoint analysis for average compound sentiment score by category. Economy (a), Political (b), Logistics (c), Info (d), Other (e), and aggregate (f) tweets.