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ORIGINAL ARTICLE

Communication during the COVID-19 pandemic: the hearing-impaired perspective

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ABSTRACT

Objective: To understand the communicational and psychosocial effects of COVID-19 protective measures in real-life everyday communication settings.

Design: An online survey consisting of close-set and open-ended questions aimed to describe the communication difficulties experienced in different communication activities (in-person and telecommunication) during the COVID-19 pandemic.

Study sample: 172 individuals with hearing loss and 130 who reported not having a hearing loss completed the study. They were recruited through social media, private audiology clinics, hospitals and monthly newsletters sent by the non-profit organisation "Audition Quebec."

Results: Face masks were the most problematic protective measure for communication in 75–90% of participants. For all in-person communication activities, participants with hearing loss reported significantly more impact on communication than participants with normal hearing. They also exhibited more activity limitations and negative emotions associated with communication difficulties.

Conclusion: These results suggest that, in times of pandemic, individuals with hearing loss are more likely to exhibit communication breakdowns in their everyday activities. This may lead to social isolation and have a deleterious effect on their mental health. When interacting with individuals with hearing loss, communication strategies to optimise speech understanding should be used.

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COVID-19; face masks; hearing loss; telecommunication; communication strategies; lipreading

1. Introduction

According to the World Health Organisation (WHO 2021), over 1.5 billion individuals present with different degrees of hearing loss, while approximately 430 million are affected by a disabling hearing loss. People with hearing loss generally adopt various strategies to promote speech understanding. For example, lip reading allows for visual integration of speech sound production, which enhances the perception of speech. However, some measures proposed to counter the spread of COVID-19 may negatively impact communication (Pinsonnault-Skvarenina et al. 2021).

The results of recent investigations revealed that the surgical mask acts as an acoustical low-pass filter, reducing the level of high-frequency sounds by 4–12 dB (Goldin, Weinstein, and Shiman 2020), while face shields and transparent masks attenuate speech signals by 11–14 dB (Corey, Jones, and Singer 2020). In a large study conducted in the UK, it was found that face masks negatively impacted speech understanding, especially when communicating in a medical setting (Saunders, Jackson, and Visram 2021). Also, the use of face masks impacted engagement and feelings of connection with the person speaking and increased anxiety and stress (Naylor, Burke, and Holman 2020; Saunders, Jackson, and Visram 2021). Regarding the increased use of telecommunication technologies during the pandemic, individuals with a higher degree of hearing loss reported poorer hearing performance during telephone and video calls when compared to when they communicate face-to-face (Naylor, Burke, and Holman 2020). Reports have shown an increase in the number of persons requesting hearing aids as a result of increased communication difficulties (Ertugrul and Soylemez 2021; Strom 2022).

It is conceivable that some COVID-19 protective measures could have a long-term effect on the social participation and quality of life of people with hearing loss. Therefore, it is important to better understand the consequences of protective measures on communication to minimise or prevent them. Most of the previous studies conducted were designed specifically to measure the effects of face masks on speech understanding. Few have documented the effects of combined protective measures (e.g. face mask and shield, fixed plastic partition, physical distancing) on communication in different specific everyday communication

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situations between individuals with hearing loss and those with normal hearing. Therefore, this study investigates the effects of COVID-19 protective measures on specific everyday activities, the strategies used to reduce communication obstacles and the challenges and obstacles of telecommunication technologies.

2. Materials and methods

2.1. Participants

Participants were adult residents of the province of Quebec, Canada, aged 18 and over. They were recruited through social media, private audiology clinics, hospitals and monthly newsletters sent by "Audition Quebec," a provincial non-profit organisation for individuals with hearing loss. Participants who reported a diagnosis of hearing loss were included in the hearing loss group (HL group; $n = 172$). The others, who reported not having a hearing loss, formed the normal hearing group (NH group; $n = 130$). Recruitment of participants occurred between August 2020 and June 2021.

2.2. Survey

A survey considering the underlying principles of the International Classification of Functioning, Disability and Health (WHO 2019) was developed (Supplementary Material 1). This survey aimed to describe, from a psychosocial perspective, the communication difficulties caused by protective measures in seven real-life everyday communication settings: 1) drug store, 2) restaurant, 3) retail/grocery store, 4) medical appointment, 5) family reunion, 6) communication at work with clients and 7) communication with co-workers. Survey items were developed by the research team, which included seven experienced audiologists and speech-language pathologists with various backgrounds (i.e. hospital, rehabilitation centre, private practice, research), two audiology graduate students and two representatives of "Audition Quebec." One of the authors (A.P.S.) wrote a first draft of the survey which was reviewed by all members of the research team following an iterative process. The final version of the survey was reviewed by two authors (A.P.S. and A.B.M.L.) and two representatives of "Audition Quebec" to ensure its readability and accessibility. A pilot was conducted with 40 participants, which confirmed the interpretability of the survey questions. Most survey items required the selection of options from a 5-point Likert scale or a 10-point scale. Other items consisted of open-ended questions. Participants could choose not to answer a question. The survey questionnaire consisted of five sections:

1. Demographic data and hearing-related items;
2. Impact of protective measures on communication and frequency of communication breakdowns;
3. Participation restrictions and psychosocial effects of communication breakdowns;
4. Communication strategies;
5. Telecommunication.

2.3. Procedures

Study data were collected using the Lime Survey online platform (http://www.limesurvey.org/), using a branching logic according to participants' responses. Participants could access the survey via a link to the online platform. Once the consent form was electronically signed, participants could answer the survey. The survey took about 30 minutes to complete and consisted of a total of 96 questions. The Lime Survey software uses IP addresses to ensure that participants cannot answer the questionnaire multiple times. Additionally, participants' names were checked by a member of the research team to ensure that there were no duplicates.

2.4. Analyses

Statistical analyses were performed using IBM SPSS Statistics (v25.0) with a significance level of 5%. First, to evaluate the homogeneity of the HL and NH groups, the responses of both groups were described and compared for each variable included in the questionnaire, using chi-square tests (χ^2) for categorical variables and Student's t-tests for continuous variables. P-values for each variable's post-hoc test were adjusted for multiplicity of tests by the Bonferroni correction.

Second, 2-way repeated measures ANOVAs were conducted for questions related to the impact and annoyance of protective measures on communication (10-point scales) and the different everyday settings, using "group" as a between-subject factor (NH and HL groups) and "everyday communication settings" as a within-subject factor (drug store, restaurant, retail/grocery store, medical appointment, and family reunion). Similarly, 2-way repeated measures ANOVAs were conducted for the perceived effectiveness and satisfaction of telecommunication technologies. For these analyses, "group" constituted the between-subject factor (NH and HL groups) and "telecommunication technologies" constituted the within-subject factor (videoconference, telephone, text messages, and emails).

The effect size was calculated and interpreted according to Cohen's (1988) benchmarks. It was considered small ($d = 0.2$), medium ($d = 0.5$) and large ($d = 0.8$) for Student's t-tests (Cohen's d, d); small ($V \leq 0.2$), medium ($0.2 < V \leq 0.6$) and large ($V > 0.6$) for χ^2 tests (Cramer's V, V); and small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$) and large ($\eta^2 = 0.14$) for repeated measures ANOVAs (Eta-squared, η^2).

Finally, a qualitative content analysis methodology (Graneheim and Lundman 2004; Knudsen et al. 2012) was used to analyse the participants' responses to the open-ended questions related to their use of communication strategies and the challenges experienced with the use of telecommunication technologies during the pandemic. Participants' written answers were analysed following an inductive approach. Content areas were defined as text samples where participants described the strategies used to improve communication, and where they described the challenges experienced with the use of telecommunication technologies. Data extracted from those content areas were divided into meaningful units, coded, and classified by subcategories.

Then, for communication strategies, induced subcategories were compiled according to three predetermined categories, corresponding to the type of strategy used (Gagné and Jennings 2008): 1) anticipation strategy, 2) repair strategy and 3) maintenance strategy. For challenges experienced by participants with the use of telecommunication technologies, themes and categories simply emerged from the collected data.

The coding, subcategory extraction, classification into categories/themes, and data interpretation were done by one author (E.T.) and then validated by two other authors (A.P.S. and A.B.M.L.). A coding comparison was performed on a representative sample of content areas to ensure a consistent coding process. The analysis was compared to the original participants'

written answers on several occasions during the process to avoid errors. When a disagreement occurred in the coding, categorisation, or interpretation, it was discussed and solved by mutual consensus.

3. Results

3.1. Participants

Results for the main socio-demographic and hearing-related variables are shown in Table 1. Most of the participants were female (79%) and reported that French was their primary language for communication (> 95%). No differences were observed between groups regarding gender (χ^2 (1, $N = 300$) = 0.01, p = .947) and primary language (χ^2 (2, $N = 301$) = 0.26, p = .878). Relative to the NH group, the HL group was significantly older (t (300) = −9.60; p < .001), had greater perceived hearing difficulties (χ^2 (2, $N = 296$) = 160.43, p < .001) and had a lower educational level (χ^2 (2, $N = 300$) = 31.50, p < .001), family income (χ^2 (5, $N = 267$) = 40.25, p < .001) and perceived health status (χ^2 (3, $N = 299$) = 42.91, p < .001). Groups also presented differences in marital status (χ^2 (3, $N = 299$) = 11.68, p = .020) and

Table 1. Socio-demographic and hearing-related variables for hearing loss (HL) and normal hearing (NH) groups.

Characteristics		HL group ($n = 172$)	NH group ($n = 130$)	p-value*
Female gender, *N* (%)		136 (79)	103 (79)	.947
French language, *N* (%)		166 (97)	123 (95)	.878
Age, mean ± SD		56.3 ± 14.8	40.4 ± 13.6	<.001
Employed, *N* (%)	Yes	87 (51)	107 (82)	<.001
	No	79 (46)	23 (18)	
	No response	6 (3)	0 (0)	
Marital status, *N* (%)				.020
	Single	37 (22)	36 (28)	.884
	Married	55 (32)	38 (29)	1.000
	Common-law partner	38 (22)	42 (32)	.192
	Separated/divorced/widowed	40 (23)	13 (10)	.012
	No response	2 (1)	1 (1)	
Educational level, *N* (%)				<.001
	Elementary and high school	36 (21)	2 (1)	.003
	Cegep/college	41 (24)	22 (17)	.435
	University	94 (54)	105 (81)	.003
	No response	1 (1)	1 (1)	
Family income, *N* (%)				<.001
	Less than 15,000$	11 (6)	7 (5)	1.000
	Between 15,000$ and 34,999$	33 (19)	7 (5)	.006
	Between 35,000$ and 49,999$	29 (17)	7 (5)	.012
	Between 50,000$ and 74,999$	29 (17)	21 (17)	1.000
	Between 75,000$ and 99,999$	22 (13)	19 (15)	1.000
	More than 100,000$	26 (15)	56 (43)	.006
	No response	22 (13)	13 (10)	
Self-perceived health status, *N* (%)				<.001
	Excellent	16 (9)	41 (31)	.005
	Very good	63 (37)	62 (48)	.280
	Good	73 (42)	23 (18)	.005
	Fair	13 (8)	2 (1)	.030
	Poor	5 (3)	1 (1)	.930
	No response	2 (1)	1 (1)	
Self-reported hearing difficulties, *N* (%)				<.001
	Rarely/Sometimes	23 (13)	109 (84)	.003
	Approximately half the time	43 (25)	12 (9)	.003
	Often/almost always	104 (61)	5 (4)	.003
	No response	2 (1)	4 (3)	
Degree of hearing loss, *N* (%)				
	Mild	10 (6)		
	Moderate	67 (39)		
	Severe	90 (52)		
	No response	5 (3)		
Hearing aids, *N* (%)				
	None	15 (9)		
	One	25 (14)		
	Two	96 (56)		
	Cochlear implant	17 (10)		
	Cochlear implant and hearing aid	10 (6)		
	Other	9 (5)		
	No response	0 (0)		
Number of years wearing hearing aids, *N* (%)				
	Less than 1 year	7 (4)		
	1–5 years	21 (12)		
	6–10 years	24 (14)		
	11–15 years	20 (12)		
	16–20 years	17 (10)		
	More than 20 years	57 (33)		
	No response	26 (15)		

*P-values for each variable's post-hoc test were adjusted for multiplicity of tests by the Bonferroni correction.

employment status (χ^2 (1, $N = 296$) = 28.86, $p < .001$). These socio-demographic results are in line with the age difference between our groups and the presence of hearing impairment in the HL group. Regarding the HL group, approximately 50% of the participants reported having severe hearing loss. Fewer than 10% reported that they did not use a hearing aid, while 86% reported using hearing aids and/or cochlear implants. About 35% of the participants in the HL group reported being hearing aid users for more than 20 years.

3.2. Speech understanding and psychosocial effects

In most everyday settings, participants reported that at least one protective measure was used. In the HL group, almost 90% of participants reported that the face mask was the most problematic measure for communication, followed by physical distancing, fixed plastic partitions and a face shield. For the NH group, the face mask was also reported as the most problematic measure (76%). Fixed plastic partitions, face shields and physical distancing were identified as the second, third and fourth measures that had the most deleterious effect on communication.

Participants were questioned on the effects of protective measures on speech understanding. The HL group displayed higher impact ratings for all everyday communication settings (Figure 1a): drug store (t (287) = −11.47, $p < .001$, $d = 1.36$), restaurant (t (250) = −12.16, $p < .001$, $d = 1.55$), retail/grocery store (t (287) = −13.60, $p < .001$, $d = 1.62$), medical appointment (t (283) = −13.33, $p < .001$, $d = 1.61$), family reunion (t (286) = −7.15, $p < .001$, $d = 0.85$), conversation with clients (t (182) = −5.07, $p < .001$, $d = 0.75$), and conversation with co-workers (t (172) = −10.74, $p < .001$, $d = 1.64$). The effect sizes were large. Similar results were obtained when participants were questioned on the annoyance from communication breakdowns caused by protective measures (Figure 1b): drug store (t (267) = −12.83, $p < .001$, $d = 1.58$), restaurant (t (236) = −11.88, $p < .001$, $d = 1.56$), retail/grocery store (t (266) = −13.20, $p < .001$, $d = 1.63$), medical appointment (t (256) = −12.46, $p < .001$, $d = 1.59$), family reunion (t (248) = −6.22, $p < .001$, $d = 0.80$), conversation with clients (t (175) = −6.22, $p < .001$, $d = 0.94$), and conversation with co-workers (t (165) = −10.38, $p < .001$, $d = 1.61$). The effect sizes were large.

To better investigate differences in responses among everyday settings, subsequent analyses were conducted using the data from participants who provided answers to the first five everyday settings listed in the survey. Speech understanding with clients and co-workers were not included in these analyses since considerably fewer participants answered the questions related to these settings. Two-way repeated measures ANOVAs showed a significant "group" × "everyday settings" interaction regarding responses on the impact of protective measures on communication (F (1, 912) = 10.98, $p < .001$, $\eta^2 = 0.05$) and the annoyance of communication breakdowns (F (1, 800) = 9.97, $p < .001$, $\eta^2 = 0.05$). The effect sizes were medium. Post-hoc t-tests with a Bonferroni correction were conducted to describe the nature of these interactions.

In the NH group, a significantly lower impact of protective measures on communication was observed in a medical appointment compared to a drug store ($\Delta = 0.821$, $p = .005$, 95%CI = [0.158, 1.484]), a restaurant ($\Delta = 0.789$, $p = .014$, 95%CI = [0.100, 1.479]) and a retail/grocery store ($\Delta = 1.116$, $p < .001$, 95%CI = [0.536, 1.696]). Additionally, a higher impact of protection measures was observed in a retail/grocery store when compared to communication in a family reunion ($\Delta = 0.916$, $p = .019$, 95%CI = [0.091, 1.741]). The annoyance caused by communication breakdowns was only significantly greater in a retail/grocery store when compared to a medical appointment ($\Delta = 0.833$, $p = .003$, 95%CI = [0.186, 1.481]).

In the HL group, the impact of protective measures on communication in a family reunion was significantly lower when compared to a drug store ($\Delta = -1.941$, $p < .001$, 95%CI = [−2.735, −1.4146]), a restaurant ($\Delta = -2.326$, $p < .001$, 95%CI = [−3.076, −1.576]), a retail/grocery store ($\Delta = -2.667$, $p < .001$, 95%CI = [−3.359, −1.974]) and a medical appointment ($\Delta = -1.778$, $p < .001$, 95%CI = [−2.439, −1.117]). Also, a significantly higher impact was observed for communication in a retail/grocery store when compared to a drug store ($\Delta = 0.726$, $p = .002$, 95%CI = [0.184, 1.268]) and a medical appointment ($\Delta = 0.889$, $p < .001$, 95%CI = [0.402, 1.375]). Similarly,

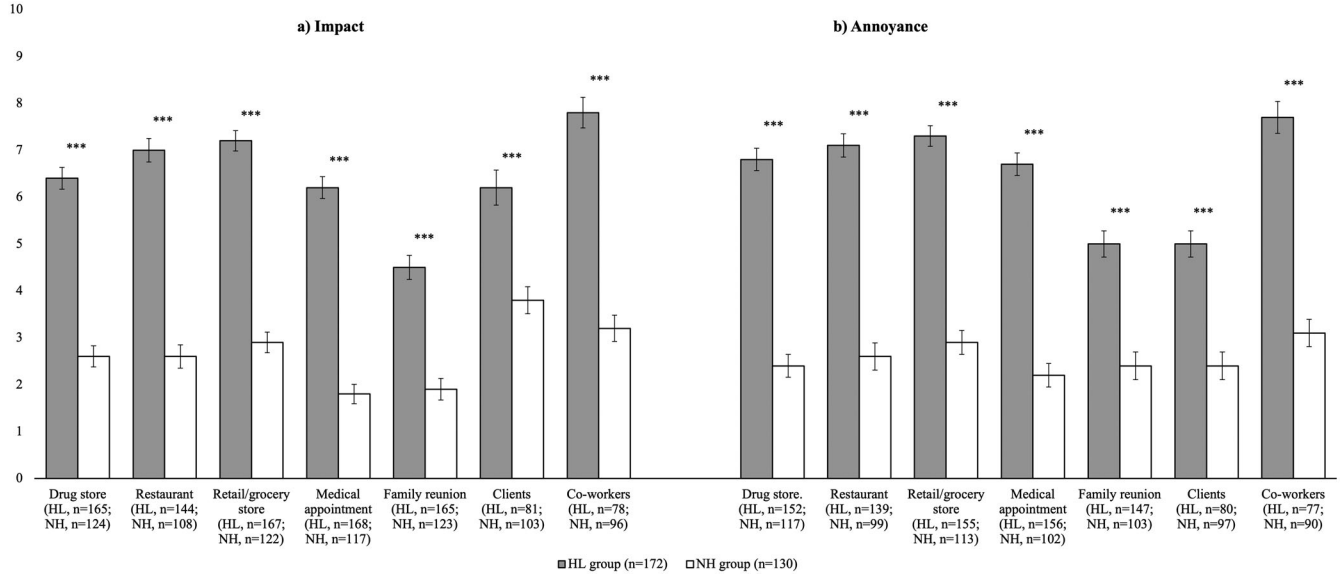

Figure 1. Impact and annoyance ratings in each of the seven everyday settings on a 10-point scale (0 is totally unaffected or not annoyed, while 10 is extremely affected or annoyed): (a) Impact; (b) Annoyance. Error bars denote standard errors. The "n" represents the total number of participants that responded to the specific question. ***$p < .001$.

significantly lower annoyance scores were observed for communication breakdowns in a family reunion when compared to a drug store ($\Delta = -1.758$, $p < .001$, 95%CI = [−2.562, −0.954]), a restaurant ($\Delta = -1.992$, $p < .001$, 95%CI = [−2.761, −1.222]), a retail/grocery store ($\Delta = -2.363$, $p < .001$, 95%CI = [−3.093, −1.633]) and a medical appointment ($\Delta = -1.815$, $p < .001$, 95%CI = [−2.528, −1.101]). Also, significantly lower annoyance scores were observed for communication breakdowns in a drug store ($\Delta = -0.605$, $p = .017$, 95%CI = [−1.143, −0.066]) and a medical appointment ($\Delta = -0.548$, $p = .028$, 95%CI = [−1.062, −0.035]) when compared to a retail/grocery store.

The frequency at which speech understanding was affected for all everyday settings was also investigated (Figure 2a). The

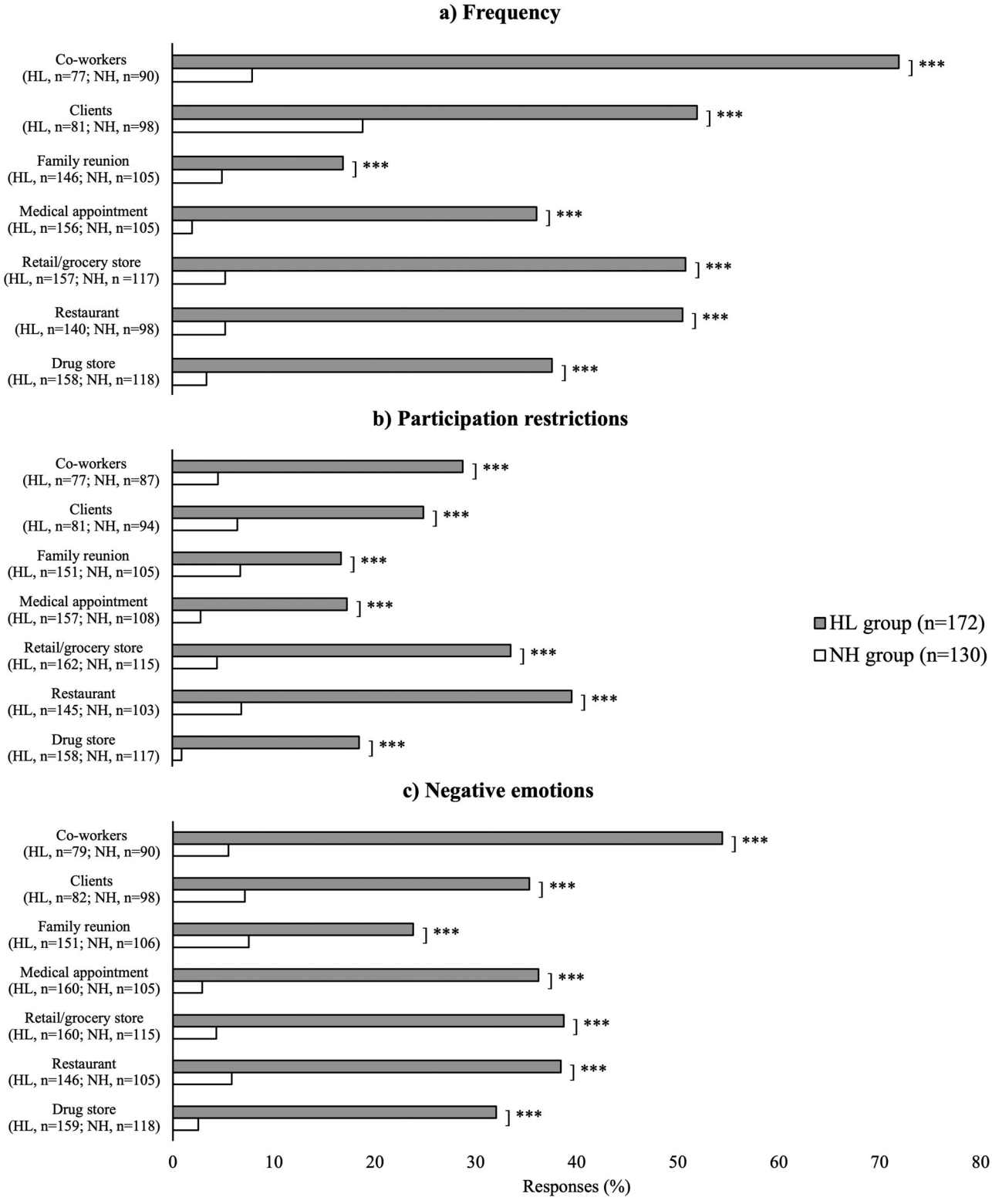

Figure 2. Proportion of participants with "often" and "always" responses in each of the seven everyday settings for (a) Frequency of communication breakdowns; (b) Participation restrictions; (c) Negative emotions. The "n" represents the total number of participants that responded to the specific question. ***$p < .001$.

proportions of respondents who reported communication breakdowns varied from 1.9% (medical appointment) to 18.4% (conversation with clients) in the NH group, while proportions varied from 16.5% (family reunion) to 70.2% (conversation with co-workers) in the HL group. For the HL group, the proportions of participants who reported impaired communication were greater for workplace settings (communication with co-workers and clients), while they were lower for a medical appointment and a family reunion. The HL group exhibited significantly more frequent communication breakdowns in all everyday settings than the NH group: drug store (χ^2 (4, $N = 276$) = 96.97, $p < .001$, $V = 0.59$), restaurant (χ^2 (4, $N = 238$) = 94.81, $p < .001$, $V = 0.63$), retail/grocery store (χ^2 (4, $N = 276$) = 99.29, $p < .001$, $V = 0.60$), medical appointment (χ^2 (4, $N = 261$) = 100.83, $p < .001$, $V = 0.62$), family reunion (χ^2 (4, $N = 251$) = 38.74, $p < .001$, $V = 0.39$), conversation with clients (χ^2 (4, $N = 179$) = 32.08, $p < .001$, $V = 0.42$), and conversation with co-workers (χ^2 (4, $N = 167$) = 79.50, $p < .001$, $V = 0.69$). The effect sizes were medium regarding the frequency of communication breakdowns for a drug store, a retail/grocery store, a family reunion, and a conversation with clients, while it was large for a restaurant, a medical appointment, and a conversation with co-workers.

The psychosocial effects of communication breakdowns were also investigated. The proportions of respondents who experienced participation restrictions varied from 0.9% (drug store) to 6.8% (restaurant) in the NH group and from 16.6% (family reunion) to 39.3% (restaurant) in the HL group (Figure 2b). The HL group exhibited significantly more participation restrictions in all everyday settings than the NH group: drug store (χ^2 (4, $N = 275$) = 46.78, $p < .001$, $V = 0.41$), restaurant (χ^2 (4, $N = 248$) = 62.37, $p < .001$, $V = 0.50$), retail/grocery store (χ^2 (4, $N = 277$) = 61.66, $p < .001$, $V = 0.47$), medical appointment (χ^2 (4, $N = 265$) = 37.54, $p < .001$, $V = 0.38$), family reunion (χ^2 (4, $N = 256$) = 22.24, $p < .001$, $V = 0.30$), conversation with clients (χ^2 (4, $N = 175$) = 31.65, $p < .001$, $V = 0.43$), and conversation with co-workers (χ^2 (4, $N = 164$) = 45.21, $p < .001$, $V = 0.53$). The effect sizes were medium.

Very similar results were obtained regarding negative emotions. The proportions of respondents who reported negative emotions varied from 2.5% (drug store) to 7.5% (family reunion) in the NH group and from 23.8% (family reunion) to 54.4% (conversation with co-workers) in the HL group (Figure 2c). The HL group exhibited significantly more frequent negative emotions in all everyday settings than the NH group: drug store (χ^2 (4, $N = 274$) = 104.22, $p < .001$, $V = 0.61$), restaurant (χ^2 (4, $N = 251$) = 90.50, $p < .001$, $V = 0.60$), retail/grocery store (χ^2 (4, $N = 275$) = 108.30, $p < .001$, $V = 0.63$), medical appointment (χ^2 (4, $N = 265$) = 101.81, $p < .001$, $V = 0.62$), family reunion (χ^2 (4, $N = 257$) = 39.11, $p < .001$, $V = 0.39$), conversation with clients (χ^2 (4, $N = 180$) = 47.51, $p < .001$, $V = 0.51$), and conversation with co-workers (χ^2 (4, $N = 169$) = 70.43, $p < .001$, $V = 0.65$). The effect sizes were medium regarding the frequency of negative emotions for a restaurant, a family reunion, and a conversation with clients, while they were large for a drug store, a retail/grocery store, a medical appointment, and a conversation with co-workers.

Supplemental analyses regarding the impact of protective measures, annoyance and frequency of communication breakdowns, participation restrictions and negative emotions are available in Supplementary Material 2. Finally, for those participants who were employed, significantly more participants in the HL group than in the NH group reported that COVID-19 protective measures negatively affected their performance in the workplace (χ^2 (4, $N = 185$) = 13.87, $p = .008$, $V = 0.27$). For instance, while 22.3% of participants in the NH group reported their performance to be affected, this proportion was 40.2% in the HL group. Significantly more participants in the HL group than in the NH group reported that protective measures increased their risk of a workplace accident (χ^2 (4, $N = 181$) = 15.02, $p = .005$, $V = 0.29$). Proportions of participants reporting to be more at risk were 3.0% in the NH group and 11.4% in the HL group. The effect sizes were medium.

3.3. Communication strategies

Open-ended responses regarding communication strategies used to offset COVID-19 protection measures were analysed using qualitative content analysis. A summary of this analysis is presented in Table 2. Compared to the NH participants (24%), a larger proportion of participants with hearing loss (43%) reported using anticipation strategies to improve communication with COVID-19 protective measures. Contrastingly, the proportion of participants who reported using repair strategies was higher in the NH group than in the HL group (56% and 38%, respectively). The proportion of participants using maintenance strategies was similar in both groups (19% for the HL group and 20% for the NH group).

3.4. Telecommunication

Participants were questioned on their use, perceived effectiveness and satisfaction with videoconference, telephone, text messages, and emails during the COVID-19 pandemic. Challenges experienced by participants while using these technologies were accessed through open-ended questions.

Table 2. The theme, categories, and exemplar quotes in response to the question regarding communication strategies used to improve communication.

Themes	Categories	Examples of quotes
Communication strategies	Anticipation	• I increase the volume of my hearing aids before a conversation.
		• I make it clear that I have hearing problems, and that I can't understand certain words.
		• I bought masks with a plastic window, and I give one to the person I need to understand.
		• I travel with someone who can help me when I don't understand (my spouse, son, or daughter).
		• I wear a badge indicating that I am hearing impaired.
	Repair	• I must ask to repeat.
		• I ask the other person to speak louder.
		• I ask the other person to remove his mask to allow me to read on his lips.
		• I turn my head and bring my ear near the plexiglass (fixed plastic partition).
	Maintenance	• I reformulate the message as I understood it for validation.
		• I use to other person's body language to better understand.
		• I use the context (for example, looking at the transaction total on the cash register rather than listening).
		• I use an application on my cell phone which transcribes the speech of my interlocutor.

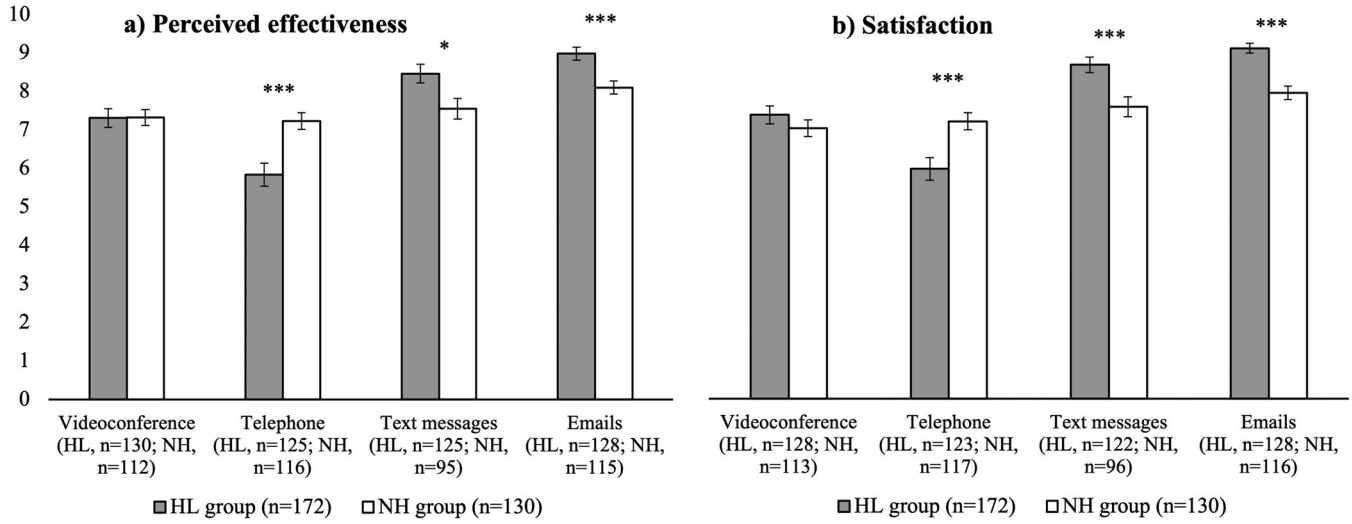

Figure 3. Telecommunication (videoconference, telephone, text messages, and emails) ratings on a 10-point scale (0 is totally ineffective or unsatisfied, while 10 is extremely effective or satisfied): (a) Perceived effectiveness; (b) Satisfaction. Error bars denote standard errors. The "n" represents the total number of participants that responded to the specific question. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

No significant difference between groups was observed regarding the frequency of use of videoconference (χ^2 (5, $N = 247$) = 10.19, $p = .070$, $V = 0.20$) and emails (χ^2 (5, $N = 247$) = 1.02, $p = .961$, $V = 0.06$). On the other hand, participants with hearing loss reported using the telephone much less frequently (χ^2 (5, $N = 250$) = 17.61, $p = .003$, $V = 0.27$) and using more frequently text messages (χ^2 (5, $N = 242$) = 14.33, $p = .014$, $V = 0.24$) than NH participants. The perceived effectiveness of telecommunication technologies (Figure 3a) was similar between groups for videoconference (t (240) = 0.04, $p = .966$, $d = 0.01$) but were significantly different for telephone (t (239) = 3.74, $p < .001$, $d = 0.48$), text messages (t (218) = −2.54, $p = .012$, $d = 0.35$) and emails (t (241) = −3.62, $p < .001$, $d = 0.47$). Participants in the HL group reported higher perceived effectiveness for text messages and emails and lower perceived effectiveness for the telephone. Similar differences between groups were obtained regarding satisfaction (Figure 3b): telephone (t (238) = 3.34, $p < .001$, $d = 0.43$), text messages (t (216) = −3.31, $p = .001$, $d = 0.45$) and emails (t (242) = −5.43, $p < .001$, $d = 0.67$). With regards to videoconference, no difference in satisfaction was observed between groups (t (239) = −1.12, $p = .266$, $d = 0.14$). Participants in the HL group reported higher satisfaction with communication through text messages and emails, and lower satisfaction with telephone. The effect sizes were medium.

To investigate possible interactions between groups and telecommunication technologies (effectiveness and satisfaction), two 2-way repeated measures ANOVAs were conducted. The analyses revealed a significant "group" × "technology" interaction for perceived effectiveness (F (1, 612) = 14.36, $p < .001$, $\eta^2 = 0.07$) and satisfaction scores (F (1, 603) = 17.07, $p < .001$, $\eta^2 = 0.08$). The effect sizes were medium. Post-hoc t-tests with a Bonferroni correction were conducted to reveal the nature of these interactions. Regarding the perceived effectiveness, a significant difference was observed between videoconference and emails ($\Delta = 0.804$, $p = .041$, 95%CI = [0.019, 1.589]) for the NH group, while significant differences were observed among all technologies for the HL group; videoconference and telephone ($\Delta = 1.711$, $p < .001$, 95%CI = [0.898, 2.523]), videoconference and text messages ($\Delta = -0.886$, $p < .029$, 95%CI = [−1.714, −0.058]), videoconference and emails ($\Delta = -1.526$, $p < .001$, 95%CI = [−2.231, −0.821]), telephone and text messages ($\Delta = -2.596$, $p < .001$, 95%CI = [−3.492, −1.701]), telephone and emails ($\Delta = -3.327$, $p < .001$, 95%CI = [−4.017, −2.457]) and text messages and emails ($\Delta = -0.640$, $p = .019$, 95%CI = [−1.210, −0.070]). Regarding satisfaction with telecommunication technologies, a significant difference was observed between videoconference and emails ($\Delta = -0.989$, $p = .002$, 95%CI = [−1.715, −0.264]) for the NH group. Significant differences were observed among all technologies for the HL group; videoconference and telephone ($\Delta = 1.627$, $p < .001$, 95%CI = [0.826, 2.249]), videoconference and text messages ($\Delta = -1.091$, $p = .029$, 95%CI = [−1.861, −0.320]), videoconference and emails ($\Delta = -1.636$, $p < .001$, 95%CI = [−2.304, −0.969]), telephone and text messages ($\Delta = -2.718$, $p < .001$, 95%CI = [−3.604, −1.832]), telephone and emails ($\Delta = -3.264$, $p < .001$, 95%CI = [−4.029, −2.498]) and text messages and emails ($\Delta = -0.545$, $p = .023$, 95%CI = [−1.042, −0.049]).

In general, we observed that while effectiveness and satisfaction in the NH group were relatively similar across telecommunication technologies, the HL group reported lower effectiveness and satisfaction for technologies that involved hearing (i.e. videoconference and telephone). Higher ratings were observed when the technology used relied solely on vision (i.e. text messages and emails).

Finally, challenges experienced by participants with the use of telecommunication technologies were assessed. The emerging themes and categories are shown in Tables 3 and 4. Three themes associated with communicating using videoconference and telephone emerged:

1. Communicational: This theme refers to challenges in communication with videoconference and telephone and changes in the way the participants communicate. It is divided into three categories according to types of communication strategies (i.e. anticipation, repair, maintenance).
2. Psychosocial: This theme refers to the cognitive and emotional challenges in the use of videoconference and telephone. The challenges reported were mainly related to fatigue, unpleasant experiences with the use of technology and negative aspects of being continuously watched.

Table 3. Themes, categories, and exemplar quote in response to the question regarding challenges or experiences while using videoconference and telephone.

Themes	Categories	Examples of quotes
Communicational	Anticipation	• I have difficulty with the speaking turn. • People make sentences that are too long and if there is no moderator, it is difficult to know who is speaking.
	Repair	• Since I can't see the person, I do a lot of mental gymnastics to supplement what I haven't heard. • I have difficulty reading on the lips because of the delay between the auditory and visual signals.
	Maintenance	• Not everyone opens their webcam. I cannot always do lip reading. • I have little access to the non-verbal communication of others.
Psychosocial	Cognitive factors	• It is very demanding in energy. It is demanding in technological, structural, but also auditory adaptation. • I fatigue quickly. I lose my attention more easily than in person.
	Emotions	• This type of technology is often frustrating because the meetings are much less dynamic and motivating. Also, in all contexts of interaction, there is a relational distance that is inherently unpleasant. • I always need to be aware that I am being constantly watched.
Technological	Usage/Organisational	• The difficulties are not in communication but in learning to use this tool. • The internet connection stability is not always good. • It is difficult to have access to the necessary equipment.
	Sound quality	• The sound signal is sub-optimal, and I have difficulties when a person has competitive noise. • Some individuals don't have a good quality microphone which gives me difficulties to understand correctly. • My speaker is not of a good quality.

Table 4. Themes, categories, and exemplar quote in response to the question regarding challenges or experiences while using text messages and emails.

Themes	Categories	Examples of quotes
Message	Interpretation	• These technologies do not easily convey the tone, which causes misinterpretations. • I cannot easily go into the details of a topic.
	Length of message	• Messages are too short to express my thought. • Information must be transmitted relatively succinctly and in writing, so some longer or more complex conversations are difficult to conduct using this technology.
	Duration	• It takes longer to write than if we speak to each other directly. • It sometimes requires several exchanges to make your point clearly understood on both sides. Therefore, it prolongs the time of the exchanges.
Technological		• It's long because as you get older the fingers are less skilled and the keys are small. • When I send a message, it is long to get an answer. • These technologies are sometimes not easily accessible and easy to use (especially for older people).

3. Technological: This theme is associated with technological challenges associated with communicating by telephone and videoconference. It included difficulties in learning to use different platforms and the quality of the internet connection, the equipment and the sound signal.

Two themes associated with communicating using emails and text messages emerged:

1. Message: This theme is associated with challenges related to the interpretation or the length of the message, and the time needed for communicating. Additional challenges included the difficulty to convey tone and the frequent misinterpretation of the messages and not being able to have complex and lengthy conversations.
2. Technological: This theme is associated with challenges in the technological aspect of communication with text messages and emails. It includes difficulties in accessibility to the devices needed to communicate, the dexterity to manipulate these devices and technology overload.

4. Discussion

4.1. Communication breakdowns and psychosocial effects

While it is well known that face masks can have a deleterious effect on speech acoustics (Corey, Jones, and Singer 2020; Goldin, Weinstein, and Shiman 2020), and speech reading (Atcherson et al. 2017; Trecca, Gelardi, and Cassano 2020), our study confirms that combined protective measures associated with the COVID-19 pandemic can have consequences far more important for individuals with hearing loss. In different everyday settings, individuals with a hearing loss reported significantly more impact from protective measures on their communication than individuals without a hearing loss. They also reported being significantly more annoyed by communication breakdowns. These results support those obtained in other countries, such as in the England and Scotland (Saunders, Jackson, and Visram 2021; Naylor, Burke, and Holman 2020).

Hearing loss has been found to reduce the quality of social interactions, which can ultimately lead to social isolation and poor quality of life (Mosnier et al. 2018). In our study, we found that the increased communication breakdowns caused by combined pandemic protective measures can lead to a higher incidence of participation restrictions and negative emotions, depending on the environment in which verbal exchanges occur. These proportions are significantly more important than what is observed for normal hearing individuals. These results clearly indicate that protective measures can have effects that extend beyond speech understanding for individuals with hearing loss and can have a negative effect on their mental health. We can hypothesise that if a pandemic situation was to continue over time, an increase in social isolation in this population could be observed. Considering that individuals with hearing loss are already at risk for social isolation (Shukla et al. 2020), this could lead to profound impacts on their quality of life and put them at greater risk of mental health problems.

Our results also reveal differences in the impact of COVID-19 protective measures on communication and the annoyance of

communication breakdowns according to the activity in which individuals are involved. Situations where more measures are in place (e.g. face mask, fixed plastic partition and physical distancing at the cash registers of a grocery store) and where there is background noise (e.g. in a drug store and a restaurant) are more problematic than settings where conversations can be carried one-on-one and in a quieter environment (e.g. the office of a health care provider and a family reunion). We can also hypothesise, based on the open-ended responses provided by participants, that protective measures are less likely to be strictly used in medical appointments and family reunions. For instance, participants reported that the health care professional often used face masks with a plastic window or removed their masks when they were at a sufficient distance, while it is likely that protective measures were more infrequent during family reunions. Although face masks with a plastic window reduce sound levels up to 14 dB (Corey, Jones, and Singer 2020), it has been demonstrated that individuals with a hearing impairment benefit from the visual input permitted with the transparent mask (Atcherson et al. 2017). Transparent face masks have been recommended in health care and school settings to optimise communication (Wolfe et al. 2020), which explains why many of the participants in our study reported being exposed to this type of mask during medical appointments.

4.2. Communication strategies

Using an open-ended question, we assessed the communication strategies used by individuals with and without hearing loss. While the same proportion of participants used maintenance strategies, individuals with a hearing loss relied more on anticipation strategies while those without a hearing loss used more repair strategies. This finding suggests that during a pandemic, people with hearing difficulties expect to have more difficulty communicating. Thus, they may feel more compelled to use strategies to avoid communication breakdowns. This is less likely for individuals with normal hearing since they don't usually experience hearing difficulties when communicating. They might be less familiar with the use of anticipation strategies and rely mostly on repair strategies to overcome communication breakdowns. Illustrations of this phenomenon were observed in the open-ended responses provided by our participants regarding communication at the retail/grocery store. Participants with hearing loss reported that they increased the volume of their hearing aids and informed the cashier of their hearing difficulties (either verbally, or by wearing a badge). On the other hand, participants without a hearing loss did not anticipate the occurrence of communication breakdowns and relied mainly on asking the cashier to speak louder or to repeat what was said.

Another interesting finding is the nature of some of the strategies reported. Individuals with hearing loss reported asking their interlocutor to remove their mask to allow them to lipread or they requested that they reduce the distance separating them. These strategies may reduce the occurrence of communication breakdowns. However, as a result of implementing these strategies, individuals with hearing loss may be at a higher risk of being infected during a pandemic. Therefore, some communication strategies that are known to be effective in optimising communication in normal circumstances may not be recommended during a pandemic. The present results provide valuable information for audiologists and other health care professionals regarding the type of strategies to recommend to their patients.

4.3. Telecommunication

When the perceived effectiveness and satisfaction of telecommunication technologies (i.e. videoconference, telephone, text messages, emails) were assessed, we found that the HL group reported lower effectiveness and satisfaction ratings for technologies that used an auditory modality and higher ratings for those who relied solely on a visual modality. Based on the challenges reported by our participants, this might be explained by difficulties to maintain the speaking turn, sub-optimal acoustic signal, and not being able to see the face and the lips of the interlocutor.

In a previous study, telephone and videoconference were perceived inferior to face-to-face communication by individuals with hearing loss (Naylor, Burke, and Holman 2020). Our results show that during in-person activities in a pandemic, individuals with hearing loss experience frequent communication breakdowns. Consequently, they may refrain from taking part in some activities. Therefore, many participants with hearing loss reported that telecommunication technologies were helpful in preventing social isolation and allowing for effective communication in certain situations (e.g. with co-workers, for a medical appointment, with family members).

4.4. Limitations

Our study has some limitations. First, we asked participants to report whether they had received a diagnosis of hearing loss. For data collected using an online survey strategy, this makes it possible to classify participants based on their hearing status and thus examine the effects of hearing loss on the variables of interest. However, responses to survey questions cannot be cross-validated. Therefore, it is possible that some NH participants were not conscious of the fact that they had mild or moderate hearing loss.

Second, for some socio-demographic variables (i.e. age, employment status, marital status, educational level, self-perceived health status, family income) significant differences were observed between the two groups. It is known that gender and age can have a modifying effect on the relationship between marital status and depression (Bulloch et al. 2017). Low socio-economic status has been associated with a higher prevalence of depression (Lorant et al. 2003). Older adults with age-related hearing loss also exhibit more depressive symptoms (Brewster et al. 2018). Therefore, the differences between groups regarding these variables could influence the responses provided by participants regarding the psychosocial consequences of communication breakdowns during the COVID-19 pandemic. Also, participants in our study were mainly women (80% in both groups). It is possible that the response pattern of our survey may differ between female and male participants, based on the difference in hearing loss risks/outcomes and coping strategies (e.g. Staehelin et al. 2011; Gattino, Rollero, and De Piccoli 2015). Because the number of males who took part in the study was small, it was not possible to conduct supplemental analyses. Therefore, it is not possible to generalise the present findings to the male population.

Finally, our study was conducted over the course of an entire year (August 2020 to June 2021). Over this period, the use of COVID-19 protective measures has changed. For instance, at the beginning of our study, face masks were not mandatory. By the end of our study, the use of face masks was mandatory and fixed plastic partitions were widely used in public spaces. These

differences in the protective measures being used over time could have tainted the responses of our participants according to when they responded to the survey.

5. Conclusion

Results show that, compared to their peers with normal hearing, individuals with hearing loss reported significantly more negative impacts and annoyance due to communication breakdowns attributable to the use of COVID-19 protective measures. They also reported significantly more participation restrictions and negative emotions. These results provide an overview of the communication difficulties experienced and their psychosocial effects among individuals with hearing loss during the COVID-19 pandemic. They also suggest that the increased communication difficulties caused by protective measures may have a negative effect on one's mental health, especially for individuals with hearing loss. While many communication strategies are used by individuals with hearing loss, some of these strategies might put them more at risk to be infected by COVID-19. Finally, perceived effectiveness and satisfaction associated with the use of telecommunication technologies that permit the use of visual information (i.e. reading and speechreading) were higher for individuals with hearing loss. Our study provides valuable information for hearing care professionals who can advise their patients to use safe and effective communication strategies to optimise communication during a pandemic.

Ethics statement

The study was approved by the aging-neuroimaging research ethics committee of the CIUSSS du Centre-Sud-de-l'Île-de-Montréal (CER VN 20-21-16; 2020-07-22).

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Author contributions

Conceptualisation, A.P.S., M.H., A.S., R.C., J.P.G. and A.L.; methodology, A.P.S., M.H., A.S., J.P.G. and A.L.; formal analysis, A.P.S., L.C., and E.T.; investigation, A.P.S., L.C. and E.T.; writing—original draft preparation, A.P.S.; writing—review and editing, M.H., A.S., R.C., A.I.A., J.P.G., and A.L.; coordination, A.P.S.; project administration, M.H., A.L.; funding acquisition, A.L, M.H. and J.P.G. All authors have read and agreed to the published version of the manuscript.

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