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Abstract

The objective of this paper was to describe the current state of speech-language pathology (S-LP) services in youth justice and to form recommendations for S-LP involvement within this population in Canada as a critical preventative and rehabilitative measure. This rapid-scoping review used a systematic search of applicable databases, including relevant grey literature. Included resources were published in English from 2000 to the present and focused on defendants under 18 years at any stage in the youth justice system. The final sample included 19 research articles and 11 additional grey literature resources. Findings were organized into two main categories: a) descriptions of existing S-LP roles in youth justice internationally, and b) S-LP-related research. Recommendations for S-LP involvement in Canada include an S-LP-guided community referral system to connect youth at risk for communication impairments to appropriate services; S-LP communication screening upon detention, with assessment and intervention postsentencing; inclusion of S-LPs in planning and execution of recidivism prevention and transition programs; training for justice and law enforcement personnel regarding the communication challenges experienced by youth in the justice system; and an increase in the use of communication intermediaries. S-LPs can play a critical role in the youth justice system by encouraging and supporting effective communication and full participation. A cohesive action plan that includes S-LP services in Canada is needed to improve health and well-being outcomes of youth in the justice system, at-risk youth, and the community.

Abrégé

L'objectif du présent article était de décrire l'état actuel des services d'orthophonie dans le système de justice pour les jeunes et de formuler des recommandations concernant la participation des orthophonistes auprès de la population en contact avec le système de justice canadien, et ce, puisqu'il s'agit d'une mesure essentielle de prévention et de réadaptation. Une recherche systématique des bases de données pertinentes et de la littérature grise a été réalisée dans cette revue exploratoire sommaire. Les ressources retenues ont été publiées en anglais entre 2000 et ce jour et portaient sur les accusés âgés de moins de 18 ans en contact avec le système de justice pour les jeunes (peu importe l'étape). L'échantillon final comprenait 19 articles de recherche et 11 ressources tirées de la littérature grise. Les résultats de ces articles et ressources grises ont été classés selon les deux catégories principales suivantes : a) la description du rôle des orthophonistes dans les systèmes de justice pour les jeunes internationaux et b) la recherche en lien avec l'orthophonie. Les recommandations concernant la participation des orthophonistes dans le système de justice pour les jeunes canadien incluent : un système de référence dirigé par des orthophonistes afin d'orienter les jeunes à risque vers des services adaptés; un dépistage orthophonique au moment de la détention, ainsi que des services d'évaluation et d'intervention après le dépistage; l'inclusion d'orthophonistes au moment de planifier et d'exécuter les programmes encadrant les récidives et les transitions; la formation du personnel du système de justice et des services de police concernant les problèmes de communication rencontrés par les jeunes dans le système judiciaire; et une augmentation de l'utilisation d'intermédiaires de communication. Les orthophonistes peuvent jouer un rôle important dans le système de justice pour les jeunes en encourageant et en soutenant une communication efficace et une participation active. Un plan d'action cohérent et qui intègre les services des orthophonistes est nécessaire pour améliorer la santé et le bien-être des jeunes en contact avec le système de justice, de ceux à risque et de la collectivité.

Communication disorders are defined as impairments in speech, language, or hearing that can significantly affect an individual's literacy and day-to-day functioning in all aspects of school, work, and community life (Holland, 2015; Hughes et al., 2012). It is estimated that up to 12% of children have a communication disorder (McLeod & McKinnon, 2007), which does not include communication challenges related to learning disability, hearing loss, or low literacy. Given the wide-ranging negative consequences of communication challenges early in life, the estimated 10% prevalence of communication disorders is a significant concern. This number is eclipsed, however, by the prevalence of communication disorders among young people in the criminal justice system.

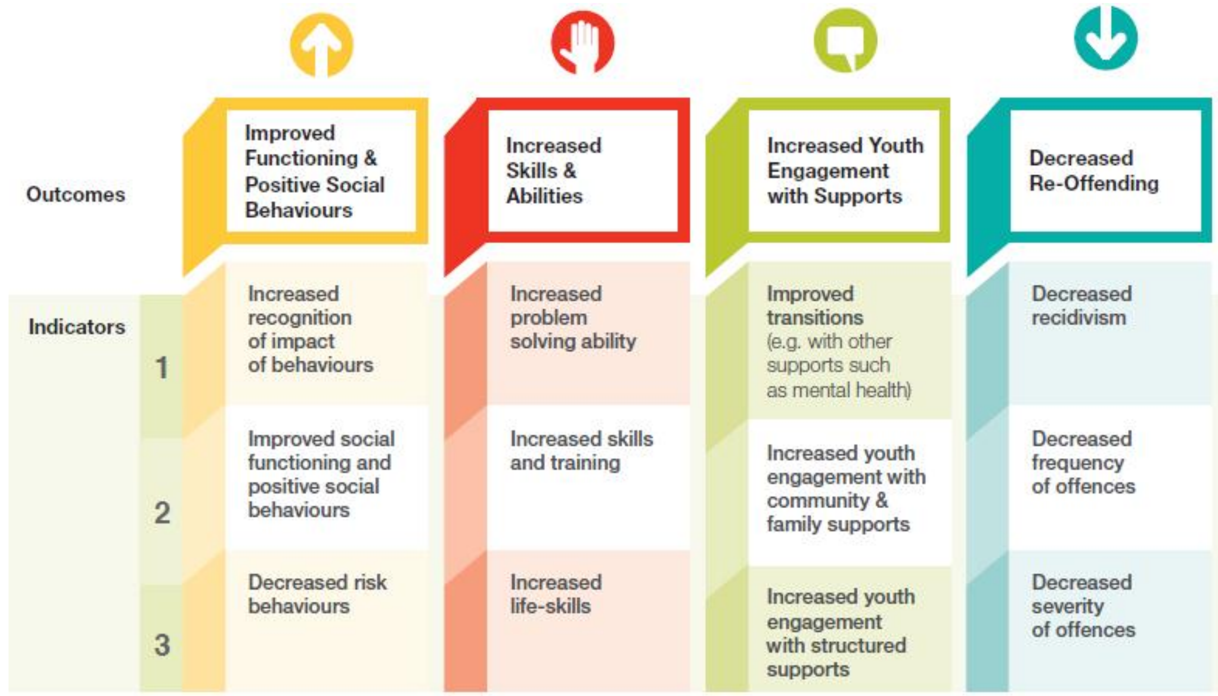
The prevalence of communication disorders among youth in the justice system has been estimated to be as high as 60%–90% (Bryan et al., 2007; Gregory & Bryan, 2011). This number is likely an underestimate, however, as communication disorders are often missed in this setting (Gregory & Bryan, 2011; Snow, 2019; Sowerbutts et al., 2021). Sowerbutts et al. (2021) reported that a "substantial number" (p. 87) of youth in the criminal justice system present with undiagnosed developmental language disorder. In the United Kingdom, Gregory and Bryan (2011) screened all youth described as "persistent and prolific offenders" (p. 202) who were sentenced to the Intensive Supervision and Surveillance Programme (ISSP) over a 12-month period. Sixty-five percent of those screened had indications of language difficulties requiring further evaluation, including 20% with severe language delay, and as a cohort, their language abilities were reported to be below those of the general population (Gregory and Bryan, 2011). Youth in the justice system have low literacy rates and high rates of early school dropout (Bryan et al., 2007; I CAN & Royal College of Speech and Language Therapists, 2018; Snow & Powell, 2011; Snowling et al., 2000), further suggesting undiagnosed language problems long before the first contact with the justice system. Communication deficits can also be misdiagnosed as mental health disorders (Bryan et al., 2007; Hughes et al., 2012; Snow, 2019; Snow et al., 2016; Stanford, 2019), contributing to underdiagnosis and lack of referral for appropriate supports (Hughes et al., 2012; Stanford, 2019).

Youth involved in criminal justice can have deficits in both understanding and expressing language, especially in interpersonal interactions (Gregory & Bryan, 2011; Hughes et al., 2012; Snow, 2019). Young offenders also may have impairments in cognitive functions that are critical for effective communication, such as executive functions and their derivatives (e.g., verbal reasoning, control of attention; Hughes et al., 2012). Cognitive-communication disorders are likely to be particularly prevalent in youth with autism spectrum disorders and traumatic brain injury, who are overrepresented in the justice system (Chiacchia, 2016; Hughes et al., 2012). The prevalence of autism spectrum disorder and traumatic brain injury in youth justice is unsurprising, as behavioural features common to both diagnoses, including reduced empathy, poor abstract reasoning, misunderstanding of social cues, and social naivety, can predispose these youth to offend (Hughes et al., 2012). These comorbidities and intersectionalities complicate the identification of communication disorders.

Communication disorders put young people at high risk for negative consequences at every stage of their contact with the criminal justice system (Bryan et al., 2007; Snow, 2019; Snow et al., 2016, 2018), from initial contacts with police (Wszalek & Turkstra, 2015) to interactions with lawyers (Bryan et al., 2007), to their ability to comprehend and engage in the legal process and accurately present themselves to the court (Hughes et al., 2012; Snow et al., 2012). Forensic interviewing in particular requires strong skills in communication, the ability to produce and understand narrative discourse, and perspective-taking (Hughes et al., 2012; Snow et al., 2012), all of which are common areas of impairment in young people with communication disorders. Not only do communication deficits negatively influence the trajectory of youth within the system, but they may also influence future outcomes, such as increasing risk of reoffending (Bryan et al., 2007; Hughes et al., 2012; Snow, 2019; Snow et al., 2018). Communication disorders also may result in difficulty engaging and complying with noncourt or extrajudicial programs designed to reduce recidivism rates (Gregory & Bryan, 2011). The presence of developmental language disorder specifically has been found to play a significant role in youth recidivism, as youth who have offended and have developmental language disorder are more than twice as likely to reoffend as those without it (Winstanley et al., 2021).

The Youth Criminal Justice Act (2002) was amended in Canada in 2013 to increase noncourt responses to minor offences. The Act states that families, youth, and the justice system should work together to provide youth with meaningful consequences, rehabilitation, and reintegration (Department of Justice, 2013). Aligning with the Act, the Ontario Ministry of Children and Youth Services (now the Ontario Ministry of Children, Community and Social Services; 2014) developed a youth justice outcomes framework (**Figure 1**). The framework identifies four key outcomes for youth within the justice system: improved functioning and positive social behaviours,

Figure 1



Youth justice outcomes framework

Note. From "Youth Justice Outcomes Framework," by the Ontario Ministry of Children and Youth Services [now the Ministry of Children, Community, and Social Services], 2014. Copyright Ontario Ministry of Children, Community and Social Services. Reprinted with permission.

increased skills and abilities, increased youth engagement with supports, and decreased reoffending.

Communication disorders and supports are relevant to multiple aspects of the youth justice outcomes framework. For example, social communication impairments may result in youth being unable to recognize the impact of their behaviours on others or to demonstrate that they recognize this impact, to demonstrate positive social behaviours, and to refrain from high-risk behaviours because they miss critical social cues. In this example, the key outcome of improved functioning and positive social behaviours would be less likely. Young people with communication challenges may be less able to show positive indicators, such as increased youth engagement with structured support, improved transitions, and decreased recidivism. For example, extrajudicial programs in Ontario include participation in multiperson spoken conferences and writing apologetic letters or essays (Justice for Children and Youth, n.d.). Successful completion of these activities relies on adequate language comprehension and expression, and without this, young defendants may fail in these programs. Overall, communication problems can reduce the likelihood of achieving target outcomes of increased youth engagement with supports and decreased reoffending.

The high prevalence of language impairments among youth in the justice system and the consequences of under- and mis-diagnosis support the need for speech-language pathologist (S-LP) involvement in youth justice (I CAN & Royal College of Speech and Language Therapists, 2018; Snow, 2019; Snow et al., 2012, 2018; Stanford, 2019), as a way to both improve outcomes and address health inequities, important aims of the Canadian Health Act (1985). S-LPs are regulated health professionals who identify, diagnose, and treat communication and swallowing disorders across the lifespan (Speech-Language & Audiology Canada, 2016). S-LPs can play a critical role in supporting young people as they navigate the criminal justice system, beginning with screening for communication disorders and including intervention, referral, and serving as a communication intermediary in judicial processes (Gregory & Bryan, 2011; Snow et al., 2016). The declaration of principle in the Youth Criminal Justice Act (2002) states, "The youth justice system is intended to protect the public by promoting the rehabilitation and reintegration of young persons" (Department of Justice, 2013, p. 2). The Youth Criminal Justice Act states that a youth justice court "may make an intensive rehabilitative custody and supervision order if . . . a plan of treatment and intensive supervision has been developed for the young person" (s. 42[7]), but specific services such as S-LP are not listed. This is also true of the Canada Health Act (1985), which states a priority of "protecting, promoting and restoring the physical and mental health and well-being of residents to Canada and to facilitate reasonable access to health services without financial or other barriers" (s. 3), but does not specify those health services.

Given the high prevalence and costs of communication challenges for youth in the criminal justice system, and the potential for S-LP services to improve critical outcomes, we asked if S-LPs are playing a role in the Canadian youth justice system and, if not, what that role should be. Thus, this review aimed to both describe the state of S-LP services and make recommendations for the future, as a critical preventative and rehabilitative measure.

Methods

We conducted a rapid scoping review following the methodological framework of Arksey and O'Malley (2005), adapted to include recommendations by Levac et al. (2010). This allowed for extraction of a wide range of information including various study designs (Arksey & O'Malley, 2005), which was appropriate for a review that would include grey literature such as policy documents.

We included literature that was published in English in or after 2000, to capture recent public and government documents, and focused on defendants under 18 years of age in any stage of the youth justice system (from arrest to final disposition). We excluded studies that did not discuss the role of the S-LP.

We identified relevant peer-reviewed articles using the search strategy and keywords outlined in **Figure 2**. The search was conducted in Embase, Medline, and CINAHL. Health-related databases were selected to yield articles relevant to S-LP. The initial search yielded 102 articles. Following the Level 1 screening process, resulting articles were screened for relevance based on title, abstract, and keywords, yielding 21 articles. During Level 2 screening, full texts of these articles were reviewed by two authors for relevance. Subsequently, an additional two articles were eliminated, resulting in 19 articles. Given the nature of the topic, grey literature was also reviewed, including government/technical reports and professional organization documents such as newsletters, blogs, and guidelines.

Results

Of the 19 identified articles, four were from the United Kingdom, four from the United States, 10 from Australia, one from New Zealand, and none from Canada. Searches of government sources and grey literature revealed an additional 11 documents: three from the United Kingdom, one from the United States, five from Australia, and two from Canada. Across the documents, S-LPs were referred to as *speech-language pathologists, speech therapists, speech-language therapists,* or *speech pathologists*. We use the acronym S-LP in this paper for consistency. Findings were divided into two sections: a) descriptions of existing S-LP roles in youth justice; and b) S-LP-related research, e.g., studies of the prevalence of communication disorders and studies aiming to demonstrate feasibility or effectiveness of S-LP services.

Section 1: Descriptions of Existing S-LP Roles

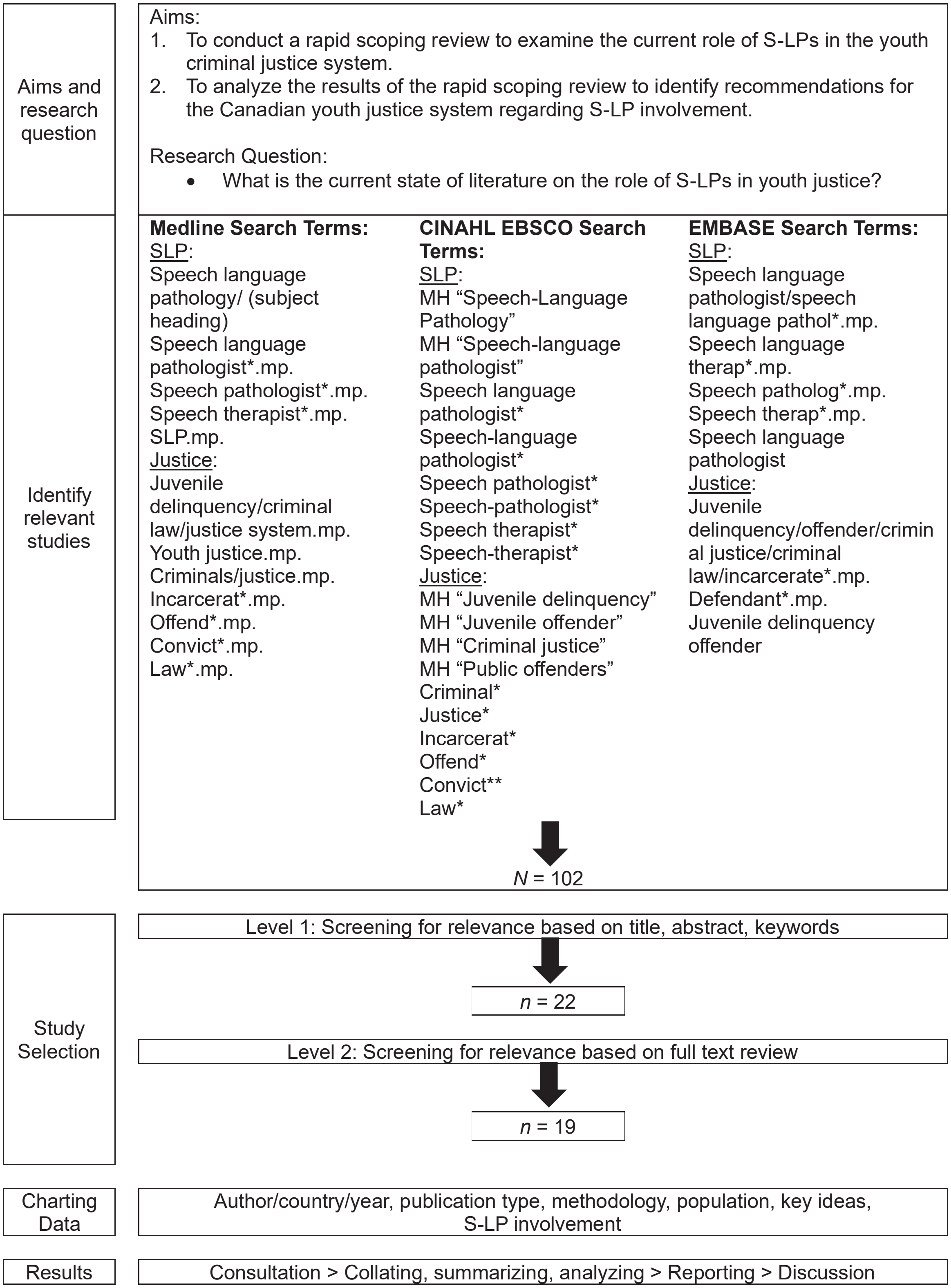
Screening and Assessment

S-LPs have played a role in the screening and assessment of youth offenders in Australia, the United Kingdom, and the United States. Martin (2019a) stated that S-LPs in Queensland, Australia were involved in one-to-one, individualized assessments of language for juvenile offenders. After the assessments, S-LPs created comprehensive communication reports that could be provided to the various parties involved in the justice system (Martin, 2019a).

In the United Kingdom, the Royal College of Speech and Language Therapists (Coles et al., 2017) declared that all youth in the justice system should receive screening and/or assessment of their speech, language, and communication needs from a qualified S-LP. This screening and/or assessment would include either the community or custodial version of the Comprehensive Health Assessment Tool (Chitsabesan et al., 2014), which had been mandated for youth entering custody in England and Wales. S-LPs also would administer the AssetPlus (Youth Justice Board, 2014), a speech, language, and neuro-disability screening tool that had been mandated within England and Wales for youth who would be in contact with any youth offending service (Coles et al., 2017).

In the United States, Stanford (2019) reported that her role as a juvenile forensic S-LP included conducting specialized speech and language forensic assessments and generating detailed reports. The reports described how the communication impairments of each young person could impact their behaviors, ability to make decisions, and actions that were the subject of the offense.

Figure 2



Flowchart detailing the scoping review process of the role of S-LP in the Canadian justice system

Note. Based on the framework outlined in "Scoping Studies: Towards a Methodological Framework," by H. Arksey and L. O'Malley, 2005, *International Journal of Social Research Methodology, 8*(1), 19–32 (https://doi.org/10.1080/1364557032000119616). Copyright Taylor & Francis.

Training Staff

S-LPs were involved in training youth justice system staff in some areas of Australia and the United Kingdom. Martin (2019b) reported that one role of the S-LP was to advocate for S-LP services by educating justice staff during information sessions or participating in staff and executive meetings. S-LPs also provided workshops for staff focusing on how to support young people who may have communication difficulties, including topics such as how to modify written documents to increase access for youth. Martin (2019a) emphasized the importance of collaborative practice between S-LPs and justice staff to connect and coordinate services, to promote a smooth transition between custody and the community. Speech Pathology Australia (2013) also reported that they assisted in developing training guidelines for police and other workers involved in youth justice, to support youth in their participation in and understanding of the justice system.

The Royal College of Speech and Language Therapists (Coles et al., 2017) emphasized the S-LP's role in training staff by helping them recognize and respond to speech, language, and communication needs. S-LPs also provided staff with strategies and recommendations following assessment of a young person (Coles et al., 2017). Results of a survey by The Communication Trust (2014) revealed that training of the youth offending team was most effective when provided face-to-face by S-LPs. The Royal College of Speech and Language Therapists developed a training program called "Mind Your Words" (https://www.rcslt.org/learning/mind-your-words/) designed to improve the understanding of children and young people with social, emotional, and mental health needs and speech, language, and communication needs. This series of online and publicly available courses included one specifically for justice professionals, called "The BOX."

Direct Intervention

S-LPs have provided direct intervention to youth offenders in the United Kingdom, Australia, and the United States. In the United Kingdom, S-LPs have been routinely employed by youth offender teams (Snow et al., 2015; Snow & Woodward, 2017). Direct services provided by S-LPs within these teams included one-to-one, paired, or group intervention services; and targeted skills such as narratives, social communication, vocabulary, time concepts, and strategy use (Coles et al., 2017; Royal College of Speech and Language Therapists, n.d.).

In Australia, there had been progress in S-LP-provided youth justice services over several years prior to a 2017 report (Snow & Woodward, 2017), but services had not yet reached the level of existing models in the United Kingdom. The first full-time youth justice S-LP in Australia was employed in 2014 at the Parkville Youth Justice Centre, a government school in Victoria, Australia, that educates young people in custody (Caire, 2014; Snow et al., 2015). More recently, S-LP services in youth justice extended to Queensland, Australia, with six S-LPs employed by the Queensland youth justice system, ensuring that young people in the justice system had direct access to S-LPs (Martin, 2019a, 2019b).

Evidence of direct S-LP intervention in the United States was difficult to locate. Snow and Woodward (2017) stated that they were unaware of any United States jurisdictions where S-LPs provided therapy services to young offenders. In a blog post in the American Speech-Language-Hearing Association publication, *The ASHA Leader*, Kerner (2016) outlined their previous role as an S-LP in a school system in Texas, United States. In this role, the author had the opportunity to provide S-LP services to incarcerated youth aged 14–17 who had been diagnosed with speech-language impairments. Treatment was provided while children were serving their sentences at the county residential centre, as the facility was part of the school district in which Kerner was employed. In providing services, Kerner was obligated to follow sets of rules from both the county residential centre and students' individualized education plans.

Also in *The ASHA Leader*, Stanford (2019) described her role as a juvenile forensic S-LP in the United States, primarily conducting assessments and writing reports. Stanford described a collaborative course entitled "Inside Out" she taught to seven master's and doctoral students and seven women incarcerated at a Washington, D.C., correctional treatment facility. The course targeted core social communication skills such as cultural communication differences, accents, dialects, and communication styles (Stanford, 2019). This course was considered to be part of the national Inside-Out prison exchange program, which partnered more than 300 university students and 400 incarcerated individuals nationwide (The Inside-Out Center, 2020). The Inside-Out program aimed to motivate future clinicians (outside) to create and deliver optimal restorative interventions to reduce recidivism risk, and to challenge offenders (inside) to strive for academic attainment while receiving educational support and mentorship (The Inside-Out Center, 2020). Overall, the evidence suggests some direct S-LP involvement within United States youth justice, but not a consistent system or process across states.

Communication Intermediaries

As described by the Royal College of Speech and Language Therapists (n.d.), a communication or registered intermediary is a trained professional who facilitates communication participation and engagement of vulnerable youth in court, including young people who are victims, witnesses, and suspects. The intermediaries function as neutral and impartial parties to assist communication between the young person and the court, legal teams, and police. The duty of the intermediary is to the court, ensuring that the communication process is as comprehensive and accurate as possible. Intermediaries were used in some courts in Australia, and S-LPs were involved as intermediaries in youth justice systems in the United Kingdom and Canada. In the United Kingdom, over 80% of registered intermediary services were provided by S-LPs. If a young offender presented with communication needs following S-LP-administered assessment, the S-LP's report included a recommendation for the individual to receive access to an intermediary in court (Coles et al., 2017).

In Canada, communication intermediaries are available through Communication Disabilities Access Canada (CDAC), a relatively new service compared to that in the United Kingdom (Birenbaum & Collier, 2017). CDAC is a national nonprofit organization with the vision of promoting human rights, accessibility, and inclusion for people with speech, language, or communication disabilities (Birenbaum & Collier, 2017). Part of the CDAC's mission is to provide all people with communication disabilities with equal rights to accommodations and support within the legal system. Communication intermediaries in Canada are required to be qualified S-LPs who have additional training from the CDAC. They are listed on provincial rosters managed by CDAC that are accessible to police and legal and justice professionals. Similar to the system in the United Kingdom, Canadian communication intermediaries provide assistance in police, legal, and justice processes, which can include assessment of communication, preparation of formal reports addressing individual communication needs and recommendations, and assistance in police interviews and throughout trial processes (Birenbaum & Collier, 2017). Although communication intermediaries are available in Canada at the time of this writing, there are barriers to widespread use, including lack of awareness of the service (Birenbaum & Collier, 2017). Unfortunately, this finding is consistent with what is reported in other jurisdictions. It is unclear if this is due to a lack of awareness, funding, or availability.

Section 2: S-LP Service-Related Research

Gregory and Bryan (2011) obtained pilot government funding to support a part-time S-LP to work 3.5 days per week for 17 months in the ISSP in the United Kingdom. The S-LP developed an individualized communication plan for each young person and discussed it with the youth's key youth justice worker in the facility. The authors noted that most staff had received no formal education or training related to communication, and they had diverse backgrounds and levels of education. The S-LP suggested resources, helped staff adapt resources, and was available to help staff support youth in their communication. The S-LP also provided direct intervention, but details were not provided and the cited source for those details was unpublished and not accessible online.

After the funding period, Bryan and Gregory (2013) surveyed and interviewed the ISSP staff about their experience working with the S-LP. The authors asked how S-LP input and the therapy they provided influenced ISSP delivery, and in general about staff members' experiences working with an S-LP. Staff reported that S-LP input was valuable and made a positive contribution to the ISSP, including helping young people comply with the program requirements. Some respondents reported initial skepticism about the usefulness of S-LPs, but after seeing how young people benefitted and learning how communication could affect behaviour, all supported regular S-LP involvement.

Snow and Woodward (2017) implemented a small-scale S-LP intervention in a secure youth justice facility in Australia. Intervention was delivered to six young males, for 12–16 weeks. The intervention was provided directly by an S-LP in a one-to-one setting, once or twice a week for 46–60 minutes. Treatment goals were created by the S-LP and individualized based on the young person's communication needs. Treatment duration and frequency were based on individual participant factors as well as uncontrollable institutional events (e.g., serious incidents requiring youth to be locked in their units for safety; Snow & Woodward, 2017). The S-LP intervention programs consisted of engaging activities of interest to the youth (e.g., writing rap songs) and were designed to improve awareness and insight of interpersonal difficulties (Snow et al., 2018). Posttreatment, the youth were reported to demonstrate increased confidence, communication skills, and positive behaviours. Additionally, staff recognized and supported the benefits of S-LP involvement within the youth justice setting (Snow et al., 2018). However, the generalizability of this study may be restricted due to the small sample size and limited setting (Snow et al., 2018; Snow & Woodward, 2017).

Also in Australia, Swain (2017) worked in a youth justice centre daily for 1 year, implementing a language intervention trial with four participants. In the intervention trial, one-to-one intervention was delivered by the S-LP, guided by individualized intervention plans. Results were not reported. Quinn and Swain (2018) conducted a single-case-study intervention for a transgender participant in a youth justice institution. Intensive voice feminization therapy was offered twice a day for 60 minutes each session over a 2-week period. This therapy plan included vocal function exercises, resonant voice therapy, and between-session practice. The participant noted an improvement from the negative feelings they felt about their voice preintervention. They expressed that the treatment was beneficial and they would be open to further therapy. However, the client experienced some difficulty implementing feminine speech strategies conversationally, resulting in inconsistent perceptions of their gender (Quinn & Swain, 2018). It is important to take into consideration that this study cannot be generalized to all youth justice populations due to the single-subject design. In addition, this study focused solely on voice, which is only one aspect of the S-LP's role.

The literature reviewed suggested six roles of S-LPs and recommendations for the future. Roles and recommendations are as follows:

- S-LP services must be viewed as essential in youth justice facilities (Snow, 2019).
- S-LPs should provide both direct and indirect intervention as well as education for other team members (Snow, 2019).
- Policymakers must take the health and developmental needs of children into account (Brookman, 2004).
- S-LPs must raise awareness of communication impairments and advocate for services when youth justice programs and research studies are being planned (Snow and Sanger, 2011). Two examples of resources developed for this purpose are *Sentence Trouble* (The Communication Trust, 2010), an information booklet designed to assist professionals working with youth offenders; and *Doing Justice to Speech, Language, and Communication Needs: Proceedings of a Round Table on Speech Language and Communication Needs in the Youth Justice Sector* (The Communication Trust, 2014), which summarizes statistics and legislation related to communication in youth justice. Both of these were produced by The Communication Trust in the United Kingdom and aimed to increase knowledge of the importance of communication within the youth justice system.
- To obtain system-wide funding, S-LPs must have both a cohesive framework to plan and deliver treatments and evidence of effectiveness and value for money, which requires funded pilot trials (Kinnane, 2015).

Discussion

A scoping review of the literature supported the need for S-LPs to be involved in communication screening, rehabilitation, and education in all sectors of the youth criminal justice system. The following section applies the scoping-review results to make recommendations for S-LP involvement within community services, law enforcement, initial detention, courts, youth correction centres, transition programs, and antirecidivism programs.

Prevention: Community Services

The literature supports pre-judicial intervention to reduce the likelihood that youth with communication disorders will enter the youth justice system. Snow (2019) described the trajectory for children with communication disorders who ultimately come into contact with youth justice services as the "school-to-prison pipeline" (p. 324). Snow argued that S-LP involvement early in this process could divert children from the court system by embedding S-LPs in community-based services that intersect with the justice system such as youth welfare, social services, and child protection agencies. A community system that connects youth with an S-LP could ensure those who are most at risk are assessed for communication difficulties and are given access to treatment if appropriate. Alternatively, Snow proposed that a whole-school approach to addressing students' communication needs could be an effective method to ensure all children have access to S-LP services. A community-service or whole-school approach could be a systematic and proactive upstream approach to decreasing contact with criminal justice. This type of early intervention would target youth in their most relevant environments, helping to decrease future risk of offending and entry into the youth justice system by promoting academic success and prosocial behaviour.

Education: Law Enforcement

The United Kingdom and Australian experiences support S-LP training for police, probation workers, and parole officers. Training should include learning about the types of communication difficulties young people may encounter, how these difficulties may present in justice contexts, how to communicate effectively, and how to engage with resources like communication intermediaries and refer for S-LP services. Research by Togher et al. (2004) in adult criminal justice showed the benefits of training frontline officers who are the first point of contact. Togher et al. (2004) implemented a 6-week training program aimed at improving the communication of police officers during service encounters with people with traumatic brain injury. Results indicated that trained police learned and incorporated strategies that made interactions clearer, more supportive, and more efficient (Togher et al., 2004). Togher et al. argued that training the communication partner shifts the focus to the communication exchange as opposed to the communication impairment, and thus has more generalized benefit. A more effective initial law enforcement encounter may help redirect youth trajectories from their point of entry into the judicial system. It should be noted that the study by Togher et al. was almost 2 decades ago, highlighting the need for new research examining the efficacy of S-LP training for law enforcement staff. Togher et al. limited their investigation to law enforcement staff working with adults with traumatic brain injuries, excluding youth or individuals without traumatic brain injuries. This indicates a need for further research in educating law enforcement on communication difficulties, with the inclusion of law enforcement staff who regularly interact with youth. If communication support training were to occur for these staff members, informative resources such as *Giving Voice* fact sheets (Royal College of Speech and Language Therapists, 2019, 2020) could serve as a method for sharing accessible S-LP education with law enforcement staff.

Screening

Upon initial detention, it would be ideal if youth were screened for communication difficulties by an S-LP (Speech Pathology Australia, 2013). Through routine administration of a screening assessment, youth with language difficulties would be more readily identified in a timely manner. Identifying communication problems early is critical to ensure that young people understand their rights, thereby allowing them to give their testimony as soon as possible after the event (Speech Pathology Australia, 2013). Identifying youth at risk for communication difficulties will allow supports to be put in place as quickly as possible and identify the need for more thorough assessment for youth who do not pass the screening process. This would result in more routine referrals for S-LP assessment (Snow & Sanger, 2011). A core element of the response to intervention framework developed by S-LPs in conjunction with other team members is a universal communication skills screening (Snow et al., 2015). This screening takes place in Tier 1 of the model: "All young people entering custody should undergo communication screening by an S-LP as part of standard operating procedures" (Snow et al., 2015). According to Coles et al. (2017), all young people in the United Kingdom criminal justice system may now receive a screening of their speech, language, and communication needs with the AssetPlus tool (Youth Justice Board, 2014). Youth in Canada could benefit from a similar process and screening tool.

An alternative to screening, and one that would benefit all youth in the justice system, is a universal design approach. Universal design was first described by Connell and colleagues (1997) and includes removing barriers to accessing information and learning (Morin, 2018). Two universal design principles that are particularly relevant to communication and the justice system are the principle of *equity*, meaning, for example, that court language would be understandable to individuals of all abilities and that persons would not be stigmatized or segregated because of their communication challenges; and *flexibility in use*, which could include supports tailored to each individual. Universal design in youth justice could involve creation and editing of materials, which may be faster to implement and may require less ongoing S-LP support than direct assessment and intervention. However, universal design lacks a client-centred approach to services from the perspective of individualized care plans, so the most effective practice might include implementation of universal design principles and tailored direct assessment and intervention. S-LP involvement would be critical for both these approaches to succeed.

Communication Supports

In 2017, CDAC published a memorandum by Birenbaum and Collier with the purpose of informing police in addition to legal and justice professionals about the benefits of involving communication intermediaries and increasing the overall accessibility of justice services in Canada. The memorandum recognized the current inequity of accessibility supports within the Canadian justice system. Further, it emphasized that communication intermediaries must be treated as a readily available and essential accommodation (Birenbaum & Collier, 2017). Birenbaum and Collier provided two primary reasons why communication intermediaries are not adequately used in the Canadian criminal justice system: a) justice system actors (e.g., police, crowns, defense counsel, judges) lack awareness of the role of communication intermediaries, and b) justice system actors may not feel open to or comfortable involving communication intermediaries. Further, many communication intermediaries have full-time S-LP employment elsewhere and consequently, may not be available to provide intermediary services on an ad hoc basis (Communication Disabilities Access Canada, 2020). Although current communication intermediary services exist and are available for use in Canada, there are significant barriers to widespread use of these services.

Optimized involvement of communication intermediaries has the potential to greatly assist in identifying and supporting communication difficulties within the youth justice system. The role of the communication intermediaries should include providing the court with a report outlining the youth's communication needs and corresponding recommendations (Birenbaum & Collier, 2017). Communication intermediaries should also be employed to facilitate complete, accurate, and coherent two-way communication in all justice-related contexts (Birenbaum & Collier, 2017). The Canadian youth justice system should be required and able to provide any youth suspected of having communication difficulties, including victims, witnesses and suspects, with communication intermediary services. Continuation of advocacy efforts for communication intermediary use by CDAC is encouraged, as well as involvement of other influential provincial and federal S-LP organizations (e.g., College of Audiologists and Speech-Language Pathologists of Ontario, Speech-Language and Audiology Canada). Additionally, educating S-LP students in graduate programs across Canada about the role of communication intermediaries should be included in the curriculum. Emphasizing the importance of the role and specifying training processes may help to recruit future S-LPs, thereby increasing the availability of communication intermediaries within the Canadian youth justice system.

Rehabilitation Postsentencing

Intervention

Evidence from Australia and the United Kingdom provides some support for a direct role for S-LPs in intervention for Canadian youth postsentencing. S-LPs would be responsible for providing comprehensive assessments of speech, language, and social communication needs to develop treatment plans and goals. Following assessment, the S-LP would provide appropriate intervention tailored to the youth's specific needs. Ideally, intervention delivery methods (such as one-to-one, paired, or group sessions as well as short- or long-term treatment blocks) would be flexible, and determined on an individual-needs basis. The S-LP role within Canadian youth justice should also include staff training and support. Similar to the program implemented by the Royal College of Speech and Language Therapists (Coles et al., 2017), S-LP-led information sessions or workshops should be held for staff who regularly interact with the youth. This training would be focused on raising awareness of communication difficulties within this population and helping staff to recognize and respond appropriately.

Transition Planning

It would be ideal for S-LPs to be directly involved in transition planning for youth in custody who are reentering the community. Overall, there is a need for follow-up of health services for youth upon release (Martin, 2019a). Effective transition planning is likely to improve reentry outcomes because services would be organized based on the youth's needs prior to release. Specifically, youth should be connected to S-LP services in the community. If participating in S-LP intervention while at a facility, it is crucial for information to be transferred to the community S-LP who is continuing intervention. This collaborative practice is key to building coordinated and connected services for youth to allow for smoother transitions back into the community (Martin, 2019a). S-LPs working in youth justice settings might be key advocates for effective transitions back to the community. For example, they can educate others about the link between speech, language, and communication needs, and educational and vocational success (Snow et al., 2015; Snow & Powell, 2004). Furthermore, S-LPs can advocate for governments to fund S-LP services to address the complex communication needs of young people, including those on community-based orders (Snow, 2019). Moving forward, it is important to consider and evaluate the effectiveness of S-LP involvement in transition planning, and in promoting engagement in education, training, and other prosocial activities.

Restorative Justice

Restorative justice conferencing (RJC) is another context in which S-LP involvement could be valuable. Restorative justice has been defined as "a range of informal justice practices designed to require offenders to take responsibility for their wrongdoing and to meet the needs of affected victims and communities" (Strang, 2001, p. 2). Snow & Sanger (2011) outlined the communicative abilities necessary for successful engagement in the verbal exchanges involved in RJC, including strong language-processing, pragmatic language, and social cognition skills. They explained that these skills are necessary for processing disparities between verbal and nonverbal communication, for displaying genuineness and empathy, and for making authentic apologies. RJC often involves face-to-face meetings between an offender and victim, presenting particular difficulties for individuals with communication deficits (Speech Pathology Australia, 2013). The involvement of S-LPs in these types of recidivism reduction programs would ideally promote the youth offender's ability to engage in and benefit from the practice. We were not able to find evidence that RJC is in widespread use in Canada, other than an older publication from British Columbia (Hillian, Reitsma-Street, & Hackler, 2004) that described giving young offenders the opportunity to participate in RJC as part of or in place of a sentencing process to a custodial order. In settings where RJC is available, however, it is recommended that S-LPs be involved in the planning and execution of programs to address communicative deficits, so youth offenders can successfully engage in the RJC, ideally decreasing their likelihood of reoffending.

Future Research

Further research is required in two main areas. First, there is a need for studies that quantify effects of S-LP involvement on the four categories of outcomes in Ontario's youth justice outcomes framework (Ontario Ministry of Children and Youth Services, 2014): functioning and positive social behaviours, skills and abilities, engagement with supports, and reoffending (or offending, for youth at risk). *Involvement* refers to all the S-LP roles discussed here including screening, assessment, and therapy for young people; training justice system personnel; and helping to modify documents and procedures so they are fully accessible to young people with communication challenges. Several resources made strong arguments supporting the benefits of S-LP involvement, and pilot studies showed promising results, but outcome data are lacking. A useful tool for evaluating intervention effects is the risk-need-responsivity model (Bonta & Andrews, 2007) for offender assessment and intervention. The three core principles of this model identify each individual's risk of reoffending, criminogenic needs (i.e., risk factors associated with criminal behaviour such as low self-control, antisocial personality, substance use, and criminal peers), and responsivity to learning. The model could be applied to study intervention for both youth already in the system and those at risk for offending, as a preventative measure.

Second, despite an acknowledgement from stakeholders that the potential role of S-LP in the Canadian justice context is underrecognized (Wiseman-Hakes et al., 2020), we were unable to locate any further research evidence examining the role of S-LPs in Canada. Grey literature revealed the involvement of S-LPs as communication intermediaries; however, there was no research evidence to support the efficacy of communication intermediaries or on any other involvement with youth with communication challenges. Although Canadians can learn from other English-speaking countries that currently have roadmaps and procedures in place, the Canadian judicial, cultural, social, and political context is unique, and practices of S-LPs are shaped by those contexts. Research is needed regarding intervention and outcomes in Canadian settings to ensure young people in the Canadian youth justice system receive fair and appropriate treatment.

Limitations

Our study had several limitations. First, a rapid scoping review is not exhaustive by nature; therefore, it is possible that relevant literature was missed. Rapid scoping reviews are appropriate, however, for research in emerging topic areas such as this one and allow for examination of both published and grey literature when there is an overall paucity of published research on the topic (Levac et al., 2010). Second, we recognize that work may have been published after the end-date of our search (e.g., the review paper by Sowerbutts et al., 2021), which is an inherent limitation of any review. Third, although we used a systematic and literature-based approach to our search, it is also possible that a pro-communication bias influenced the interpretation of results, given that all the authors were S-LPs or S-LP graduate students at the time. Last, in certain jurisdictions, for example some parts of Australia, young people aged 17–20 years at the time of their offending can be detained within the youth justice system. As we included only studies of individuals under age 18, we might have excluded some studies from jurisdictions in which older adolescents are part of the youth justice system.

Conclusion

Among youth in the justice system, there is a high prevalence of un/misdiagnosed and untreated communication impairments, including speech deficits, poor comprehension and expression of language, and appropriate use of language in context. S-LPs are trained healthcare professionals who provide assessment and intervention for young people with these impairments and provide support to this population within other English-speaking countries. This study aimed to investigate the role of S-LPs within the youth criminal justice system across English-speaking countries around the world.

We identified 19 published articles related to S-LP involvement in the youth justice system, as well as 11 additional resources and grey literature articles. Although there was modest evidence to support the efficacy of an S-LP role within community services, in law enforcement, across various stages of the court process, and during community reintegration, we found considerable inconsistencies between and within countries in the extent, location, and nature of S-LP involvement. Overall, there was a paucity of research available surrounding the role of the S-LP in the youth justice system, especially within Canada.

A cohesive action plan is needed to engage justice organizations, S-LPs, educators, policy makers, public health professionals, communities, individuals, and families in an integrated effort to improve communication abilities for at-risk youth. The need for this cohesive action plan is based on the principles that all youth have the right to understand and access information that helps them make informed decisions, and access S-LP services to habilitate or rehabilitate language and communication abilities. S-LPs can play a critical role in reducing the health inequities of these vulnerable youth, ensuring youth criminal justice processes meet the principles of the Youth Criminal Justice Act (2002), that young people are treated fairly and that their right to fully participate in youth justice processes are respected (Department of Justice, 2013, p. 2). With the proper delivery of screening, habilitation, and rehabilitation, we can foster a culture of improved communication outcomes to promote the health and well-being of youth in the justice system, at-risk youth, and their communities.

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A Critical Appraisal of Nonconformity of New Hearing Aids with American National Standards Institute Standards

Évaluation critique de la non-conformité de nouveaux appareils auditifs aux normes de l'*American National Standards Institute*

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KEYWORDS

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HEARING AIDS

QUALITY CONTROL

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Abstract

Some studies have found an alarming rate of hearing aids' nonconformity with American National Standards Institute standards, but research in this area is limited. This study reports a comprehensive assessment of the compliance rate of hearing aids of various brands and styles. The Audioscan Verifit-1 analyzer was used to examine the compliance of 62 new hearing aids with the S3.22-2014 standard of the American National Standards Institute. Audioscan Verifit-2 and Aurical test systems were also used to determine the potential influence of hearing aid test systems on the compliance rate. With the Verifit-1 test system, most hearing aids (96.8%) were found to be out of specification for the equivalent input noise measure. Compared to equivalent input noise, the compliance rates for output sound pressure level, high-frequency average at 50 dB, and total harmonic distortion were higher and did not differ between brands and styles. The type of analyzer had a considerable impact on the measured equivalent input noise compliance rate: Compared to the Verifit-1, the Verifit-2 and Aurical test systems indicated a higher compliance rate (> 90% versus ~ 5%). However, there were no differences in compliance rates across the analyzers for the rest of the tests. This study reveals that hearing aids mostly comply with the standard. There is a need to establish clinically reproducible and easily accessible testing protocols for the quality control of hearing aids at various stages of use.

Abrégé

Certaines études indiquent qu'un nombre alarmant d'appareils auditifs ne sont pas conformes aux normes de l'*American National Standards Institute*, mais les recherches sur cette question demeurent limitées. La présente étude a évalué de façon exhaustive le taux de conformité d'appareils auditifs de différents modèles et fabricants. Le système d'analyse Verifit-1 d'Audioscan a été utilisé pour déterminer la conformité de 62 nouveaux appareils auditifs à la norme S3.22-2014 de l'*American National Standards Institute*. Des tests ont également été réalisés à l'aide des systèmes Verifit-2 d'Audioscan et Aurical afin de déterminer l'influence potentielle des systèmes d'analyse utilisés sur le taux de conformité. Les résultats des tests réalisés à l'aide du système Verifit-1 ont indiqué que la plupart des appareils auditifs (96,8 %) étaient non conformes pour le bruit équivalent en entrée. Comparés au taux de conformité du bruit équivalent en entrée, les taux de conformité pour le niveau de pression acoustique de sortie, pour la valeur moyenne du niveau de pression acoustique de sortie pour un niveau de pression acoustique d'entrée de 50 dB aux hautes fréquences et pour la distorsion harmonique totale étaient plus élevés et ne différaient pas selon les fabricants ou modèles. L'impact du type de système d'analyse sur les taux de conformité concernant le bruit équivalent en entrée était considérable. Spécifiquement, en comparaison au système Verifit-1, les taux de conformité obtenus avec les systèmes Verifit-2 et Aurical étaient supérieurs (> 90 %, versus ~ 5 %). Cependant, aucune différence n'a été constatée concernant les taux de conformité entre les différents appareils d'analyse pour les autres mesures. Cette étude révèle que, de façon générale, les appareils auditifs respectent les normes établies. Il existe un besoin de mettre au point des protocoles reproductibles en clinique pour contrôler la qualité des appareils auditifs aux différents stades d'utilisation.

To ensure a successful clinical outcome and patient compliance, hearing aids (HAs) must provide specified performance (Gallagher & Woodside, 2018; McCormack & Fortnum, 2013; Mueller, 2005; Yong et al., 2019). Manufacturers, therefore, generally examine the performance of each HA before dispatch and provide information about key measures such as maximum output sound pressure level (OSPL) with a 90 dB input (Max OSPL 90), high-frequency average OSPL with a 90 dB input (HFA-OSPL 90), HFA @ 50 dB, equivalent input noise (EIN), and total harmonic distortion (THD), that can be used for performance validation (Levitt et al., 1990). The American National Standards Institute (ANSI) has developed recommendations for evaluating HA performance (ANSI, 1992). As HA technology advances and new features are introduced, the ANSI requirements are typically reaffirmed, updated, or removed every 5 years (Blaeser & Struck, 2019; Ravn & Preves, 2015). In the United States, the Food and Drug Administration has described HA performance (as stated in the ANSI standard S3.22 2014) as a quality control provision (Frye, 2005; U. S. Food and Drug Administration, 2021). If HAs fail to meet ANSI standards, manufacturers may face penalties, including forced market withdrawal; although, more commonly, HAs are returned to the manufacturer if ANSI standards are not met (Frye, 2005).

ANSI defines a standard set of criteria and tests that enable industry-wide consensus among HA professionals and manufacturers (ANSI, 1992; Struck, 2015). ANSI S3.22 2014 includes electroacoustic tests to characterize the performance and evaluate the reliability of air conduction HAs (Bentler et al., 2016). Standard tests used for the performance assessment of HAs include Max OSPL 90, HFA-OSPL 90, HFA @ 50 dB, EIN, and THD (ANSI, 1992; Frye, 2005; Lewis et al., 2010; Valente et al., 2008). The Max OSPL90 represents the highest output level that the HA can deliver, HFA-OSPL 90 is the average HA output in dB SPL at 1000, 1600, and 2500 Hz, with a 90 dB SPL input and the HFA@50 dB is the average output of HA in dB SPL at 1000, 1600, and 2500 Hz, with the 50 dB SPL input with the gain control setting in the reference test setting. The EIN, or circuit noise of the HA, is considered within specification if the measured noise is within 3 dB of the value specified by the manufacturer (ANSI, 2014). The THD is the ratio of the power of total harmonics generated with respect to the power of the fundamental/standard input signal.

Previous research raised concerns about the poor compliance of HAs with ANSI standards, reporting that more than 30% of HAs did not meet ANSI specifications (Callaway & Punch, 2008; Townsend & Olsen, 1982). According to one study, none of the HAs tested were within the permitted tolerance for all ANSI criteria (Holder et al., 2016). It was stressed that the performance of a HA may fall short of expectations particularly in the presence of excessive background noise, feedback, and/or poor sound quality (Abrams & Kihm, 2015). Recent advancements in digital technology have enabled the inclusion of advanced processing algorithms and functionalities in HAs, further accentuating the need for homogeneity of quality control measures used at the manufacturers' and clinical sites (Bentler & Duve, 2000).

This study examines the compliance of HAs with ANSI standard S3.22-2014 using three analyzers with different frequency ranges. A separate series of experiments were carried out that closely mimicked the experimental conditions used by Holder et al. (2016). Previous research has focused primarily on the measurements of behind-the-ear HAs; this study expands the research by including HAs with receiver-in-canal, in-the-ear, completely-in-canal, and behind-the-ear styles. Notably, HAs can have a bandwidth ranging from 100 to 10000 Hz, but the frequency response range of HA analyzers such as the Verifit-1 is up to only 8000 Hz. Consequently, three distinct analyzers were used in this study (Verifit-1: 100–8000 Hz, Verifit-2: 100–12500 Hz and Aurical: 100–10000 Hz).

Methods

The Institutional Review Board at Bloomsburg University of Pennsylvania approved this study (IRB# 2017-42). Measurements were performed at Bloomsburg University's Speech and Hearing Clinic, on digital HAs that were received between 2017 and 2020. All electroacoustic measurements were performed according to the instructions provided in the HA test system manuals. All measurements were made in a quiet HA dispensing room in the clinic. The room was not acoustically treated. Included electroacoustic measurements were Max OSPL 90, HFA-OSPL 90, and HFA @ 50 dB, measured at a full-on gain; EIN and THD were measured at the reference test gain. The current standard (ANSI S3.22-2014) was used for tolerance measurements in this study. The ANSI S3.22-2014 model specifies a 2 cc acoustic coupler tailored to fit a HA with a specific acoustic impedance. The measured levels were compared with the manufacturers' specifications plus tolerances provided by ANSI. If the measured levels were within tolerances, the HA was classified as compliant. The ANSI compliance rate for an electroacoustic measurement was defined as the proportion of HAs with measured values within the tolerance specified by the manufacturer. The gain settings and tolerances used for the ANSI measurement are listed in **Table 1**.

Table 1

Hearing Aid Gain Setting and Tolerance Levels for Each ANSI Standard Parameter

Parameter	Definition	Gain setting	Tolerance
Max OSPL 90	The maximum value of the OSPL 90 curve	FOG	+ 3 dB
HFA-OSPL 90	Average high-frequency average output saturation sound pressure level	FOG	± 4 dB
HFA @ 50 dB	Average of the full-on gain at the HFA frequencies	FOG	± 5 dB
EIN	SPL of an external noise source at the input that would result in the same coupler SPL as that caused by all internal noise sources in the hearing aid	RTS	+ 3 dB
THD	The ratio of the sum of the powers of all the harmonics to the power of the fundamental	RTS	+ 3%

Note. ANSI = American National Standards Institute; EIN = equivalent input noise; FOG: full-on gain; HFA = high-frequency average, meaning the average of values at 1000, 1600, and 2500 Hz; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input; RTS = reference test setting; SPL = sound pressure level; THD = total harmonic distortion.

Testing was completed according to the publicized protocol and the test mode recommended by the manufacturers. The calibration of the test box microphone was completed before measurement. The coupler connection, positioning, and measurement were performed as recommended in the manual, using 2 cc HA-1 and HA-2 couplers and a new HA battery. Investigators conducted the tests strictly following the manufacturer's protocols to minimize measurement errors, calibrated each analyzer according to the manual, and evaluated HAs in three separate analyzers. New batteries were used for each HA.

Compliance Rate Assessment Using Verifit-1

One of the goals of this research was to reexamine the findings of Holder et al. (2016), who found that none of the included HA satisfied all the ANSI requirements. Therefore, in the first part of this study, the ANSI compliance rate of 62 new HAs was examined using an Audioscan Verifit-1 analyzer, which is the same model that Holder et al. used. Rather than focusing on only one type of style, in this work, four different styles (completely-in-canal, in-the-ear, receiver-in-canal, behind-the-ear) from five different brands were included to have a more comprehensive evaluation (Palmer, 2009). The selected HAs represent the most commonly used models at the Bloomsburg University Speech and Hearing Clinic.

Compliance Rate Assessment Using Three Different Analyzers

In the second part of this study, the possible influence of various analyzers with different frequency ranges on the ANSI compliance rate was investigated. A different set of 20 new HAs was examined using three different analyzers: Audioscan Verifit-1 (up to 8000 Hz), Audioscan Verifit-2 (version 4.2; up to 12500 Hz), and Aurical Freefit HA test system (up to 10000 Hz). To control the variability due to style and coupling method within the test box, all 20 HAs were receiver-in-canal style. The sample size of 20 was sufficient to have adequate power measured using G*power analysis. The frequency responses of the HAs included in this study were 100–7500 Hz (n = 1), 100–7800 Hz (n = 2), 100–9600 Hz (n = 15), and 100–10000 Hz (n = 2).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows (version 26), and Microsoft Excel for Mac (version 2016). Descriptive statistics were performed to calculate the mean and standard deviations or median and interquartile range (IQR: Q1–Q3) for the HA outputs across the ANSI specifications. A frequency distribution analysis was performed to determine the percentage of HAs that met the ANSI specifications. As the data followed a nonnormal distribution, the Kruskal-Wallis test was conducted to compare different groups. The Fleiss kappa was used to determine if the three analyzers agreed on whether or not each HA met the ANSI requirements.

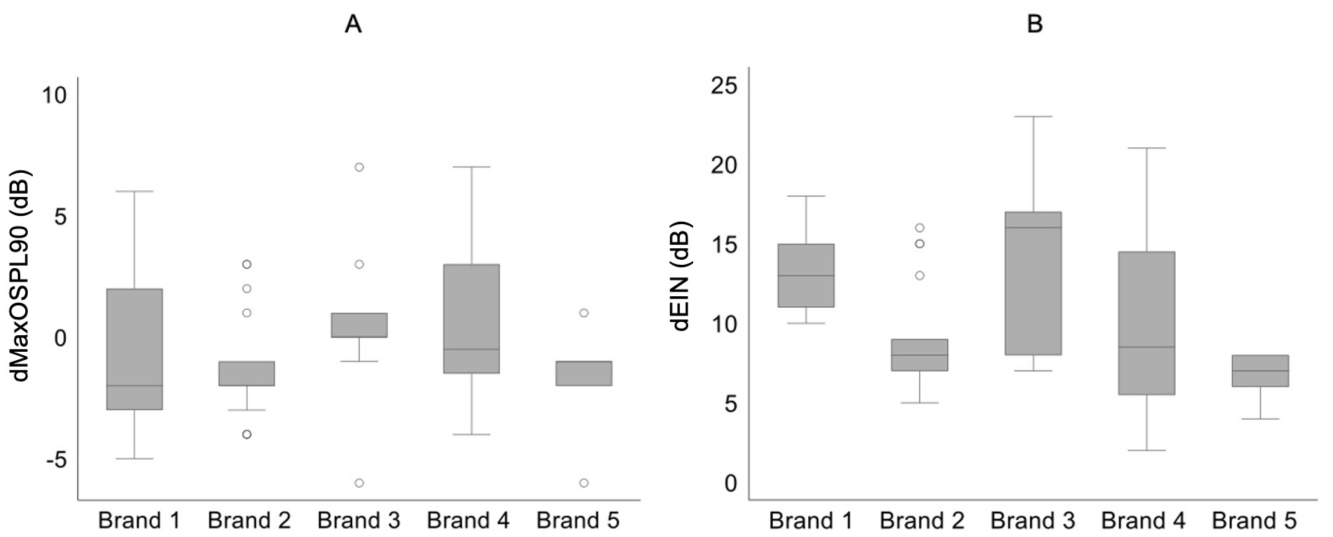
Results

Assessment of the ANSI Compliance Rate Using Verifit-1

Figure 1A represents the deviation of the measured Max OSPL90 (dMaxOSPL90) from the manufacturer-specified values. The number of HAs for Brands 1, 2, 3, 4, and 5 was 13, 22, 9, 12, and 6, respectively.

The median measured Max OSPL90 was 115.0 (IQR: 113.0–119.0), and there was no difference across different brands (p = .513, **Table 2**). It can be seen that Brands 1 and 4 have a relatively broader range of dMaxOSPL90.

Figure 1



Compliance rate for different hearing aid brands using the Verifit-1 analyzer

Note. Panel A: Deviation of the measured Max OSPL90 (dMaxOSPL90) from the manufacturer-specified value. Panel B: Deviation of the measured EIN from the manufacturer-specified EIN (dEIN). Max OSPL90 = maximum output sound pressure level at 90dB input; EIN = equivalent input noise.

A negative dMaxOSPL90 suggests that the HA saturates with distortion; conversely, with a positive dMaxOSPL90, high performance can be achieved without distortion or saturation. The output of noncompliant HAs (Brands 1, 3, and 4) was higher than the manufacturer's specification with M = 3.25 dB (SD = 0.95, minimum = 2 dB; maximum = 4 dB). Regarding the conformity of the measured Max OSPL90 with ANSI standards, the overall compliance rate was 93.5% (**Table 3**). Notably, for two brands (2 and 5), there were no incidents of noncompliance with respect to Max OSPL90, and the lowest compliance rate by a brand was 84.6% (Brand 1), although the difference in compliance rate was not statistically significant across brands (**Table 3**).

If the performance of a HA is within ± 4 dB of the manufacturer's specification, it is deemed to be consistent with the ANSI specification for HFA-OSPL90. Brands 3 and 5 had a 100% compliance rate for the HFA-OSPL90 measurement, and Brands 1, 2, and 4 had compliance rates of 92.3%, 95.5%, and 83.3%, respectively (p = .513, **Table 3**). The median measured HFA-OSPL 90 was 111.5 dB (IQR: 108.0–116.0), and there was no difference among different brands (p = .115, **Table 2**). Of 62 HAs, four not in compliance for HFA-OSPL90 were from Brands 1 (n = 1), 2 (n = 1), and 4 (n = 2). After applying the tolerance levels, three HA had higher values (maximum deviation +3 dB), and one had lower values (−1 dB) than the manufacturer's specification.

If a HA's output is within ± 5 dB of the manufacturer's specification, it is considered ANSI compliant for HFA@50 dB. Brands 3 and 5 had a 100% compliance rate and Brands 1, 2, and 4 had compliance rates of 84.6%, 77.3%, and 66.7% (p = .226, **Table 3**). The median HFA@50 dB was 46.5 dB (44.0, 52.0), and there was no statistically significant difference across brands (p = .381, **Table 2**). Four noncompliant HAs had higher values (maximum deviation +6 dB), and seven had values lower (maximum deviation −7 dB) than the manufacturer's specification.

The deviation of the measured EIN from the manufacturer-specified EIN (dEIN) is shown in **Figure 1B** for each brand. The median measured EIN was 34.0 dB (IQR: 33.0–36.0; **Table 2**). In four of the five brands included in this work, none of the HAs complied with the ANSI specification for EIN. Only 16.7% of Brand 3's HAs met the EIN test tolerance specified in the ANSI standard (**Table 3**). The median EIN specified by the company was 25.0 dB (IQR: 22.0–26.0), which was considerably lower than the measured EIN (Mdn = 34.0 dB [33.0–36.0], **Table 2**). The EIN represents the level of environmental input noise needed to generate an output voltage equal to the voltage of the device's internal noise; therefore, if a HA has an excessively high EIN, the noise can be noticeable to listeners with low thresholds. It can be seen in **Figure 1B** that for all brands, the EIN values are considerably higher than the manufacturer-specified values.

Table 2

ANSI Test Parameters Across Different Brands Measured With the Verifit-1 Analyzer

Parameter	Brand 1 (n = 13) median (Q1–Q3)	Brand 2 (n = 22) median (Q1–Q3)	Brand 3 (n = 9) median (Q1–Q3)	Brand 4 (n = 12) median (Q1–Q3)	Brand 5 (n = 6) median (Q1–Q3)	Total (N = 62) median (Q1–Q3)	p value
Measured Max OSPL 90	116.0 (114.0–121.0)	114.0 (113.0–117.0)	117.0 (115.0–125.0)	115.5 (114.0–118.0)	118.0 (114.0–119.0)	115.0 (113.0–119.0)	.513
Manufacturer Max OSPL 90	116.0 (116.0–119.0)	115.0 (115.0–116.0)	118.0 (115.0–123.0)	115.0 (114.0–115.0)	120.0 (115.0–123.0)	115.0 (115.0–119.0)	.03
dMax OSPL 90	−2.0 (−3.0–2.0)	−2.0 (−2.0– −1.0)	0.0 (0.0–1.0)	−0.5 (−1.5–3.0)	−1.0 (−2.0– −1.0)	−1.0 (−2.0–1.0)	.117
Measured HFA-OSPL 90	113.0 (111.0–115.0)	109.0 (108.0–114.0)	115.0 (111.0–118.0)	111.5 (109.5–115.0)	115.5 (110.0–116.0)	111.5 (108.0–116.0)	.115
Manufacturer HFA-OSPL 90	114.0 (113.0–114.0)	109.0 (109.0–110.0)	114.0 (109.0–117.0)	109.5 (109.0–111.0)	115.0 (109.0–117.0)	110.0 (109.0–114.0)	.036
Measured HFA @ 50 dB	48.0 (45.0–50.0)	45.0 (42.0–51.0)	48.0 (48.0–55.0)	45.5 (44.0–53.5)	54.0 (46.0–55.0)	46.5 (44.0–52.0)	.381
Manufacturer HFA @ 50 dB	51.0 (45.0–51.0)	45.0 (44.0–46.0)	47.0 (45.0–54.0)	50.0 (45.0–55.5)	54.0 (45.0–54.0)	46.0 (45.0–52.0)	.195
Measured EIN	35.0 (33.0–36.0)	34.0 (32.0–34.0)	34.0 (34.0–37.0)	34.0 (31.5–38.0)	32.0 (31.0–33.0)	34.0 (33.0–36.0)	.15
Manufacturer EIN	23.0 (21.0–23.0)	26.0 (25.0–26.0)	18.0 (18.0–26.0)	25.0 (21.5–26.0)	25.5 (25.0–26.0)	25.0 (22.0–26.0)	< .001
dEIN	13.0 (11.0–15.0)	8.0 (7.0–9.0)	16.0 (8.0–17.0)	8.5 (5.5–14.5)	7.0 (6.0–8.0)	8.5 (7.0–14.0)	.001
Harmonic distortion measured 500 Hz	0.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (1.0–2.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	.073
Manufacturer harmonic distortion 500 Hz	0.5 (0.5–0.6)	3.0 (3.0–3.0)	2.0 (2.0–3.0)	3.0 (2.0–3.0)	3.0 (3.0–3.0)	3.0 (2.0–3.0)	< .001
Harmonic distortion measured 800 Hz	1.0 (0.0–1.0)	1.0 (1.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (1.0–1.0)	1.0 (0.0–1.0)	.405
Manufacturer harmonic distortion 800 Hz	0.6 (0.6–0.6)	3.0 (3.0–3.0)	2.0 (2.0–3.0)	3.0 (2.0–3.0)	3.0 (3.0–3.0)	3.0 (2.0–3.0)	< .001
Harmonic distortion measured 1600 Hz	0.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	0.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	.425
Manufacturer harmonic distortion 1600 Hz	1.2 (0.9–1.2)	3.0 (3.0–3.0)	2.0 (2.0–3.0)	2.5 (2.0–3.0)	3.0 (3.0–3.0)	3.0 (1.2–3.0)	< .001

Note. ANSI = American National Standards Institute; dEIN = deviation of the measured EIN from the manufacturer-specified EIN; dMax = deviation of the measured maximum from the manufacturer-specified maximum; EIN = equivalent input noise; HFA = high-frequency average, meaning the average of values at 1000, 1600, and 2500 Hz; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input; Q1–Q3 = range from first to third quartile.

Table 3

ANSI Compliance Rates for Hearing Aids From Five Different Brands

Parameter	Brand 1 (*n* = 13)	Brand 2 (*n* = 22)	Brand 3 (*n* = 9)	Brand 4 (*n* = 12)	Brand 5 (*n* = 6)	Total (*N* = 62)	*p* value
Max OSPL 90 (< +3 dB)	11 (84.6%)	22 (100.0%)	8 (88.9%)	11 (91.7%)	6 (100.0%)	58 (93.5%)	.400
HFA-OSPL 90 (± 4 dB)	12 (92.3%)	21 (95.5%)	9 (100.0%)	10 (83.3%)	6 (100.0%)	58 (93.5%)	.513
HFA @ 50 dB (± 5 dB)	11 (84.6%)	17 (77.3%)	9 (100.0%)	8 (66.7%)	6 (100.0%)	51 (82.3%)	.226
THD (< +3%)	13 (100.0%)	20 (90.9%)	8 (88.9%)	11 (91.7%)	6 (100.0%)	58 (93.5%)	.743
EIN (< +3 dB)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (16.7%)	0 (0.0%)	2 (3.2%)	.072

Note. Variance allowances from the ANSI standard are shown with each parameter. ANSI = American National Standards Institute; EIN = equivalent input noise; HFA = high-frequency average, meaning the average of values at 1000, 1600, and 2500 Hz; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input; THD = total harmonic distortion.

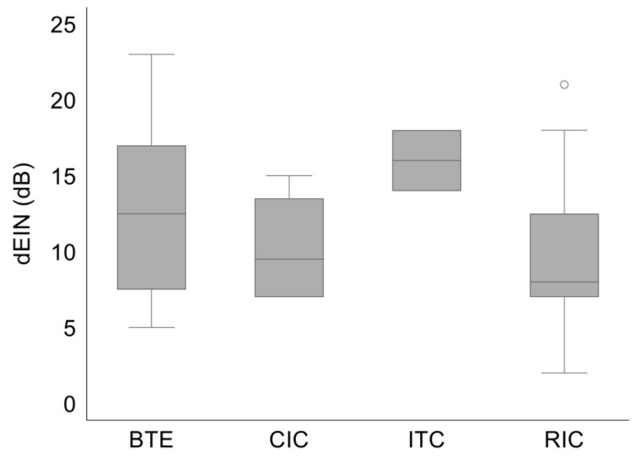
A HA is considered in compliance with the ANSI standards specified for THD if it does not exceed the manufacturer's specification by 3% (**Table 1**). In the case of Brands 1 and 5, all HAs were compliant at all three frequencies: 500 Hz, 800 Hz, and 1600 Hz. Whereas in the case of Brand 2, two HAs were out of specification: one at 500 Hz and a different one at 800 Hz. One HA from each of Brands 3 and 4 was out of specification at 500 Hz. Two of the brands (1 and 5) were within the specification for THD, and the compliance rates for Brands 2, 3, and 4 were 90.9%, 88.9%, and 91.7% (p = .743, **Table 3**). Overall, 45 of the 62 HAs met all benchmarks except EIN. When EIN test compliance was included, none of the HA met the ANSI requirements.

Figure 2 represents the dEIN, that is, the difference between the measured and specified EIN values for HAs of different styles. It can be seen that all styles had a positive deviation from the specified value. The median values for behind-the-ear, completely-in-canal, in-the-ear, and receiver-in-canal types of HA were 12.5 dB (IQR: 7.5–17.0), 9.5 dB (7.0–13.5), 16.0 dB (14.0–18.0), and 8.0 dB (7.0–12.5) respectively (p = .204). Other parameters of interest are presented in **Table 4** for HAs of different styles.

Comparison of ANSI Compliance Rates Using Three Different Analyzers

According to the findings described in the preceding section, HAs have poor conformity with ANSI standards for EIN. To rule out the possible influence of the analyzer on the assessment of EIN, we examined the HA output using different analyzers. HA output was compared with three analyzers for a different set of 20 new receiver-in-canal HAs. The Max OSPL90 compliance rate calculated by different analyzers did not vary significantly (p = .765, **Figure 3A**, **Table 5**). The compliance rates with respect to HFA-OSPL90, HFA @50 dB, and THD were also not different between analyzers (all p > .05, **Table 5**). However, the three analyzers showed a substantial difference in the EIN compliance rate (**Table 5** and **Table 6**). It can be seen that Verifit-1 has the highest positive deviation from the manufacturer-specified values (**Figure 3B**). The median EIN output was highest in the Verifit-1 at 30.5 dB (IQR: 27.0–32.0) followed by the Aurical at 27.6 dB (25.0–28.1) and the Verifit-2 at 24.5 dB (22.0–26.0; p < .001). EIN compliance rate was only 5% in the Verifit-1 and 95% and 90% for the Verifit-2 and Aurical, respectively (p < .001, **Table 5**).

Figure 2



Values of dEIN for hearing aids of different styles using the Verifit-1 analyzer

Note. dEIN = deviation of the measured equivalent input noise from the manufacturer-specified value; BTE = behind the ear; CIC = completely in canal; ITC = in the canal; RIC = receiver in canal.

To determine the agreement between the three analyzers, we performed Fleiss kappa analysis. The Fleiss kappa values were interpreted according to the recommendations of Landis and Koch (1977). A substantial agreement between the analyzers was noted for Max OSPL90, $\kappa = .73$ (95% CI [.72,.74]), $p < .01$ and moderate agreements were observed for HFA-OSPL 90 $\kappa = .56$ (95% CI [.55,.57]), $p < .01$, HFA@50 dB, $\kappa = .51$ (95% CI [.50,.52]), $p < .01$; and THD, $\kappa = .48$ (95% CI [.47,.49]), $p < .01$. Poor or no agreement was found for EIN $\kappa = -.29$ (95% CI [−.30, −.28]), $p = .02$.

When the Verifit-1 was used, only 14 of the 20 HAs met all the ANSI criteria except EIN (when EIN was included, none were compliant). In other words, according to the assessment made using Verifit-1, the majority of HAs were out of compliance with at least one ANSI criterion. Using the Verifit-2, 16 out of 20 HAs met all the standards, including EIN. EIN was over tolerances for one HA of the four that did not meet the guidelines. Using the Aurical, 16 out of 20 HAs met all the standards, including EIN. EIN was outside the limits for two of the four HAs that did not match the criterion. Notably, when both the Verifit-2 and Aurical assessments were considered, 14 of the 20 HAs satisfied all of the ANSI requirements. The rest (6 HAs) were out of compliance for at least one parameter on either the Verifit-2 or the Aurical. The number of HAs that met each norm on all three analyzers was as follows: MaxOSPL 90 (18/20), HFA 90 (17/20), HFA 50 (16/20), THD (19/20), and EIN (1/20). When using only the Verifit-2 and Aurical analyzers with a frequency response of 10 kHz or above for EIN, 18/20 HA satisfied the ANSI criterion for EIN.

Discussion

Compliance with ANSI standards is desired to ensure that the sound output of HAs falls within the clinically prescribed range (Sabin et al., 2020). This study has clarified several aspects of the reported noncompliance of HAs (Holder et al., 2016; Lewis et al., 2010). Using the Verifit-1 analyzer, our analysis revealed that approximately 4% of HAs met the ANSI tolerance requirement for EIN. Notably, even after excluding EIN, our study found that only 45 of the 62 HAs met the remaining ANSI benchmarks (Max OSPL 90, HFA-OSPL 90, THD, and HFA@50 dB). This noncompliance of HAs brings the manufacturers' quality control procedures into doubt, creating a serious concern of introducing inefficiencies in the process due to the rejection of noncompliant HAs and suboptimal patient satisfaction.

Taking the investigation further, we discovered no difference in compliance rates amongst various brands and styles of HAs (behind-the-ear, completely-in-canal, in-the-ear, and receiver-in-canal). However, surprisingly, the compliance rate for EIN was found to be greater than 90% when Verifit-2 and Aurical analyzers were used. To a great extent, these results clarify previous findings, implying that observed noncompliance of HAs with ANSI standards may be due to the limitations of the Verifit-1 analyzer (Holder et al., 2016; Lewis et al., 2010). Therefore, a more comprehensive testing framework is needed to allow accurate measurements in clinical settings.

The findings of our research and those of the aforementioned studies are alarming from a patient care perspective. According to a study by Abrams and Kihm (2015), one of the most common reasons patients stops wearing or return their HAs is the poor performance of the devices. Patient satisfaction plummets when the HAs deliver background noise or do not deliver the desired sound output. From a clinical standpoint, hearing healthcare professionals should verify the performance of HAs to ensure fewer return visits for adjustment.

As stated above, with the Verifit-1 analyzer, noncompliance with ANSI specifications was observed across brands and styles, primarily concerning EIN. EIN is one of the quality control criteria recommended by the ANSI. The presence of high levels of EIN may contribute to fitting failure of HAs. Internal noise in this context is the noise generated by the HAs anywhere in the processing path that

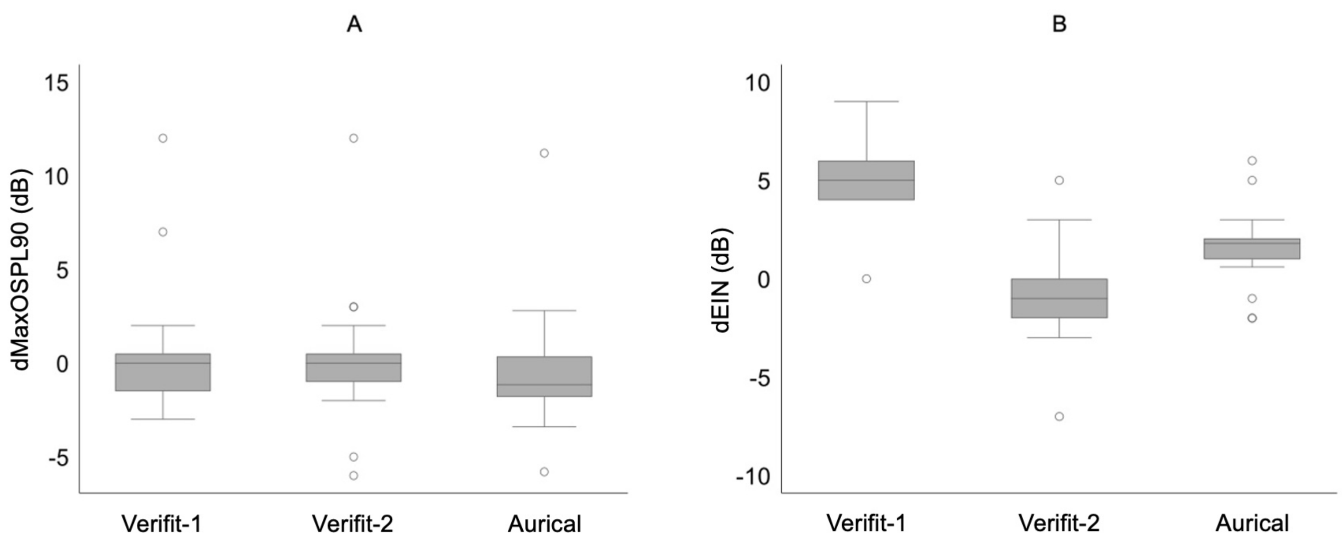
Table 4

ANSI Test Parameters Measured for Different Hearing Aid Styles

Parameter	BTE ($n = 12$) median (Q1–Q3)	CIC ($n = 4$) median (Q1–Q3)	ITE ($n = 2$) median (Q1–Q3)	RIC ($n = 44$) median (Q1–Q3)	Total ($N = 62$) median (Q1–Q3)	p value
Measured Max OSPL 90	127.0 (125.5–131.5)	111.5 (110.0–112.5)	115.0 (114.0–116.0)	114.0 (113.0–117.0)	115.0 (113.0–119.0)	< .001
Manufacturer Max OSPL 90	130.5 (126.5–135.0)	112.5 (110.0–115.0)	119.0 (119.0–119.0)	115.0 (115.0–116.0)	115.0 (115.0–119.0)	< .001
dMax OSPL 90	−1.5 (−4.0–0.5)	−2.0 (−3.5–1.0)	−4.0 (−5.0– −3.0)	−1.0 (−2.0–2.0)	−1.0 (−2.0–1.0)	.126
Measured HFA-OSPL 90	118.5 (116.0–125.5)	107.0 (104.0–110.0)	113.0 (113.0–113.0)	109.0 (109.0–112.5)	110.0 (109.0–114.0)	< .001
Manufacturer HFA-OSPL 90	118.5 (116.0–125.5)	107.0 (104.0–110.0)	113.0 (113.0–113.0)	109.0 (109.0–112.5)	110.0 (109.0–114.0)	< .001
Measured HFA @ 50 dB	54.0 (50.5–63.0)	35.0 (33.0–41.0)	43.5 (42.0–45.0)	46.0 (44.0–49.0)	46.5 (44.0–52.0)	< .001
Manufacturer HFA @ 50 dB	55.5 (48.0–66.0)	36.5 (35.0–38.0)	45.0 (45.0–45.0)	45.0 (45.0–51.0)	46.0 (45.0–52.0)	< .001
Measured EIN	34.0 (32.0–38.0)	32.5 (32.0–34.5)	37.0 (35.0–39.0)	34.0 (33.0–36.0)	34.0 (33.0–36.0)	.51
Manufacturer EIN	23.0 (18.0–25.5)	23.0 (21.0–25.0)	21.0 (21.0–21.0)	25.0 (23.0–26.0)	25.0 (22.0–26.0)	.04
dEIN	12.5 (7.5–17.0)	9.5 (7.0–13.5)	16.0 (14.0–18.0)	8.0 (7.0–12.5)	8.5 (7.0–14.0)	.204
Harmonic distortion measured 500 Hz	1.0 (1.0–2.5)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	.02
Manufacturer harmonic distortion 500 Hz	2.5 (2.0–4.5)	1.8 (0.6–3.0)	0.7 (0.7–0.7)	3.0 (2.0–3.0)	3.0 (2.0–3.0)	.416
Harmonic distortion measured 800 Hz	1.0 (0.0–1.5)	0.0 (0.0–0.5)	0.0 (0.0–0.0)	1.0 (1.0–1.0)	1.0 (0.0–1.0)	.105
Manufacturer harmonic distortion 800 Hz	2.0 (2.0–3.0)	1.8 (0.6–3.0)	0.8 (0.8–0.8)	3.0 (2.0–3.0)	3.0 (2.0–3.0)	.244
Harmonic distortion measured 1600 Hz	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	.005
Manufacturer harmonic distortion 1600 Hz	2.0 (1.0–2.5)	2.0 (1.0–3.0)	0.9 (0.9–0.9)	3.0 (2.0–3.0)	3.0 (1.2–3.0)	.006

Note. BTE = behind the ear; CIC = completely in canal; ITE = in the ear; RIC = receiver in canal; dEIN = deviation of the measured EIN from the manufacturer-specified EIN; dMax = deviation of the measured maximum from the manufacturer-specified maximum; EIN = equivalent input noise; HFA = high frequency average, meaning the average of values at 1000, 1600, and 2500 Hz; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input; Q1–Q3 = range from first to third quartile.

Figure 3



Hearing aid compliance rate with three different analyzers

Note. Panel A: deviation of the measured Max OSPL90 (dMaxOSPL90) from the manufacturer-specified values. Panel B: deviation of the measured EIN from the company specified EIN (dEIN). Max OSPL90 = maximum output sound pressure level at 90dB input; EIN = equivalent input noise.

Table 5

ANSI Compliance Rates for 20 Receiver-in-Canal Hearing Aids Using Three Different Analyzers

Parameter	Verifit-1 (*n* = 20)	Verifit-2 (*n* = 20)	Aurical (*n* = 20)	Total (*N* = 60)	*p* value
Max OSPL 90 (< +3 dB)	18 (90.0%)	19 (95.0%)	19 (95.0%)	56 (93.3%)	.765
HFA-OSPL 90 (± 4 dB)	18 (90.0%)	18 (90.0%)	19 (95.0%)	55 (91.7%)	.804
HFA @ 50 dB (± 5 dB)	18 (90.0%)	17 (85.0%)	18 (90.0%)	53 (88.3%)	.851
EIN (< +3 dB)	1 (5.0%)	19 (95.0%)	18 (90.0%)	38 (63.3%)	< .001
THD (< +3%)	19 (95.0%)	20 (100.0%)	19 (95.0%)	58 (96.7%)	.596

Note. Variance allowances from the ANSI standard are shown with each parameter. ANSI = American National Standards Institute; EIN = equivalent input noise; HFA = high-frequency average, meaning the average of values at 1000, 1600, and 2500 Hz; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input; THD = total harmonic distortion.

is not present in the initial acoustic input. Internal noise may come from various sources, including the microphone, the analog-to-digital converter, the digital-to-analog converter, and the receiver; however, the microphone is the most common source of internal noise (Chong & Jenstad, 2017; Lee & Geddes, 1998; Ohlenforst et al, 2017). EIN becomes a problem when it becomes audible to the listener. Patients with better low- and mid-frequency hearing levels may be more vulnerable to EIN, depending on which frequencies have the most noise energy (Nabelek et al., 2006). According to the research, individual patients consider varying levels of background noise tolerable, so if a patient has a lower tolerance to background noise and the HA is producing EIN, the patient may be dissatisfied with the HA (Chong & Jenstad, 2017; Cox et al., 2016; Lewis et al., 2010). Furthermore, it should be noted that a high-frequency hearing loss configuration produces higher noise levels in the HAs compared to a flat configuration (Rawool, 1998), and the internal level at which the noise is perceived to be audible also depends on the audiometric configuration (Agnew, 1996).

Notably, little research has been done on how the analyzer used to examine compliance affects the ANSI test results (Ravn & Preves, 2015). To investigate the possible effect of the analyzers on the ANSI test results, three different analyzers were used in this work. Our findings revealed that the performance of the HA tested using the three analyzers differed significantly for EIN. The EIN

Table 6

ANSI Hearing Aid Test Parameters Obtained Using Different Analyzers

Parameter	Verifit-1 (n = 20) median (Q1–Q3)	Verifit-2 (n = 20) median (Q1–Q3)	Aurical (n = 20) median (Q1–Q3)	Total (N = 60) median (Q1–Q3)	p value
Measured Max OSPL 90	115.0 (114.0–116.0)	115.0 (114.0–116.0)	114.3 (113.2–115.3)	114.8 (113.8–115.9)	.387
Manufacturer Max OSPL 90	115.0 (115.0–115.0)	115.0 (115.0–115.0)	115.0 (115.0–115.0)	115.0 (115.0–115.0)	1.000
Measured HFA-OSPL 90	109.5 (107.5–112.0)	109.0 (108.5–111.5)	108.7 (107.8–109.5)	109.0 (108.0–111.0)	.393
Manufacturer OSPL 90	109.0 (109.0–112.0)	109.0 (109.0–112.0)	109.0 (109.0–112.0)	109.0 (109.0–112.0)	1.000
Measured HFA @ 50 dB	46.0 (45.5–48.5)	46.0 (46.0–48.5)	45.2 (44.2–46.0)	46.0 (45.0–47.5)	.022
Manufacturer HFA @ 50 dB	45.0 (45.0–47.0)	45.0 (45.0–47.0)	45.0 (45.0–47.0)	45.0 (45.0–47.0)	1.000
Measured EIN	30.5 (27.0–32.0)	24.5 (22.0–26.0)	27.6 (25.0–28.1)	27.0 (24.0–30.0)	< .001
Manufacturer EIN	26.0 (25.0–26.0)	26.0 (25.0–26.0)	26.0 (25.0–26.0)	26.0 (25.0–26.0)	1.000
Harmonic distortion measured 500 Hz	1.0 (1.0–2.0)	1.0 (1.0–1.0)	1.3 (1.1–1.8)	1.0 (1.0–1.8)	.067
Manufacturer harmonic distortion 500 Hz	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	1.000
Harmonic distortion measured 800 Hz	1.0 (1.0–1.0)	1.0 (1.0–2.0)	1.4 (1.1–1.8)	1.0 (1.0–1.8)	.162
Manufacturer harmonic distortion 800 Hz	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	1.000
Harmonic distortion measured 1600 Hz	1.0 (1.0–2.0)	1.0 (1.0–1.0)	1.4 (1.1–1.6)	1.0 (1.0–1.6)	.057
Manufacturer harmonic distortion 1600 Hz	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	1.000
Max OSPL 90 difference between measured and manufacturer	0.0 (−1.5–1.5)	0.0 (−1.0–6.0)	−1.8 (−2.3– −1.5)	−1.0 (−2.0–0.0)	< .001
OSPL 90 difference between measured and manufacturer	0.0 (−1.0–4.0)	0.0 (−1.0–4.0)	−2.0 (−4.0– −1.2)	−0.1 (−2.7–1.0)	< .001
HFA @ 50 dB difference between measured and manufacturer	0.0 (−1.5–1.0)	1.0 (−0.5–2.0)	−0.9 (−4.3– −0.3)	0.0 (−1.7–1.0)	.007
EIN difference between measured and manufacturer (dEIN)	5.0 (4.0–6.0)	−1.0 (−2.0–0.0)	1.8 (1.0–2.0)	2.0 (−1.0–4.0)	< .001
HD 500 difference between measured and manufacturer	−2.0 (−2.0– −1.0)	−2.0 (−2.0– −1.5)	−1.6 (−1.9– −1.3)	−1.9 (−2.0– −1.0)	.053
HD 800 difference between measured and manufacturer	−2.0 (−2.0– −1.0)	−2.0 (−2.0– −1.0)	−1.5 (−1.8– −1.2)	−1.8 (−2.0– −1.0)	.211
HD 1600 difference between measured and manufacturer	−2.0 (−2.0– −1.0)	−2.0 (−2.0– −2.0)	−1.4 (−1.9– −0.6)	−2.0 (−2.0– −1.0)	.007

Note. ANSI = American National Standards Institute; EIN = equivalent input noise; HFA = high frequency average; HD = harmonic distortion; Max = maximum; OSPL 90 = output sound pressure level with a 90 dB input.

is dictated by the bandwidth of the HAs (ANSI, 1992). Of the HAs that were noncompliant on the Verifit-1, most were compliant with the Verifit-2 and the Aurical. Fleiss kappa analysis confirmed a significant discrepancy. Most current digital HAs have extended frequency responses up to 10000–12000 Hz. If HAs with extended frequency responses were tested using analyzers that have limited analyzing bandwidth up to 8000 Hz, the frequencies beyond 8000 Hz and harmonics of the HAs at higher frequencies might be counted towards the noise (Florentine et al., 1987; Martin, 2009; Moore et al., 2010).

Usually, HAs with EIN levels beyond tolerances from the manufacturer's specifications are considered out of compliance and sent for repair or replacement. However, as our findings indicate, considerable variability in EIN is possible when assessments are made using different analyzers, making it plausible to erroneously classify some of the HAs as out of specification for EIN (ANSI, 1992). Other factors that may increase EIN are a leak between the HAs, coupler connection, and microphone connection; open vents; ambient noise levels in the environment leaking into the test chamber; and vibrations of other equipment placed on the same table/platform. All these variables were controlled in this study, but in clinical settings this may not always be the case. Furthermore, Holder et al. (2016), who reported similar findings using the Verifit-1, cross-checked EIN levels obtained from Verifit-1 with the Fonix 8000 test box system (Frye, 2005) to rule out the impact of test box isolation on EIN measurement. In particular, the noise isolation provided by Verifit-1 was 25 dB, and for Fonix 8000, it was 45 dB at 1000 Hz. The authors concluded that noncompliance is because the measurement protocols cannot be replicated in the clinical setting or the HAs are not designed to have lower EIN levels. Such factors can therefore contribute to the apparent anomalies in the performance assessment of HAs, underscoring the need for testing protocols that can be homogeneously implemented in different test settings (Lewis et al., 2010).

Furthermore, even if EIN levels are high, they are not directly linked to patients' perceptions of HAs noise sensitivity (Kates et al., 2018; Lee & Geddes, 1998; Lopez-Poveda et al., 2017; Nabelek et al., 2006; Ohlenforst et al., 2017). Because the EIN is an average of noise levels at specific frequencies and does not account for all frequencies on the audiogram, internal noise from the HAs cannot be reliably reflected by the EIN in real-world situations, and any noise introduced into the HAs after the application of the gain is not accurately represented in the EIN (Kates et al., 2018). The clinical application of EIN levels is further limited, as the individual's perception of HAs noise depends on lower-level gain, compression, circuit noise, venting, and the individual's auditory thresholds. Additionally, the perception depends on the spectral shape of the noise and cannot be represented by a single value.

A variety of other factors can influence HA testing in clinics. Although HAs and the software used to fit them have advanced technologically, the quality management of the fitting process has not. Some manufacturers have a test mode and precise measurement setup with their HAs, but not all have this, making it difficult to replicate test results in the clinical setting. Such challenges defeat the purpose of the ANSI standard for HA quality assurance. In the absence of a clinically replicable protocol, professionals may classify HAs that are not meeting the specifications as defective and return them to the manufacturer. This may not be a time-efficient practice for the dispenser, the patient, or the manufacturer.

Ambient noise is another factor that can affect the reliability of ANSI tests. In the study by Holder et al. (2016), after finding that the EIN measurements were significantly out of specification in both test boxes used, they contacted representatives from the HA companies. They found that the manufacturers' measurements were conducted in an anechoic chamber. Because measurement in the anechoic chamber cannot be repeated in a regular clinical setting, such discrepancies violate the fundamental principle of quality control. If quality management is the goal, the testing process and procedure must be well-publicized and applicable to the clinical environment. Future research comparing measurements taken in a sound-treated environment with those taken in a quiet room could help determine whether ambient noise affects EIN levels; however, using anechoic chambers in clinical settings may not be feasible.

Verification and quality control measures of the HAs should be replicable across settings and quality. Although performing ANSI measurements of HAs before fitting is considered best practice, only 67% of hearing health professionals own a HA analyzer, and only a portion of them perform the measurements (Mueller, 2005). When polled regarding the utility of verifying the HAs before fitting, dispensers indicated the absence of compelling scientific evidence to support the benefits of performing all HA fitting protocols (Kochkin et al., 2010). Notably, many audiologists believed the ANSI compliance test to have limited practical benefit, be time-consuming, and produce inconsistent results with different HA analyzers (Holder et al., 2016; Walden et al., 2000). Although our results support the fact that differences in analyzer and testing setup may lead to some inconsistency, it is important to conduct an ANSI compliance test to avoid the problems that patients might face during use. The prudent approach is to standardize testing procedures and configurations, ensuring that they are highly repeatable and independent of the testing location.

Our study has certain limitations that should be acknowledged before generalizing our findings. First, this study is a single-centre study and does not have any data or perspective from HA users to gauge the real impact of HA noncompliance with standards. Second, we have found that the type of analyzer can affect the test results; however, solely on the basis of the current study, we cannot conclusively ascribe the reasons for such deviations. More controlled experiments are needed to fully elucidate the factors that might influence the reliability of tests using different analyzers. The different styles and different brands were not equally represented in the sample. Furthermore, it is also important to examine the variability in results obtained when conducting repeated measurements on the same HAs using the same analyzer. Because the ANSI standard contains multiple parameters, it would be helpful if the parameters were weighted with respect to their clinical significance. A homogeneous, easy and accurate testing standard and test setup are necessary to avoid spurious rejections or dispense of substandard HAs.

Conclusion

When using the Verifit-2 or Aurical analyzers, our findings indicate that HA noncompliance rates are lower than those previously reported. Rates of noncompliance for EIN were found to be exceptionally high with the Verifit-1 analyzer. Given that extended frequency ranges of HAs can contribute erroneously to EIN, failure to meet the standard EIN levels should not be the sole criterion for rejection of HAs, especially if using the Verifit-1 analyzer. Because EIN is a function of bandwidth, the observed noncompliance of a HA with EIN may not necessarily indicate a problem with the HA; rather, it could be an error due to the analyzer's restricted frequency response. Manufacturers are encouraged to provide clinically replicable quality control protocols to avoid the unnecessary rejection of HAs due to noncompliance with ANSI standards. There is also a need to establish more uniform and easily accessible testing protocols to assess and validate the efficacy of HAs.

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Indicateurs normatifs du développement du langage en français québécois à 54, 60 et 66 mois : résultats du projet ELLAN

Normative Indicators of Language Development in Québec French at 54, 60, and 66 Months of Age: Results of the ELLAN Study

MOTS-CLÉS
DÉVELOPPEMENT LANGAGIER
PRÉSCOLAIRE
FRANÇAIS

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Cet article vise à présenter des indicateurs normatifs du développement du vocabulaire réceptif et expressif, de la phonologie et de la morphosyntaxe expressives chez des enfants québécois unilingues francophones âgés de 54, 60 et 66 mois. Ces indicateurs sont basés sur les résultats obtenus par 99 enfants recrutés à l'âge de 36 mois (± 1 semaine; *M* = 36,1 mois; *É-T* = 0,2) et suivis jusqu'à l'âge de 66 mois. Les données ont été recueillies lors de trois visites à domicile réalisées à six mois d'intervalle, à l'aide d'outils fréquemment utilisés par les orthophonistes dans leur pratique clinique et valides sur le plan psychométrique. Une technique statistique de rééchantillonnage utilisant l'intervalle de confiance à 95 % du 10^{e} rang centile a permis de déterminer les scores reflétant la présence de difficultés pour chaque mesure de langage chez les enfants et de former trois regroupements de scores pour identifier les enfants en difficulté, ceux se situant dans une zone d'incertitude et ceux ayant un développement typique. Les résultats confirment une progression significative des habiletés langagières mesurées entre l'âge de 54 et 66 mois. Ils suggèrent également que les mesures utilisées sont suffisamment sensibles pour détecter cette évolution chez les enfants, justifiant ainsi leur pertinence clinique. L'interprétation des normes issues des outils originaux est discutée à la lumière des résultats obtenus. Les données de la présente étude contribuent à l'accroissement du corpus de connaissances sur les indicateurs normatifs du développement du langage en français québécois et, en ce sens, constituent des points de repère indispensables pour le travail clinique en orthophonie et la recherche.

Abstract

This article aims to present normative indicators of receptive and expressive vocabulary development and of phonological and morphosyntactic components of expressive language among unilingual francophone Québec children aged 54, 60, and 66 months. These indicators are based on the results obtained by 99 children recruited at the age of 36 months (± 1 week; *M* = 36.1 months; *SD* = 0.2) and followed until the age of 66 months. Data were collected during three visits conducted 6 months apart, using psychometrically valid tools frequently used by speech-language pathologists in clinical practice. A statistical resampling technique using the 95% confidence interval of the 10^{th} percentile was used to determine scores reflecting the presence of difficulties on each language measure, and to form three categories of scores to identify children presenting with difficulties, those in a zone of uncertainty, and those presenting with typical development. The results confirm a significant increase in children's language skills between 54 and 66 months of age. They also suggest that the measures used were sufficiently sensitive to detect changes in the language skills of these children, confirming their clinical relevance. Interpretations of the normative data developed for the original tools are discussed in light of the current indicators. The data provided in this study contribute to a body of knowledge on normative indicators of language development in Québec French and constitute indispensable benchmarks for clinical work and research in speech-language pathology.

Une évaluation du langage doit s'appuyer sur des critères précis et des données de références fiables et valides pour une population donnée. Les chercheurs doivent aussi compter sur de telles données pour déterminer, par exemple, l'admissibilité des participants à une recherche sur la base de résultats jugés typiques ou non. Or, les normes développementales sur lesquelles appuyer ces prises de décisions font encore largement défaut en français québécois (Monetta et al., 2016). Sur le plan clinique, cette lacune complique le processus d'évaluation du langage et peut même entrainer des conclusions non fondées et, par le fait même, donner lieu à des interventions injustifiées. Cela est inacceptable en soi, mais plus encore dans un contexte où les ressources professionnelles sont limitées (Michallet et al., 2018). Sur le plan de la recherche, l'absence ou l'insuffisance de normes développementales en français québécois peut influencer la justesse des conclusions scientifiques tirées des études menées auprès des jeunes enfants.

Dans un article paru en 2020 dans cette même revue, Sylvestre et al. ont publié des indicateurs normatifs du développement lexical réceptif et expressif, de la phonologie et de la morphosyntaxe expressive d'enfants québécois unilingues francophones âgés de 36, 42 et 48 mois. En continuité avec cette première recherche de l'étude longitudinale sur le langage et la négligence (ELLAN; Sylvestre, 2014-2019), le présent article a pour but de présenter des indicateurs normatifs pour les mêmes aspects du développement langagier, en ajoutant cette fois les résultats des enfants âgés de 54, 60 et 66 mois. C'est dans cet esprit d'arrimage que s'inscrit la structure du présent article, semblable au précédent.

Normes actuellement disponibles en français québécois

Au Québec, l'évaluation du vocabulaire réceptif des enfants est fréquemment effectuée à l'aide de l'Échelle de vocabulaire en images Peabody (ÉVIP; Dunn et al., 1993) et l'évaluation du vocabulaire expressif, par la version francophone de l'*Expressive One Word Picture Vocabulary Test–Revised* (Gardner, 1990) ou de l'*Expressive One Word Picture Vocabulary Test*–2000 (EOWPVT-2000, Brownell, 2000). Or, des chercheurs ont montré que les résultats obtenus à ces tests par des enfants franco-québécois se situent entre 1 et 1,4 écart-type au-dessus des normes établies auprès d'un échantillon d'enfants franco-canadiens (Elin Thordardottir et al., 2010; Sylvestre et al., 2020). Ceci tend à démontrer que les normes de l'ÉVIP et de l'EOWPVT-2000 ne sont pas représentatives du stade de développement du lexique réceptif et expressif des enfants francophones du Québec. Le degré de la variabilité de l'exposition au français de la population de référence composée d'enfants qui sont souvent bilingues (Elin Thordardottir et al., 2010; Godard et Labelle, 1995) a été avancé comme explication de cette situation (Sylvestre et al., 2020). Compte tenu des répercussions que ces constats peuvent avoir sur la pratique clinique et la recherche, il importe de réviser les normes s'appliquant aux enfants franco-québécois au moyen d'études additionnelles.

À la suite de l'administration du protocole structuré d'Évaluation sommaire de la phonologie chez les enfants d'âge préscolaire (MacLeod et al., 2014), le pourcentage moyen de consonnes correctement produites a été établi à 90 % (*É.-T.* = 12) chez un groupe d'enfants québécois francophones âgés de 48 à 53 mois. Par ailleurs, la production correcte de tous les phonèmes à l'intérieur des mots est en voie d'acquisition (75 %) à l'âge de 48 mois (Sylvestre et al., 2020). Or, aucune donnée sur le pourcentage moyen de consonnes correctement produites n'est disponible pour les enfants plus âgés, pas plus d'ailleurs que sur la proportion de mots correctement produits (c.-à-d. sans aucune erreur). De telles données relatives à la composante phonologique se révèlent pourtant fort utiles pour guider le travail clinique des orthophonistes, considérant que les difficultés phonologiques constituent le motif de consultation le plus fréquent chez les jeunes enfants (Thomas-Stonell et al., 2010).

Sur le plan de la morphosyntaxe, la longueur moyenne des énoncés (LMÉ) en mots et en morphèmes chez les enfants unilingues franco-québécois âgés en moyenne de 5 ans a été établie dans deux études successives par Elin Thordardottir (Elin Thordardottir, 2015; Elin Thordardottir et al., 2010). La LMÉ était similaire dans ces deux études, quoique des scores légèrement supérieurs ressortent dans celle menée en 2010 (LMÉ en mots = 4,72 vs 4,2; LMÉ en morphèmes = 5,9 vs 5,4). Les échantillons limités de ces études (*n* entre 18 et 30) incitent à mener des travaux supplémentaires afin de valider ces résultats et de contribuer à la précision de normes développementales pour cette composante du langage en français québécois.

En somme, les normes développementales associées aux outils disponibles pour l'évaluation du vocabulaire réceptif et expressif ne sont pas appropriées pour les enfants francophones du Québec. Quelques données normatives sur le développement de la phonologie et de la morphosyntaxe sont disponibles en français québécois pour des enfants âgés de plus de 48 mois. Elles doivent toutefois être appuyées par des données additionnelles, notamment avec des échantillons plus substantiels. Cela contribuerait à augmenter la confiance des cliniciens et des chercheurs envers la fiabilité et la validité des résultats qu'ils obtiennent lors de l'évaluation du langage d'un enfant. Des données longitudinales sont également nécessaires afin de déterminer la progression de ces habiletés langagières au cours de la période préscolaire. Globalement, de telles données contribueraient à l'accroissement du corpus de connaissances sur le développement langagier en franco-québécois, connaissances qui sont à ce jour très parcellaires. Le processus d'évaluation et la prise de décision clinique s'en trouveraient renforcés, de même que la recherche dans le domaine de l'orthophonie.

Objectifs

La présente étude vise à présenter des indicateurs normatifs du développement du vocabulaire réceptif et expressif, de la phonologie et de la morphosyntaxe expressives chez des enfants québécois unilingues francophones âgés de 54, 60 et 66 mois. En combinant ces données à celles de l'étude de Sylvestre et al. (2020) qui la précède, elle a également comme objectif de brosser un portrait exhaustif de la progression des habiletés langagières relatives à ces mêmes composantes au cours de la période allant de 36 à 66 mois.

Méthodologie

Les données du présent article sont tirées de l'étude longitudinale sur le langage et la négligence (ELLAN; Sylvestre, 2014-2019). Cette étude visait notamment à décrire les trajectoires développementales du langage d'enfants québécois francophones âgés de 3 à 5,5 ans pris en charge par la Direction de la protection de la jeunesse pour négligence ou risque sérieux de négligence. L'étude visait aussi à comparer le développement de ces enfants à celui d'enfants non négligés du même âge. Sa réalisation a été approuvée par les comités d'éthique à la recherche du Centre jeunesse de Québec – Institut universitaire (CJQ-IU-2014-03) et du Centre jeunesse de Montréal – Institut universitaire (CJM-IU : 14-05-06).

Participants

Les normes développementales présentées dans cet article proviennent de données collectées auprès du groupe d'enfants non négligés (groupe de comparaison) lors des trois derniers temps de mesure de l'étude longitudinale, soit lorsque les enfants étaient âgés de 54, 60 et 66 mois. À leur entrée dans l'étude (T1), ces 99 enfants québécois francophones (46 garçons; 53 filles) étaient âgés en moyenne de 36,1 mois (*É-T* = 0,2). Ils ont tous été recrutés dans des centres de la petite enfance des régions de Québec et de Montréal. Pour être considérés unilingues, les enfants devaient avoir été exposés au français plus de 90 % du temps depuis leur naissance (Pearson et al., 1997). Ceux qui présentaient une condition biologique susceptible d'être associée à des difficultés de langage (p. ex. surdité) n'ont pas été retenus dans l'échantillon, pas plus que ceux qui recevaient ou avaient reçu des services en orthophonie au moment de l'entrée dans l'étude. Les caractéristiques sociodémographiques des participants, recueillies lors de l'entrée dans l'étude, sont présentées dans le **tableau 1**.

Lorsque comparé aux données populationnelles disponibles (Institut de la statistique du Québec, 2018a, 2018b), l'échantillon ne se distingue pas significativement de la population générale sur la base de la structure de la famille (93,9 %, 87,0 %; p = 0,06), et du nombre d'enfants dans la famille (76,8 %, 84,4 %; p = 0,07). Aucune donnée n'est toutefois disponible sur le niveau de scolarité des parents ou sur le revenu brut annuel des familles du Québec ayant des enfants de cet âge. Pour faciliter la comparaison de l'échantillon à la population générale, notons que le revenu familial brut moyen des couples avec un ou plusieurs enfants dépassait 110 000 $ par année en 2014 (112 700 $), année du début de l'étude (Institut de la statistique du Québec, 2019).

Procédure et matériel

Le niveau de développement langagier a été mesuré au domicile de l'enfant, selon les disponibilités de la famille, lorsque celui-ci était âgé de 54, 60 et 66 mois. Les rencontres ont majoritairement été tenues en avant-midi afin de favoriser la disposition et la collaboration de l'enfant. Un auxiliaire de recherche remplissait les questionnaires avec le parent répondant pendant qu'un second auxiliaire effectuait la passation des différentes tâches de mesures langagières avec l'enfant. Un questionnaire rempli au premier temps de mesure de l'étude principale a permis de documenter les caractéristiques sociodémographiques rapportées précédemment. Le vocabulaire réceptif et expressif, la phonologie et la morphosyntaxe expressives ont été évalués à l'aide d'outils fréquemment utilisés par les chercheurs et par les orthophonistes dans leur pratique clinique. L'entretien avec l'enfant a été entièrement enregistré sur bande vidéo pour permettre la transcription ultérieure des corpus de langage spontané et de la phonologie.

Vocabulaire réceptif

La forme A de l'Échelle de vocabulaire en images Peabody (ÉVIP; Dunn et al., 1993) a été utilisée pour mesurer le vocabulaire réceptif de l'enfant. Au total, ce test inclut 170 planches comprenant quatre images chacune. Le nombre de planches administrées à l'enfant varie selon son âge et son niveau de performance. Sur chaque planche, l'enfant doit montrer l'image mentionnée à voix haute par l'expérimentateur. Ce dernier met fin à

Tableau 1

Caractéristiques sociodémographiques des participants au début de l'étude (T1)

Variables	% (*n*)	Données populationnelles[a]
Structure familiale (*N* = 99)		
Biparentale	93,9 (93)	87,0 %
Monoparentale	6,1 (6)	13,0 %
Nombre d'enfants dans la famille (*N* = 99)		
Deux et moins	76,8 (76)	84,4 %
Plus de deux	23,2 (23)	15,6 %
Scolarité du répondant principal (*N* = 99)		
Secondaire ou professionnelle	9,1 (9)	-
Collégiale	21,2 (21)	-
Universitaire	69,7 (69)	-
Scolarité de l'autre figure parentale (*N* = 94)		
Secondaire ou professionnelle	27,7 (26)	-
Collégiale	23,4 (22)	-
Universitaire	48,9 (46)	-
Revenu familial brut (*N* = 98)		
≤ 39 999 $	4,1 (4)	-
40 000 $ - 79 999 $	24,5 (24)	-
≥ 80 000 $	71,4 (70)	-
Sous le seuil de faible revenu[b] (*N* = 95)		
Oui	3,2 (3)	-

[a]Les données proviennent du recensement de 2016 (Institut de la statistique du Québec, 2018a, 2018b);
[b]Le seuil de faible revenu est calculé en fonction du revenu familial brut et de la taille du ménage (Institut de la statistique du Québec, 2019).

l'administration après que l'enfant a commis six erreurs parmi huit items consécutifs.

L'étalonnage de ce test a été fait dans quatre régions du Canada, auprès de 2 038 sujets, autant de filles que de garçons, répartis également sur 20 niveaux d'âge entre 0 et 24 ans. Plus de la moitié de ces jeunes (60 %) habitaient en Ontario et au Québec, les autres venant du Nouveau-Brunswick et de l'Alberta. Dans la forme originale de l'ÉVIP, les coefficients d'homogénéité (corrélations de Spearman-Brown) sont respectivement de 0,78 (groupe d'âge : 4;0 à 4;5), 0,77 (groupe d'âge : 4;6 à 4;11) et 0,85 (groupe d'âge : 5;0 à 5;5). Le coefficient de stabilité (corrélation test-retest) est de 0,72 pour les deux formes de l'ÉVIP. La démarche utilisée s'appuie sur celle effectuée pour le *Peabody Picture Vocabulary Test-R* original et les termes retenus constituent un échantillon représentatif de la langue française (Pauzé et al., 2004), ce qui en assure la validité de contenu.

Vocabulaire expressif

La version francophone de l'outil standardisé *Expressive One Word Picture Vocabulary Test*-2000 (EOWPVT-2000; Brownell, 2000) a été retenue pour évaluer le vocabulaire expressif. Cette version est la seule dont l'adaptation est normée en franco-québécois. Cette normalisation a été réalisée auprès de 404 enfants âgés de 2 à 5 ans 11 mois, recrutés dans des centres de la petite enfance (CPE) de la région de la Capitale-Nationale. Une centaine d'enfants ont été sélectionnés par groupe d'âge (2;0-2;11, 3;0-3;11, 4;0-4;11, 5;0-5;11) et distribués le plus uniformément possible dans chaque groupe selon le mois de naissance et le sexe (Gauthier et al., 2011).

Ce test comporte 170 images qui illustrent des objets, des actions ou des concepts que l'enfant doit nommer. Le nombre de planches administrées varie selon l'âge et le niveau de performance de l'enfant. Dans la présente étude, la prononciation du mot n'a pas été prise en considération pour autant que celui-ci était reconnaissable. Le test se termine lorsque l'enfant produit six erreurs consécutives.

Phonologie

Le protocole d'Évaluation sommaire de la phonologie chez les enfants d'âge préscolaire (MacLeod et al., 2014) a été utilisé pour évaluer le développement phonologique. Dans ce test, l'enfant doit nommer spontanément les images ou les répéter après évocation de la part de l'expérimentateur. Une transcription large en alphabet phonétique international a ensuite été réalisée et deux calculs de proportions en ont découlé : les mots correctement produits (sur 40 mots) et les consonnes correctement produites (sur 103 consonnes). Les calculs relatifs au respect du nombre de syllabes et à celui de la structure syllabique de chaque mot, réalisés dans l'étude précédente, n'ont pas été reconduits dans la présente étude puisque ces habiletés étaient considérées comme acquises respectivement à l'âge de 36 et de 42 mois (Sylvestre et al., 2020). La grille de cotation utilisée pour calculer ces proportions, adaptée avec la permission de MacLeod et al. (2014) par Martel-Sauvageau, est disponible sur demande auprès de l'auteure de correspondance.

Lors de la transcription, chaque mot était réécouté jusqu'à trois fois, en utilisant un casque d'écoute, avant d'être considéré comme inintelligible. La procédure de Heilmann et al. (2008) a été suivie pour mesurer l'accord interjuge. Un accord sur la transcription phonétique des mots a été calculé sur 20 % des transcriptions à chaque temps de mesure. Le pourcentage d'accord en relecture des transcriptions (15 % du matériel) atteignait 96,3 % en moyenne (*É-T* = 2,5-3,7) et celui des transcriptions indépendantes (5 % du matériel) s'élevait à 91,0 % en moyenne (*É-T* = 2,7-6,8).

Morphosyntaxe

L'analyse des flexions verbales produites (temps et modes) et le calcul de la LMÉ de l'enfant en mots et en morphèmes ont permis d'estimer le niveau de développement de la morphosyntaxe. La LMÉ en morphèmes tient compte de l'ensemble des manipulations grammaticales effectuées par l'enfant et est considérée un indicateur plus précis du développement morphosyntaxique que ne l'est la LMÉ en mots (Parisse et Maillart, 2004). L'acquisition d'une flexion verbale par un enfant a été calculée sur la base d'au moins une occurrence de production dans son corpus de langage spontané.

L'échantillon de langage spontané a été recueilli dans le contexte du « Jeu de village », un jeu symbolique semi-structuré et standardisé d'une durée de 15 minutes entre l'enfant et l'expérimentateur (Sylvestre et Morissette, 1989; version révisée par Sylvestre et Di Sante, 2015). Ce jeu implique des personnages (figurines d'une fille et d'un garçon, deux pompiers et un chien) interagissant dans un quartier comprenant une maison, une station-service/lave-auto et une caserne de pompiers. Il comprend également deux voitures, une dépanneuse et un camion de pompiers. Le jeu est présenté à l'enfant selon une approche standardisée qui commence par une introduction : « On va jouer avec des personnages et des voitures dans un quartier ». Ensuite, l'expérimentateur met le jeu en place avec l'aide de l'enfant, en s'assurant qu'il connait les personnages et les lieux. Tout au long du jeu, l'expérimentateur suit un scénario prédéterminé impliquant un script, divisé en sept épisodes. Le respect du scénario prédéterminé assure une passation uniforme qui offre à tous les enfants les mêmes occasions de s'exprimer pour parler de différents sujets, d'actions et d'événements qui ont cours pendant le jeu. Cependant, l'ordre des épisodes peut être modifié pour faciliter le déroulement naturel du jeu.

La transcription orthographique de 50 énoncés produits par l'enfant a ensuite été effectuée. Les limites des énoncés ont été établies en considérant les pauses et l'intonation (Leadholm et Miller, 1994). Comme pour la phonologie, chaque mot ou énoncé était réécouté jusqu'à trois fois, en utilisant un casque d'écoute, avant qu'un mot ou un énoncé soit considéré comme inintelligible. Les trois premières minutes de l'enregistrement ont été exclues afin de permettre à l'enfant de se familiariser avec l'activité. Une analyse de 50 énoncés est considérée comme valide pour mesurer les habiletés morphosyntaxiques des jeunes enfants (Elin Thordardottir, 2016; Paul, 2001).

Par la suite, un protocole de codification basé sur les directives du logiciel d'analyse systématique de transcriptions de langage (SALT; Miller et Iglesias, 2012) et incluant les procédures pour le français définies par Elin Thordardottir (2005) a été utilisé pour coder les échantillons de langage spontané. Selon ces procédures, un code est attribué pour les flexions grammaticales impliquant les temps, les modes, les personnes, les accords en genre des adjectifs et des pronoms, les accords en nombre des substantifs, des pronoms et des adjectifs. Les lignes directrices précisent aussi les procédures de codification pour les groupes de mots qui comptent pour un seul (p. ex. par terre, à cause de). Enfin, la codification ne pénalise pas les particularités du français québécois jugées acceptables (p. ex. je vais a : maison = je vais a|à a|la maison, pronoms « il/elle » souvent contractés « i/a »).

L'utilisation du logiciel informatique SALT a permis de réduire le risque d'erreurs liées au codage et de garantir la cohérence du calcul des indicateurs (Miller et al., 2016). Les procédures du logiciel SALT prévoient un code pour la personne (/Px) et le temps/mode (/Tx) pour toutes les flexions verbales. Les accords en nombre et en genre sont imputés aux substantifs (/PLN), aux adjectifs (/PLA, /GA) et aux participes passés (/PLA). Aucun code n'est prévu dans les procédures originales pour l'accord en temps des verbes produits à l'indicatif présent qui est marqué par l'accord à la personne (p. ex. Je marche = Je marche|marcher/P1; Ils marchent = Ils marchent|marcher/P6). Tel que mentionné dans Sylvestre et al. (2020), un code a été ajouté dans la présente étude pour l'accord en temps de l'indicatif présent, et ce, afin de rendre compte de l'ensemble des flexions verbales produites par les enfants. L'enjeu relatif à la différence rarement audible entre l'indicatif et l'impératif présent (p. ex. je marche vs marche) a été résolu par les indices fournis par la vidéo et le script.

La fiabilité des transcriptions a aussi été vérifiée par un accord interjuge en suivant la procédure proposée par Heilmann et al. (2008). Dans un premier temps, 15 % des transcriptions ont été relues par un transcripteur indépendant qui regardait l'enregistrement de l'interaction et la transcription originale, et notait les désaccords. L'accord obtenu était de 91,4 %. Des transcriptions indépendantes de 5 % du matériel ont ensuite été réalisées. L'accord était alors de 80,1 %, ce qui est considéré comme acceptable.

À la suite de la transcription, tous les échantillons de langage ont été codés par une première assistante de recherche formée par une experte de ce type d'analyse. Un accord interjuge portant sur la procédure de codification SALT a été réalisé sur 15 % de ces échantillons par une deuxième personne également formée par la même experte. Le coefficient de corrélation intraclasse est de 0,98 avec un intervalle de confiance (IC) de 95 % se situant entre 0,94 et 0,99, $F(1, 56) = 55{,}29$, $p < 0{,}001$ pour la LMÉ en mots. Pour la LMÉ en morphèmes, il est de 0,98 avec un IC de 95 % entre 0,93 et 0,99, $F(1, 56) = 56{,}27$, $p < 0{,}001$. Ces coefficients de corrélation intraclasse témoignent d'une excellente fidélité interjuges (Koo et Li, 2016) et du consensus obtenu lors des transcriptions.

Analyses

Les analyses ont été réalisées avec les logiciels *IBM SPSS Statistics* (version 25.0) et *R Statistical Software* (version 3.4.3). Le seuil du 10^e^ rang centile, typiquement utilisé pour juger de difficultés cliniquement significatives (Tomblin, 2000), a été privilégié pour déterminer les scores reflétant la présence de difficultés à une mesure langagière donnée.

Comme dans l'étude précédente (Sylvestre et al., 2020), les indicateurs normatifs ont été estimés par une technique de rééchantillonnage (*bootstrapping*, N = 5 000 : Efron et Tibshirani, 1993). Cette technique modifie légèrement la composition de l'échantillon à chaque réitération du calcul du 10^{e} rang centile, ce qui s'est fait 5 000 fois dans le cas présent. Le rééchantillonnage permet d'identifier dans quelle zone (IC à 95 %) le 10^{e} rang centile peut varier. Cette zone constitue alors une zone d'incertitude, c'est-à-dire qu'il est incertain si l'enfant se situe à l'intérieur ou à l'extérieur de la norme. Cependant, au-delà de la borne supérieure et en deçà de la borne inférieure de l'IC, la qualification norme/hors norme est appuyée par l'analyse statistique. Un autre avantage de la technique de rééchantillonnage est qu'elle est applicable à n'importe quel type de distribution, de sorte qu'il n'est pas nécessaire de présumer que les variables sont distribuées normalement pour l'utiliser.

Des seuils de coupure entre ces trois zones ont ainsi été établis. La première zone regroupe les enfants dont les scores se situent sous la borne inférieure de l'IC à 95 % du 10^{e} rang centile. Ce sont ceux pour qui l'on peut affirmer avec confiance que leur niveau de développement langagier se situe en deçà du 10^{e} rang centile et qu'ils présentent des difficultés dans la variable langagière mesurée. La deuxième zone est composée des enfants dont les scores se situent entre les bornes inférieure et supérieure de l'IC à 95 % du 10^{e} rang centile (bornes incluses). Cette zone intermédiaire regroupe les participants pour lesquels il est impossible de conclure avec certitude que leur résultat se situe en deçà ou au-delà du 10^{e} rang centile. La troisième zone comprend les enfants dont les scores se situent au-dessus de la borne supérieure de l'IC à 95 % du 10^{e} rang centile. Ces enfants ne présentent vraisemblablement pas de difficultés dans la variable langagière mesurée.

Des analyses de variance (ANOVA) ont été réalisées afin de vérifier si les scores progressent en fonction de l'âge des participants. La procédure nparLD (Logiciel R, progiciel nparLD, version 2.1) est une ANOVA non paramétrique à mesures répétées. Elle a été développée spécifiquement pour des situations qui altèrent la fiabilité des ANOVA paramétriques (Noguchi et al., 2012), ce qui en fait une analyse de choix pour la présente étude. En effet, on ne peut pas présumer que l'influence de l'âge consiste uniquement à faire varier les moyennes. Avec des données développementales, il est fréquent que la diversité augmente avec l'âge, car les enfants ne se développent pas nécessairement tous au même rythme. L'hétérogénéité des variances est alors courante. Les formes des distributions peuvent changer radicalement par l'atteinte d'un plafond ou par segmentation de l'échantillon, comme lorsqu'une partie de l'échantillon commence à suivre une dynamique différente de l'autre partie. On ne peut pas non plus garantir que la matrice des corrélations entre les mesures répétées manifeste une structure apte aux ANOVA paramétriques.

Un autre avantage de la procédure nparLD est qu'elle fonctionne avec toutes les échelles, au moins ordinales ou dichotomiques, sans aucune exigence quant à la forme de la distribution ni même à sa constance. Parce qu'il s'agit d'une analyse des rangs, les données marginales ont peu d'impact. Finalement, cette procédure n'exige pas l'exclusion des participants avec des données manquantes ni l'imputation de ces données. Au lieu de produire un rapport F, la procédure nparLD produit une statistique ATS (ANOVA-*type statistic*). Bien que non paramétrique, cette procédure produit aussi une mesure de la taille d'effet appelée *relative treatment effect*, dont la valeur varie entre 0 et 1, avec 0,5 comme valeur associée à l'hypothèse nulle (c.-à-d. l'absence de progression). Une valeur *relative treatment effect* représente la probabilité qu'un score puisé dans une condition donnée soit plus grand qu'un score puisé n'importe où dans l'ensemble des conditions. Il est convenu de considérer les effets comme étant petits, moyens ou grands selon que les *relative treatment effect* soient supérieurs à 0,56, 0,64 ou 0,71 ou inférieurs à 0,44, 0,36 ou 0,29 (Vargha et Delaney, 2000).

Résultats

Le **tableau 2** présente la moyenne et l'écart-type de l'ensemble de l'échantillon pour chacune des variables langagières. Il rapporte également la valeur du 10[e] rang centile et l'IC à 95 % autour de cette valeur, par groupe d'âge. Le nombre de participants varie légèrement pour chaque mesure et pour chaque temps, compte tenu de difficultés techniques (p. ex. bris de la caméra) ou pour des considérations méthodologiques (p. ex. non-collaboration de l'enfant à la tâche).

Tableau 2

Résultats à chacune des mesures langagières (moyenne et écart-type) et valeur du 10[e] rang centile avec intervalle de confiance à 95 % autour de cette valeur à 54, 60 et 66 mois

	54 mois (*N* entre 86 et 91)		60 mois (*N* entre 90 et 94)		66 mois (*N* = 96)	
	M (*É-T*)	10[e] *rang* centile IC (95 %)	*M* (*É-T*)	10[e] *rang* centile IC (95 %)	*M* (*É-T*)	10[e] *rang* centile IC (95 %)
Vocabulaire réceptif						
ÉVIP	118,2 [a] (15,1)	44,2 [b] 39,0-49,0	123,2 [a] (13,4)	52,4 [b] 50,0-60,0	125,8 [a] (13,1)	63,8 [b] 56,0-69,0
Vocabulaire expressif						
EOWPVT-2000	113,5 [a] (13,7)	44,0 [b] 38,9-49,0	111,1 [a] (16,6)	47,5 [b] 44,0-53,0	113,6 [a] (11,9)	58,7 [b] 50,0-61,4
Phonologie						
Mots correctement produits (% moyen)	82,0 (16,1)	64,1 52,6-67,2	84,5 (17,0)	60,0 55,0-65,3	85,1 (15,0)	64,3 60,0-69,8
Consonnes correctement produites (% moyen)	92,9 (8,5)	84,2 82,0-86,4	94,0 (7,8)	85,4 82,5-86,4	94,3 (7,0)	87,0 84,5-88,7
Morphosyntaxe						
Longueur moyenne des 50 énoncés en mots	4,9 (0,8)	4,1 3,6-4,2	5,1 (1,0)	3,8 3,5-4,1	5,3 (1,0)	4,1 3,8-4,4
Longueur moyenne des 50 énoncés en morphèmes	7,3 (1,2)	5,9 5,4-6,2	7,7 (1,4)	5,7 5,3-6,3	7,9 (1,5)	6,0 5,8-6,5

Note. IC = Intervalle de confiance; ÉVIP = Échelle de vocabulaire en images Peabody, Forme A (Dunn et al., 1993); EOWPVT-2000 = Expressive One Word Picture Vocabulary Test – 2000 Edition (Brownell, 2000).
[a]Score normalisé (moyenne et écart-type); [b]Calculé à partir des scores bruts.

Les résultats indiquent que, tout comme chez des enfants québécois francophones âgés de 42 et 48 mois (Sylvestre et al., 2020), les scores pour le vocabulaire réceptif et expressif se situent à environ un écart-type au-dessus des moyennes établies avec les outils originaux pour les trois tranches d'âge d'enfants évalués. Les scores moyens à l'ÉVIP à 60 et 66 mois se situent même autour de 1,5 écart-type au-dessus de la moyenne des normes originales.

Concernant les variables phonologiques à l'étude, une habileté langagière était considérée comme acquise si elle était observée dans 90 % ou plus des occasions de production (Paul, 2001; Sylvestre et al., 2020) tandis que pour les temps et modes verbaux, un seuil de groupe a été privilégié (production du morphème par 90 % ou plus du groupe). Ainsi, le pourcentage de consonnes correctement produites est considéré comme acquis à l'âge de 54 mois (92,9 %). La production correcte de l'entièreté des mots (c.-à-d., sans aucune transformation phonologique) tend vers le critère d'acquisition à 66 mois (85,1 %).

La LMÉ passe de 4,9 à 5,3 mots et de 7,3 à 7,9 morphèmes entre l'âge de 54 et 66 mois. Le **tableau 3** rapporte la proportion d'enfants ayant produit les temps et modes verbaux au moins une fois dans le corpus de langage spontané. Rappelons que l'indicatif présent était déjà produit par la totalité des enfants à l'âge de 36 mois, ce qui explique son absence du **tableau 3** (Sylvestre et al., 2020). Le futur proche est considéré comme acquis à 54 mois (96,7 %), tandis que la production du passé composé tend vers le critère d'acquisition à 66 mois (85,4 %). L'imparfait est en voie d'acquisition, avec une production chez un peu plus de la moitié des enfants entre 54 et 66 mois. La production du futur simple et du plus-que parfait reste marginale à 66 mois.

Le **tableau 4** rapporte la répartition des participants dans les trois zones identifiées par la technique de rééchantillonnage, en fonction des IC (95 %) du 10e rang centile, pour chaque groupe d'âge. On peut voir, par exemple, qu'un enfant de 54 mois qui aurait une LMÉ en morphèmes de 4,8 se situerait dans la zone « difficulté », alors qu'un autre dont la LMÉ se situerait à 5,6 serait dans la zone d'incertitude, et un troisième enfant ayant une LMÉ de 6,7 se trouverait dans la zone correspondant au développement typique. Une LMÉ en morphèmes de 5,4 ou 6,2 (bornes inférieure et supérieure de l'IC) situerait le niveau de développement de l'enfant dans la zone d'incertitude.

Globalement, entre 3,2 % et 4,7 % des participants se situent en deçà de la borne inférieure du 10e rang centile dans l'une ou l'autre des variables langagières mesurées, à l'un ou l'autre des trois temps de mesure. Les proportions relevées dans la zone d'incertitude (entre 12,1 % et 16,5 %) et dans la zone de développement typique (entre 79,1 % et 83,5 %) sont aussi relativement stables dans le temps.

La progression des habiletés langagières au cours de la période allant de 36 à 66 mois (6 temps de mesure) est

Tableau 3

Temps et modes verbaux produits au moins une fois à l'âge de 54, 60, et 66 mois

	54 mois (*N* = 91) %[a]	60 mois (*N* = 92) %	66 mois (*N* = 96) %
Temps verbaux			
Passé composé	78,0	84,8	85,4
Futur proche	96,7	98,9	100,0
Imparfait	58,2	69,6	59,4
Futur simple	12,1	26,1	22,9
Plus-que-parfait	18,7	22,8	20,8
Modes verbaux			
Impératif	84,6	88,0	93,8
Subjonctif	47,3	52,2	52,1
Conditionnel	23,1	35,9	37,5

[a] Les pourcentages reflètent la proportion du groupe ayant produit un temps de verbe ou un mode verbal au moins une fois dans un verbatim de 50 énoncés.

Tableau 4

Répartition des participants dans les trois regroupements d'habiletés langagières en fonction des intervalles de confiance à 95 % du 10e rang centile à l'âge de 54, 60, et 66 mois

		Difficulté			Zone d'incertitude			Développement typique		
	N	Score	*n*	%	Score	*n*	%	Score	*n*	%
Vocabulaire réceptif										
ÉVIP (score brut)										
54 mois	91	< 39,0	4	4,4	39,0-49,0	15	16,5	> 49,0	72	79,1
60 mois	93	< 50,0	4	4,3	50,0-60,0	13	14,0	> 60,0	76	81,7
66 mois	96	< 56,0	4	4,2	56,0-69,0	13	13,5	> 69,0	79	82,3
Vocabulaire expressif										
EOWPVT-2000 (score brut)										
54 mois	89	< 38,9	4	4,5	38,9-49,0	14	15,7	> 49,0	71	79,8
60 mois	94	< 44,0	3	3,2	44,0-53,0	14	14,9	> 53,0	77	81,9
66 mois	96	< 50,0	4	4,2	50,0-61,4	12	12,5	> 61,4	80	83,3
Phonologie										
Mots correctement produits (% moyen)										
54 mois	91	< 52,6	4	4,4	52,6-67,2	11	12,1	> 67,2	76	83,5
60 mois	94	< 55,0	4	4,3	55,0-65,3	12	12,8	> 65,3	78	83,0
66 mois	96	< 60,0	4	4,2	60,0-69,8	12	12,5	> 69,8	80	83,3
Consonnes correctement produites (% moyen)										
54 mois	91	< 82,0	4	4,4	82,0-86,4	12	13,2	> 86,4	75	82,4
60 mois	94	< 82,5	4	4,3	82,5-86,4	13	13,8	> 86,4	77	81,9
66 mois	96	< 84,5	4	4,2	84,5-88,7	12	12,5	> 88,7	80	83,3
Morphosyntaxe										
Longueur moyenne des 50 énoncés en mots										
54 mois	86	< 3,6	4	4,7	3,6-4,2	12	14,0	> 4,2	70	81,4
60 mois	90	< 3,5	4	4,4	3,5-4,1	11	12,2	> 4,1	75	83,3
66 mois	96	< 3,8	4	4,2	3,8-4,4	13	13,5	> 4,4	79	82,3

Tableau 4 (suite)

Répartition des participants dans les trois regroupements d'habiletés langagières en fonction des intervalles de confiance à 95 % du 10e rang centile à l'âge de 54, 60, et 66 mois

Longueur moyenne des 50 énoncés en morphèmes										
54 mois	86	< 5,4	4	4,7	5,4-6,2	12	14,0	> 6,2	70	81,4
60 mois	90	< 5,3	4	4,4	5,3-6,3	12	13,3	> 6,3	74	82,2
66 mois	96	< 5,8	4	4,2	5,8-6,5	12	12,5	> 6,5	80	83,3

Note. ÉVIP = Échelle de vocabulaire en images Peabody, Forme A (Dunn et al., 1993); EOWPVT-2000 = Expressive One Word Picture Vocabulary Test – 2000 Edition (Brownell, 2000).

présentée dans le **tableau 5** qui montre les résultats de l'analyse de variance, amalgamés pour l'ensemble de l'étude longitudinale (incluant les données tirées de Sylvestre et al., 2020). Sans surprise, on peut y constater que le développement du vocabulaire réceptif et expressif augmente graduellement du premier au sixième temps de mesure, soit entre l'âge de 36 et 66 mois. Le même phénomène s'observe pour la LMÉ en mots et en morphèmes. Les deux calculs de proportions rendant compte du développement phonologique atteignent leur développement maximal à l'âge de 60 mois. Dans l'ensemble, la production des flexions verbales poursuit sa progression jusqu'à l'âge de 60 mois bien que les données suggèrent la possibilité d'un plateau entre 48 et 54 mois. Les tailles d'effet reflètent l'importance de la différence de performances de l'ensemble du groupe entre deux temps de mesure. Le fait que les tailles d'effet augmentent entre l'âge de 36 et de 66 mois indique que le développement se fait de plus en plus rapidement au fil du temps.

Discussion

Cet article avait pour objectif de présenter des indicateurs normatifs pour le vocabulaire réceptif et expressif, la phonologie et la morphosyntaxe expressives d'enfants québécois unilingues francophones âgés de 54 à 66 mois. Ces indicateurs s'appliquent aux enfants qui ne présentent pas de conditions particulières pouvant être associées à des difficultés de langage et pour lesquels aucune difficulté langagière n'a été dépistée à l'âge de 36 mois, lors de l'entrée dans l'étude.

Globalement, les résultats suggèrent que les habiletés relatives à la structure du langage – phonologie et morphologie – progressent jusqu'à l'âge de 60 mois où elles atteignent un plateau. Une progression significative de la LMÉ et du vocabulaire réceptif et expressif est aussi confirmée par les scores obtenus à chacun des temps de mesure. Ces résultats, une fois combinés, suggèrent que les mesures langagières utilisées sont suffisamment sensibles pour pouvoir détecter l'évolution des habiletés langagières des enfants de 54, 60 et 66 mois, comme c'était le cas pour les enfants plus jeunes (Sylvestre et al., 2020), confirmant ainsi leur pertinence clinique.

En ce qui concerne la phonologie, la production correcte des consonnes est acquise à 54 mois, un résultat qui s'apparente à ceux obtenus par MacLeod et al. (2014) auprès d'enfants de 48 à 53 mois. L'habileté à produire correctement un mot (c.-à-d. sans aucune transformation phonologique) demeure en voie d'acquisition à l'âge de 66 mois (85,1 %). Ce constat est cohérent avec les données indiquant que la production stable de toutes les consonnes se consolide vers l'âge de 7 ans (Brosseau-Lapré et al., 2018).

La LMÉ s'enrichit progressivement au fil du développement de l'enfant. Une étude antérieure avait révélé des résultats inférieurs à ceux de la présente étude pour la LMÉ en morphèmes chez des enfants âgés de 54 mois (Elin Thordardottir, 2015). Le fait d'avoir inclus le calcul de l'indicatif présent dans le cadre de la présente étude peut vraisemblablement expliquer cet écart. L'ajout du calcul de l'indicatif présent visait à brosser un portrait exhaustif des flexions verbales produites par les enfants (Sylvestre et al., 2020). Or, bien que le script utilisé pour recueillir les échantillons de langage spontané sollicite la production d'une variété de flexions verbales, le contexte de la collecte de ces échantillons se situe dans l'ici et maintenant, ce qui entraine une plus grande probabilité que des flexions verbales s'y rattachant soient produites (indicatif présent, impératif, flexions avec des auxiliaires au présent : passé composé, futur proche).

Tableau 5

Résultats des analyses de comparaison pour les enfants à l'âge de 36, 42, 48, 54, 60 et 66 mois

	ANOVA		Tailles d'effet RTE selon l'âge						Posthocs
	ATS (*dl*)	*p*	36	42	48	54	60	66	
Vocabulaire réceptif	389,3 (4,4)	< 0,001	0,19	0,32	0,44	0,58	0,70	0,78	T1<T2<T3<T4<T5<T6
Vocabulaire expressif	322,5 (4,3)	< 0,001	0,20	0,33	0,46	0,59	0,66	0,76	T1<T2<T3<T4<T5<T6
Phonologie									
Mots correctement produits	174,9 (4,3)	< 0,001	0,23	0,36	0,49	0,60	0,66	0,66	T1<T2<T3<T4<(T5=T6)
Consonnes correctement produites	184,6 (4,3)	< 0,001	0,23	0,36	0,48	0,61	0,66	0,67	T1<T2<T3<T4<(T5=T6)
Morphosyntaxe									
Flexions verbales	47,8 (4,7)	<0,001	0,32	0,37	0,51	0,54	0,64	0,62	T1<T2<(T3=T4)<(T5=T6)
Longueur moyenne des 50 énoncés en mots	79,4 (4,8)	< 0,001	0,26	0,40	0,47	0,59	0,62	0,65	T1<T2<T3<T4<T5<T6
Longueur moyenne des 50 énoncés en morphèmes	84,7 (4,7)	< 0,001	0,25	0,39	0,48	0,58	0,62	0,66	T1<T2<T3<T4<T5<T6

Note. ANOVA = analyses de variance; ATS = ANOVA-type statistic (Noguchi et al., 2012); RTE = Relative treatment effect (Vargha et Delaney, 2000).

Très peu de progression est observée au niveau de la diversité des temps et des modes verbaux dans un contexte de langage spontané entre 36 et 66 mois. Il est vrai que les enfants produisent une plus grande variété de flexions verbales au fil du temps, mais dans les faits, ce sont les mêmes quatre flexions qui étaient considérées comme acquises entre 36 et 48 mois qui demeurent produites par des proportions importantes d'enfants entre 54 et 66 mois (présent, passé composé, futur proche, impératif). Ce plateau peut refléter une limite du calcul réalisé dans le cadre de cette étude, puisqu'une seule occurrence d'une flexion verbale suffit pour qu'elle soit comptabilisée dans les scores d'acquisition. Or, bien qu'il ne semble pas y avoir de progression sur le plan des nouveautés dans les modes et temps verbaux produits, il y en a certainement une dans la quantité de flexions verbales produites puisque la LMÉ en morphèmes progresse significativement entre 54 et 66 mois. Par rapport à la période allant de 36 à 48 mois (Sylvestre et al., 2020), l'utilisation de l'imparfait connait une progression tandis que le passé composé tend à être moins fréquemment utilisé. Cette apparente diminution peut s'expliquer par l'augmentation de l'usage de l'imparfait au cours de la même période, lequel offre une alternative à l'enfant pour exprimer le passé.

La production du futur simple et du plus-que-parfait demeure très marginale à 66 mois. Il est possible que le contexte de collecte des corpus de langage spontané se prête peu à l'expression de ces temps de verbes moins fréquents. Souvent, le sens d'un énoncé produit avec ces temps de verbes peut être véhiculé en employant une flexion verbale précédemment acquise, qui serait alors privilégiée par les enfants (p. ex. on va manger des nouilles / on mangera des nouilles). Or, si ces flexions étaient sollicitées spécifiquement, comme c'est le cas dans certains tests formels, il est probable qu'une plus grande proportion d'enfants serait en mesure de les produire. Rappelons que, dans le cas présent, les proportions présentées s'appliquent à des productions sollicitées dans une situation écologique, soit dans un contexte de jeu symbolique entre un expérimentateur et l'enfant. En ce sens, elles reflètent l'utilisation des habiletés de l'enfant dans ce type de contexte davantage que ses connaissances. D'ailleurs, pour utiliser au mieux les indicateurs normatifs présentés pour la LMÉ et les flexions verbales, l'idéal serait de collecter un échantillon de langage spontané de l'enfant dans une situation de jeu libre et familière à l'enfant qui se rapproche du contexte du « Jeu de village » si cette procédure même n'est pas utilisée (p. ex. un corpus produit par l'enfant pendant une activité de lecture ne fournirait pas nécessairement des données qui soient comparables à celles produites dans un contexte plus libre).

Les écarts aux normes originales de l'ÉVIP et de l'EOWPVT-2000, constatés dans d'autres études (Elin Thordardottir et al., 2010; Godard et Labelle, 1995; Sylvestre et al., 2020), sont confirmés par cette étude. Ils s'accentuent même au fil du temps pour ce qui est de l'ÉVIP. Les présents résultats, combinés à ceux de Sylvestre et al. (2020), confirment que l'ÉVIP ne rend pas justice aux habiletés des enfants franco-québécois, et ce, dès l'âge de 42 mois. Les scores obtenus par les enfants francophones du Québec dépassent ceux de la population franco-canadienne de l'outil original de près d'un écart-type à partir de 48 mois et l'écart augmente progressivement, pour finalement atteindre presque deux écarts-types (1,7) à 66 mois. En ce qui concerne l'EOWPVT-2000 les différences des scores pour les enfants franco-québécois se maintiennent à environ un écart-type au-dessus des moyennes des normes originales. Cela dit, ces tests disposent maintenant de versions plus récentes qui n'étaient pas encore publiées au moment de la réalisation de la présente étude. Les versions du PPVT-5-CDN-F (Échelle de vocabulaire en images Peabody—Cinquième édition : Version pour francophones du Canada) et de l'EVT-3-CDN-F (Test de vocabulaire expressif—Troisième édition : Version pour francophones du Canada) ont été publiées en 2019. Néanmoins, les cliniciens et les chercheurs ont encore largement recours aux versions employées dans cette étude, ce qui rend utiles les indicateurs normatifs présentés, du moins à court et moyen terme.

Dans la présente étude comme dans la précédente (Sylvestre et al., 2020), la technique statistique utilisée pour établir la présence de difficultés chez les enfants génère des scores conservateurs. En effet, en recourant au calcul de l'IC, cette technique a permis d'estimer le score le plus bas associé au 10e rang centile, et ce, pour chaque habileté langagière mesurée. Ainsi, la délimitation de trois zones de performance atteste que les enfants dont les scores se situent dans la zone « difficulté » (entre 3,2 % et 4,7 % de l'échantillon) obtiennent effectivement des résultats plus faibles que la majorité des enfants du même âge et présentent des difficultés cliniquement significatives en fonction de leur âge chronologique. Or, il importe de rappeler que certains enfants dont les scores se situent dans la zone d'incertitude peuvent tout de même présenter des difficultés dans la composante langagière évaluée, tout comme ils peuvent avoir un développement typique.

Les indicateurs normatifs présentés constituent des points de repère indispensables pour l'évaluation du vocabulaire réceptif et expressif, de la phonologie et de la morphosyntaxe expressives. Conjuguées à ceux disponibles pour des enfants de 36 à 48 mois (Sylvestre et al., 2020), ces données auprès d'enfants âgés de 54, 60 et 66 mois permettent de compléter le portrait longitudinal du développement de ces composantes langagières en franco-québécois. En consultant à la fois les données descriptives des **tableaux 2** et **3** et celles relatives à la répartition des participants dans les regroupements du **tableau 4**, l'orthophoniste ayant recours à ces normes pourra conclure avec confiance à la présence ou non de difficultés dans le développement des habiletés langagières étudiées chez les enfants. En plus de permettre la planification de l'intervention, l'évaluation normative contribuera aussi à en vérifier l'efficacité (Garcia et al., 2006).

Comme toujours lors de la référence à des normes développementales, il importe de s'assurer d'une correspondance étroite entre les caractéristiques des enfants évalués et celles de l'échantillon de référence. Pour offrir une représentation juste des habiletés langagières des enfants, l'évaluation normative doit également être complétée par une évaluation dynamique (American Speech-Language-Hearing Association, 2021) et par celle des impacts des difficultés langagières de l'enfant dans son quotidien (Bishop et al., 2017). Une analyse des facteurs de risque et de protection présents dans l'environnement de l'enfant complète l'analyse de la situation (Guralnick, 2011). L'examen de l'ensemble du portrait clinique de l'enfant permet à l'orthophoniste de tirer les conclusions qui s'imposent. Cela soutient également l'identification des objectifs d'intervention les plus appropriés en matière de complexité, et qui s'inscrivent avec une probabilité accrue dans la zone proximale de développement des enfants.

Ces indicateurs normatifs sont précieux pour l'évaluation en orthophonie; ils le sont aussi pour mieux comprendre la séquence selon laquelle les enfants développent certaines habiletés (p. ex. quelles flexions verbales, à quel âge et dans quel ordre). Pour les chercheurs, outre le fait de contribuer à valider l'admissibilité des participants à leurs études, ces indicateurs normatifs ajoutent des balises sur lesquelles s'appuyer pour comparer les résultats d'études réalisées auprès d'enfants québécois francophones. En effet, que ce soit pour le développement de connaissances théoriques ou la validation de l'efficacité d'interventions novatrices, la nécessaire et judicieuse confrontation des résultats de recherche de différentes études est indispensable. Que les chercheurs puissent avoir recours à des indicateurs normatifs comparables contribuera à ce recoupement des résultats et, du même coup, à l'enrichissement des connaissances.

Bien que les résultats de la présente étude constituent un apport aux connaissances actuelles, des études additionnelles sont nécessaires pour valider ces indicateurs normatifs et compléter le tableau pour l'ensemble des composantes langagières. Il pourrait notamment s'agir du développement de la pragmatique du langage, plus précisément encore, de la séquence développementale des intentions de communication qui est très peu documentée au-delà de l'âge de 2 ans. Par ailleurs, étudier les patrons de transformations phonologiques ou des aspects précis du développement syntaxique, comme le développement des divers types d'énoncés, serait certainement d'intérêt pour compléter le portrait langagier d'enfants francophones. Cela dit, il est souhaité que les résultats de cette recherche contribuent au travail clinique et à la recherche en orthophonie.

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Déclaration

Les auteurs déclarent n'avoir aucun conflit d'intérêts, financiers ou autres.

Early Information and Clear Recommendations to Parents Positively Influence the Use of Bone Anchored Hearing Systems for Young Children With Unilateral Microtia/Atresia

Fournir des informations aux parents tôt dans la séquence développementale et leur formuler des recommandations claires influencent positivement l'utilisation des systèmes auditifs à ancrage osseux chez les jeunes enfants atteints de microtie ou d'atrésie unilatérale

KEYWORDS
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DECISION-MAKING

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Abstract

Hearing with two ears is better than one. That said, consensus is lacking on recommendations around hearing devices for children with unilateral hearing loss. This study explores factors influencing parents' decision making around bone anchored hearing systems for young children with microtia/atresia to help inform standardized, evidence-based recommendations for those with unilateral hearing loss. An online survey completed by 16 parents of children (6 years old and younger) with unilateral (n = 13) or bilateral (n = 3) microtia/atresia explored how information about amplification was offered to parents and how this may have affected their decision-making process to get a hearing device and use it full-time. Qualitative and descriptive analyses showed that parents of children with unilateral microtia/atresia reported varied experiences with their audiologists, including when information was shared, who initiated the conversation, the extent to which a hearing device was recommended, and the degree to which their audiologist influenced their decision. The majority of children with unilateral microtia/atresia had not achieved full-time use, but earlier information sharing and stronger recommendations were linked to earlier trial of a bone anchored hearing system and greater ongoing usage. These findings contrast with those from children with bilateral microtia/atresia, where quicker achievement of full-time use was reported. These results suggest that audiologists and other professionals have important roles to play in helping parents of children with unilateral microtia/atresia understand the long-term risks and benefits related to amplification. There is a need for greater consistency in what, when, and how these parents receive information and recommendations.

Abrégé

Pour bien entendre, deux oreilles valent mieux qu'une. Cela dit, il n'existe actuellement pas de consensus quant aux recommandations entourant les appareils auditifs à ancrage osseux pour les enfants atteints d'une perte auditive unilatérale. La présente étude a exploré les facteurs qui ont influencé les parents à accepter et à utiliser un système auditif à ancrage osseux pour leur enfant atteint de microtie ou d'atrésie, et ce, afin de développer des recommandations standardisées s'appuyant sur des données probantes pour les personnes atteintes de perte auditive unilatérale. Seize parents d'enfants âgés de six ans et plus et atteints de microtie ou d'atrésie unilatérale (*n* = 13) ou bilatérale (*n* = 3) ont répondu à un questionnaire portant sur la façon dont les informations au sujet de l'amplification leur avaient été communiquées et sur la façon dont celles-ci avaient influencé leur décision à procurer un appareil auditif à ancrage osseux à leur enfant et à l'utiliser à temps plein. Les résultats des analyses qualitatives et descriptives réalisées montrent que les parents d'enfants atteints de microtie et d'atrésie unilatérale ont eu des expériences variées avec les audiologistes. Cela inclut le moment où des informations sur les systèmes auditifs à ancrage osseux leur ont été transmises, la première personne qui a amorcé la conversation à propos des systèmes auditifs à ancrage osseux, la mesure dans laquelle l'appareil auditif à ancrage osseux leur a été recommandé et le degré d'influence de l'audiologiste sur leur décision. La majorité des enfants atteints de microtie ou d'atrésie unilatérale n'utilisait pas encore leur appareil auditif à ancrage osseux à temps plein. Cependant, le fait d'avoir fourni des informations aux parents plus tôt dans la séquence développementale et de leur avoir fait des recommandations plus fortes étaient associés à l'essayage d'un appareil auditif à ancrage osseux chez l'enfant plus tôt dans la séquence développementale et à une utilisation plus importante de ce dernier au moment de remplir le questionnaire. Ces résultats contrastent avec ceux des enfants atteints de microtie ou d'atrésie bilatérale, pour qui les parents ont rapporté avoir adopté une utilisation à plein temps plus rapidement. Les résultats de la présente étude suggèrent que les audiologistes et les autres professionnels ont un rôle important à jouer pour aider les parents d'enfants atteints de microtie ou d'atrésie unilatérale à comprendre les risques à long terme liés à la condition de leur enfant et les avantages associés à l'amplification. Une plus grande cohérence est nécessaire en ce qui concerne le contenu, le moment et la manière dont les parents d'enfants ayant une microtie ou atrésie unilatérale reçoivent des informations et des recommandations au sujet des systèmes auditifs à ancrage osseux.

There is substantial evidence that binaural hearing improves speech perception in noise as well as the ability to localize sounds and to hear in the presence of background noise (Bronkhorst & Plomp, 1990; Lieu et al., 2012; Van Wanrooij & Van Opstal, 2007). Research indicates that children with unilateral hearing loss (UHL), who do not have access to typical binaural cues, may show a higher proportion of language delays and/or speech difficulties than their typically hearing peers (Anne et al., 2017; Lieu, 2004) and have more difficulty listening in the presence of background noise (Griffin et al., 2019) or in school situations that require focused attention (Cañete et al., 2021). Furthermore, children with UHL tend to have greater academic difficulties (Kesser et al., 2013; Lieu et al., 2012; Smit et al., 2021), greater need for educational assistance, and more perceived behavioural problems (Lieu, 2004; Lieu et al., 2010; Tharpe, 2008) than their typically hearing cohort.

Although the benefits of binaural hearing have been known for some time, this has not historically resulted in consistent recommendations for amplification for children with UHL. Children with typical hearing in one ear have often been considered to have sufficient access to develop speech and language normally, and thus amplification has not always, or not consistently, been recommended (Fitzpatrick et al., 2016; Lieu, 2004). Although newborn hearing screening programs have become more widespread, resulting in the early identification of UHL, clear consensus on how children with UHL should be managed audiologically has been slow to emerge (Briggs et al., 2011; Liu et al., 2013).

More recently, the growing body of research on the academic, social, and other impacts on children with UHL (Appachi et al., 2017; Bagatto et al., 2019; Griffin et al., 2019; Kesser et al., 2013; Lieu, 2004; Lieu et al., 2010, 2012) is leading to changes in the audiological management recommendations for these children, with some now being fit with amplification as infants (Bagatto et al., 2018; McCreery et al., 2013, 2017/2019; Rohlfs et al., 2017). Nevertheless, the heterogeneity within the population of children with UHL presents a complex management challenge, as different amplification options are available depending on the type and degree of hearing loss (Bagatto et al., 2018). This can lead to confusion in parents' understanding of the impact of UHL on their children's overall development due to a lack of clarity in the information and counselling provided by professionals regarding recommendations for the management of UHL (Fitzpatrick et al., 2016).

To examine this predicament, we focused on a group of children with similar audiological profiles: those with unilateral microtia/atresia (m/a) in British Columbia (BC), Canada. Microtia describes malformations of the external ear, and atresia refers to the absence or closure of the external ear canal (van Hövell Tot Westflier et al., 2018). These conditions usually occur together (90%; van Hövell Tot Westflier et al., 2018) and most often affect one side, with 77%–93% of cases being unilateral (Luquetti et al., 2012). Prevalence of microtia is estimated at 2.0–2.9 per 10,000 (Luquetti et al., 2011), based on population-based studies in the contiguous United States. Given the reported numbers of births in BC in 2013–2019 (Government of BC, 2020), there are an estimated 9–13 children born with m/a each year in BC.

Although there is strong support and recommendations for the use of bone anchored hearing systems (BAHS) for those individuals with bilateral m/a (Hol et al., 2005; Verhagen et al., 2008; Wang et al., 2018), there has not historically been the same consensus in support for individuals with unilateral m/a (McDermott & Sheehan, 2009; Snik et al., 2008; Tietze & Papsin, 2001). Despite a growing base of research into this topic (Alexander et al., 2020; Graham et al., 2015; Kunst et al., 2008), and evidence that some individuals with UHL can receive significant benefit from use of a BAHS (Appachi et al., 2017; Banga et al., 2013; Hol et al., 2005; Snik et al., 2002; Wazen et al., 2001), there appears to be great variability in the type of support, information, and recommendations parents of children with unilateral m/a receive regarding their child's use of a hearing aid device (Bagatto et al., 2018, 2019; Liu et al., 2013, 2017).

For example, the BC Early Hearing Program follows the early hearing detection and intervention best practice guidelines commonly referred to as the 1-3-6 model, meaning screen by age 1 month, identify by age 3 months, and fit with amplification and enroll in intervention services by age 6 months (Joint Committee on Infant Hearing, American Academy of Pediatrics, 2007). Although the BC Early Hearing Program established full implementation of their early hearing detection and intervention program by 2010 (BC Early Hearing Program, 2010) consistent recommendations and guidelines on how to support amplification trials for children with unilateral m/a have only recently emerged (McCreery et al., 2017/2019).

Prior to 2017, amplification for children in BC with UHL (including those with unilateral m/a) was left to the individual audiologist's discretion. These children were not routinely referred to early intervention services but were monitored by speech-language pathologists through the

BC Early Hearing Program at 9–12, 18, and 24 months of age using the Communication & Symbolic Behaviour Scales Developmental Profile Infant-Toddler Checklist (Wetherby & Prizant, 2002) during a phone interview with a parent. Children under 2 years of age were referred by the BC Early Hearing Program for early intervention services if any concerns were identified (as reported by the parent or based on results of the Infant-Toddler Checklist), if there was a change in hearing, or if the family decided to trial a hearing aid (L. Bell, personal communication, December 15, 2021).

The revised amplification and early intervention guidelines in BC, developed in 2017 and updated in 2019 (McCreery et al., 2017/2019), recommend a BAHS for infants with permanent UHL due to m/a as soon as the child can sit without assistance, which is typically around 6–9 months of age (Government of BC, 2019). This is in contrast with the guidelines for those with permanent bilateral hearing loss due to m/a (as well as those requiring behind-the-ear hearing aids for other types of unilateral or bilateral hearing loss), where amplification is recommended as soon as feasible following confirmation of hearing loss, ideally between 3 and 6 months of age.

This difference in recommended age of fit is due to the unique challenge of having a baby wear a softband device; it is difficult to keep the device positioned correctly on the mastoid while still allowing it to vibrate freely when a child spends most of the time lying down. Through anecdotal experiences of individuals, we are aware that the BAHS must vibrate freely to work properly; when it is touched, the vibration is impeded and the sound is altered, resulting in decreased clarity, sound distortion, and/or acoustic feedback.

For children with bilateral m/a, the recommendation for early amplification supersedes placement concerns because without it the child does not have adequate access to spoken language. For a child with typical hearing on one side, the potential benefit of the BAHS is more directly linked to correct placement of the device, given that the child already has auditory access on one side, and the goal is to add binaural information. Thus, we could expect a child with bilateral m/a to be fit with a BAHS a few months earlier than a child with unilateral m/a. It is also worth noting that the BC guidelines recommend fitting only a single BAHS for children with bilateral m/a, and do not fund a second BAHS (McCreery et al., 2017/2019). This recommendation is based on the assumption that one device will stimulate both cochleae. Although the guidelines acknowledge the impact of head shadow effect and transcranial attenuation, they do not recommend bilateral BAHS as the standard of care due to limited evidence of the benefit of bilateral systems for this population (McCreery et al., 2017/2019).

Given that recommendations for children with unilateral m/a have historically differed from other groups (bilateral m/a, other types of hearing loss) and have changed over time, it is not surprising that we have observed and received anecdotal parent reports suggesting that families are given differing information and recommendations regarding the benefits of hearing device use for children with unilateral m/a. In our clinical practice working with children who are deaf[1] and hard-of-hearing in BC (birth to 5 years old), we have observed that although many families of children with bilateral hearing loss are able to achieve full-time hearing aid use at a young age, families of children with UHL are more varied in their ability to reach this level of use, a trend also observed by Fitzpatrick et al. (2016). On the one hand, parents of children with unilateral m/a have often reported being advised that a BAHS could be considered as an option when their child grows older. On the other hand, we have also observed older children with unilateral m/a who were less receptive to using a BAHS than younger babies and their parents were, as was also noted by McDermott and Sheehan (2009). We have also encountered many parents struggling to make the decision to trial or obtain a nonsurgical option of a BAHS to use for their child. This aligns with research finding that parents can be overwhelmed with hearing loss diagnosis, including when mild or unilateral in nature, and these feelings can be exacerbated when faced with having to decide about hearing technology (Fitzpatrick et al., 2016). Even when families make the decision to use a BAHS, many struggle with attaining full-time use – they can be less determined to keep the hearing aid on at all times when their child still has some access to sound without it.

With the objective of understanding these variations in the level of BAHS use in infants and children with unilateral m/a, this study explored various factors that may influence a family's decision to accept and use a BAHS for their child. Specifically, we explored how families reacted to the information they received early in their journey (as well as when and how that information was shared), and how this information affected decisions about getting and using a device. We hypothesized that the experiences of parents of children with unilateral m/a were inconsistent with respect to (a) receiving clear information and recommendations about the need for and the benefits of a BAHS for their child as an intervention option, (b) choosing to use a BAHS for their child, and (c) attaining full-time use of the BAHS. We further hypothesized that those parents who received clearer, more consistent information and recommendations earlier about the need for and the benefits of a BAHS for their children

[1]We use the terminology deaf rather than Deaf when referring to children because they have not yet had an opportunity to identify with a particular cultural group.

would be more likely to trial a BAHS earlier and achieve full-time BAHS use for their children.

Method

This research was approved by and conducted in accordance with the requirements of the University of British Columbia Behavioural Research Ethics Board (#H17-03354) on March 13, 2019.

Online Survey

We developed an online survey of 66 questions for primary caregivers of children with m/a (available on request). After rigorous question development, the language level of the content was reviewed to ensure it was appropriate for families not familiar with the research study, free from technical terms, and was at a level that was accessible to caregivers with at least a high-school level of education and fluency in written English. Some questions were conditional on responses given to previous questions, thus, not all participants were required to respond to all questions. Questions included a combination of response options (Likert scales, yes/no, and open-ended).

Following an initial statement of information, instructions, and consent, the 66 questions of the main survey content were divided into five sections. The first 12 questions collected demographic information about the primary caregiver and the child, and the following eight questions focused on the child's hearing (e.g., type and level of loss, presence of m/a in each ear). The next 11 questions asked how the primary caregiver first learned about options for amplification for their child (when and how they received information from the audiologist, who initiated the discussion, and the degree to which a BAHS was recommended). Participants were also asked in this section about the extent to which others informed their learning as well as their perception of the risks and benefits of amplification and options for owning their own device (e.g., whether it was provided for free or they had to purchase the device privately). The fourth section of the survey consisted of 27 questions about the child's experience with a BAHS or other hearing equipment: if they tried/owned a BAHS, at what age, for how long; whether the child had used a conventional hearing aid or a second BAHS if bilateral; type of BAHS, perceived benefit; methods of wearing the BAHS (e.g., headband, abutment); and level of use. Last, the survey asked eight questions about factors (appearance, acceptance, benefit, risk, cost, other) and people (audiologist, Deaf or hard-of-hearing adult, ear nose and throat doctor, early interventionist/therapist, family doctor, family/friend, parent of child with m/a, parent of child with different type of hearing loss) and other sources (internet resources, social media, other) influencing the primary caregiver's decision to try, keep and/or stop using a BAHS for their child.

The finalized survey was entered into the University of British Columbia Survey Tool provided by Qualtrics, an online survey tool platform that complies with the BC Freedom of Information and Protection of Privacy Act, keeping survey data secure, stored, and backed up in Canada. It was accessible using a smartphone, computer, or tablet, and pilot testing by three parents of older children with m/a indicated that the full survey took less than 30 minutes to complete (with participants able to pause and come back to complete the survey). Feedback from these parents led to minor changes in wording only. The survey was advertised in written English, and the survey was offered only in written English.

Participants

Eligible participants were primary caregivers of a child aged 6 years or younger with bilateral or unilateral m/a, who self-selected to complete the survey. Caregivers of children with bilateral m/a were included in this study, despite the expectation that the much lower incidence of bilateral m/a would result in a small sample size that would prevent quantitative comparison with the unilateral group. Responses from this smaller cohort were gathered to provide context and additional information.

Participants were offered a $10 Amazon gift card in return for their participation. The study targeted such families in BC, with a flyer advertising the study distributed by email to the province's three early intervention agencies that specialize in supporting families with young deaf and hard of hearing children, a parent-driven, nonprofit organization dedicated to supporting families with children who are deaf or hard-of-hearing in BC (BC Hands & Voices), and three Facebook groups that support families of children who are deaf and hard-of-hearing in BC.

Data Analyses

The survey was available for completion between May 15 and September 18, 2019. During this 4-month period, we received 709 responses (648 completed surveys and 61 partially completed ones). A qualitative and descriptive analysis was done on the 16 genuine responses to the survey. The high number (n = 693) of fraudulent responses detected were eliminated from further consideration.

The incentive behind these fraudulent responses was most likely the offer of a $10 Amazon gift card in return for completion. The antifraud tools available from Qualtrics are testament to the problem online surveys face from fraudulent responses. However, fraudulent attempts could be readily discriminated from genuine responses using a combination of technology embedded within the Qualtrics software and a series of filter questions designed to cross-check these automated detections. Filter questions included a series of questions about the children's hearing which needed to logically agree and open-ended questions whose written responses needed to make sense and bear some relation to the topic being asked. The data were then sorted independently by two raters into three categories ("fraudulent" to be excluded, "genuine" to be included, and "unsure" to be discussed between the two raters and a co-principal investigator). A response was identified as fraudulent (either from bots or cheaters) and excluded from the data set if it met two or more of these criteria:

- Flagged as a duplicate by the ballot box stuffing feature and/or the relevant ID technology implemented in the survey design or had a duplicated IP address.
- Flagged as a bot response by the Q-RecaptchaScore feature implemented in the survey design.
- Latitudinal and longitudinal coordinates were outside the province of BC.
- Nonsensical responses (e.g., giving contradictory information when describing child's hearing loss, such as indicating bilateral hearing loss but then responding that hearing levels in one ear are typical).

Using these criteria, two raters unanimously identified 660 responses as fraudulent (606 completed surveys; 54 partially completed responses). The remaining responses were further reviewed for validity. Fifteen genuine responses were clearly identified as meeting none of the above criteria (14 completed surveys and one partially complete one). They also exhibited a familiarity of the subject (e.g., naming early intervention agencies or providing logical comments or answers about hearing loss and/or equipment). This left 34 "unsure" responses (28 completed surveys and six partially complete ones), which had one criterion from the fraudulent response list or did not seem genuine in their comments or answers. The two raters reviewed these unsure responses with a co-principal investigator. Of these, one incomplete response was confidently considered to be genuine, bringing the total number of genuine responses to 16 (14 completed and two partially completed surveys). Of the remaining responses, 16 (12 completed and four partially completed surveys) were confidently considered to be fraudulent, and 17 (16 completed and one partially completed surveys) were considered to be likely fraudulent. Although we went to lengths to protect participants' anonymity and we did not gather identifying information as part of our response validation, we are highly confident that the independent data screening by three people using the criteria described did indeed yield 16 genuine responses.

Results

Demographic information for the participants is summarized in **Table 1**. Briefly, participants were mothers who varied in their country of origin. Eight respondents were born in BC and four were born in other provinces or territories in Canada. The remaining four respondents were from other countries. Twelve respondents use English as their first language, but the other four indicated that it was not their native language. Two participants reported having a high-school education, four a bachelor's degree, and five a graduate degree. Two reported having a diploma in early childhood education and the remaining participant self-identified as a care attendant.

Background information on the participants' children with m/a is summarized in **Table 2**. All respondents indicated that their children were born in BC and that their hearing loss was identified at birth. Thirteen reported having a child with unilateral m/a and three a child with bilateral m/a.

The reported years of birth for the children ranged from 2013 to 2018. Six of the children with unilateral m/a were born in the years 2017 and 2018; the remaining seven and all three of the children with bilateral m/a were born prior to 2017, at a time when recommendations regarding amplification were left to the discretion of the individual audiologist.

Device Use

Fifteen of the 16 participants reported usage of BAHS. For those with unilateral m/a, the age of first fit for trialing the device was between 6 and 33 months (M = 12.0, SD = 8.6) whereas those with bilateral m/a were first fit for trialing their first device earlier, at 5 weeks, 6 weeks, and 8 weeks (M = 6.34, SD = 1.5; **Table 2**). The single participant whose child with unilateral m/a had not used a BAHS was the only participant who did not report receiving specialized early intervention services (**Table 2**). All participants who reported having trialed a device used only either a softband headband provided by the company or a homemade/purchased headband.

Of the three parents of children with bilateral m/a, one family reported receiving their second BAHS at 9 months, a second family reported 10 months, and a third family did not indicate when they received a second BAHS. All three families reported being informed that only the first BAHS

Table 1

Respondent (Parent) Demographic Information

Variable	Child with unilateral microtia/atresia (n = 13)	Child with bilateral microtia/atresia (n = 3)
Relationship to child		
Mother	13	3
Level of education		
High school/GED	2	0
Bachelor's degree	4	1
Graduate degree	5	1
Other		
ECE diploma	2	0
Care attendant	0	1
Birthplace		
British Columbia	6	2
Other:		
Province/territory		
Manitoba	1	0
Ontario	0	1
Alberta	1	0
Yukon	1	0
Outside Canada		
Switzerland	1	0
Japan	1	0
Hong Kong	1	0
Unspecified	1	0
First language		
English	7	3
Other	4	0

Note. GED = General Educational Development test; ECE = early childhood education

would be provided for free and that they were responsible for purchasing the second themselves or securing funding through an alternate source.

Some parents of children with unilateral m/a reported full-time use of BAHS (n = 4), but many of them were still working to achieve full-time use (n = 6), were satisfied with part-time use (n = 2), or did not use a BAHS (n = 1). This was consistent with the number of hours per week of BAHS usage that the parents reported (M = 42.0, SD = 25.1). There was also a range in the reported use of the BAHS across different environments for children with unilateral m/a (**Figure 1A**). The three parents of children with bilateral m/a all reported full-time use across almost all environments (**Figure 1B**), with an average of 84 hr per week.

Sources of Information and Influencing Factors

Parents of children with unilateral m/a reported varied experiences in terms of learning about BAHS as an option for their child. This discussion was most commonly initiated by the audiologist (n = 7) but for some it was started by the parent or family member (n = 2) or by "other" (n = 3; where "other" indicated a range of self-initiatives: "myself," "audiologist of course," "parents I met at baby groups at

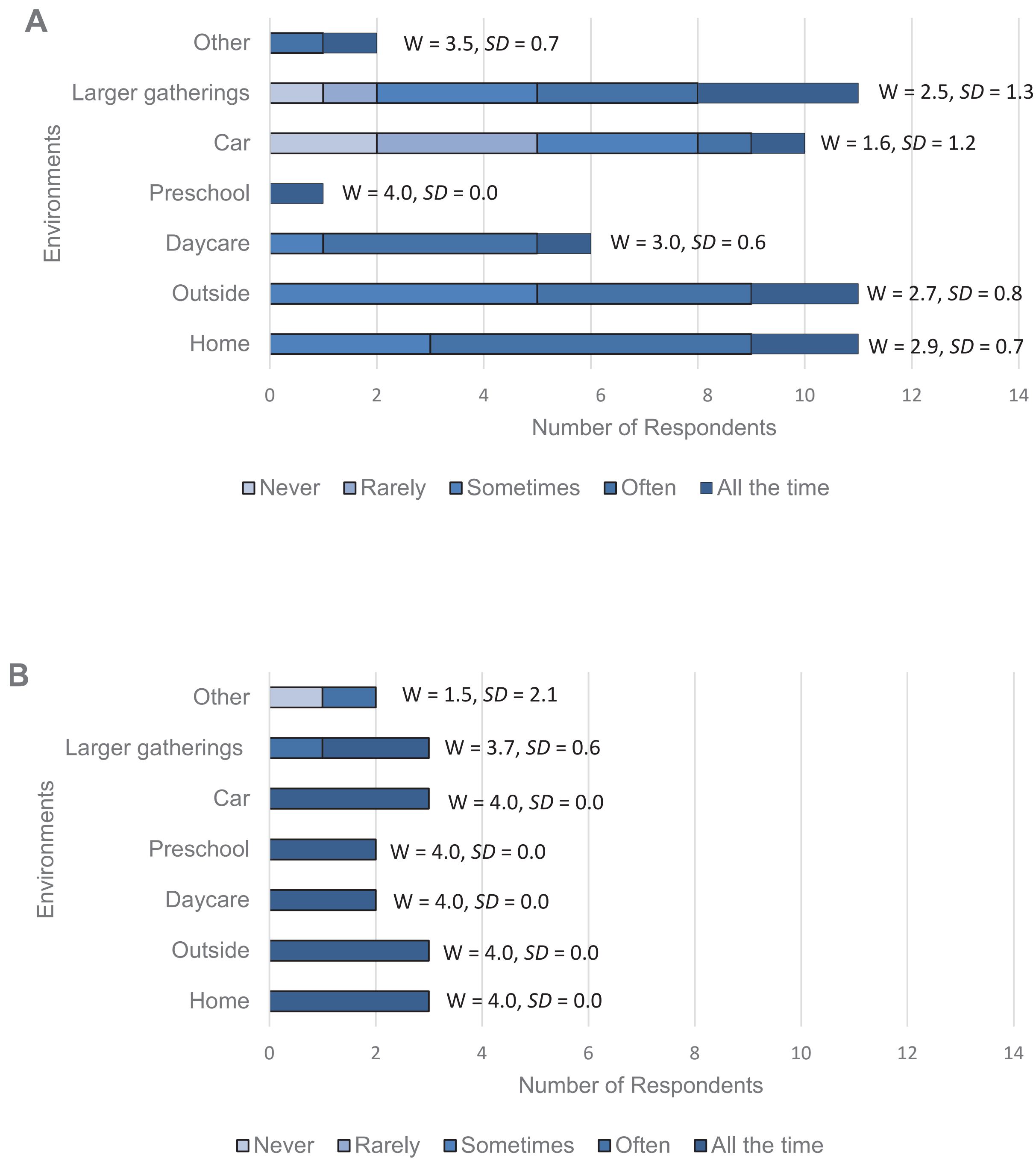
Table 2

Children's Birth Statistics, Amplification Trial, and Service Enrollment Data

Variable	Unilateral microtia/atresia (*n* = 13)	Bilateral microtia/atresia (*n* = 3)
Birth year		
2019	0	0
2018	5	0
2017	1	0
2016	3	2
2015	2	0
2014	0	1
2013	2	0
Birthplace/residence		
Fraser Valley	6	1
Interior BC	5	0
Northern BC	0	0
Vancouver Coastal	0	1
Vancouver Island	2	1
Additional needs		
Yes	1	1
No	10	2
Unsure	2	0
Service enrollment[a]		
Child development centre	4	1
Specialized early intervention agency	12	3
Public health agency	4	0
Other	2	0
None indicated	1	0
Age of identification		
Newborn (at birth)	13	3
Age at which first trialed bone anchored hearing system		
≤6 months	3	3
≤1 year	5	0
≤2 years	3	0
≤3 years	1	0
Never trialed	1	0
Ear(s) affected		
Right	7	3
Left	6	3

Note. BC = British Columbia.
[a]Participants could select more than one service agency because families in BC are able to receive services from more than one agency when the child may benefit from support from other service providers (e.g., occupational therapists, physiotherapists, etc.) or when they receive services from a local service provider as well as from a service provider specialized in working with children who are deaf or hard-of-hearing.

Figure 1



Extent of bone anchored hearing system use in different environments

Note. Panel A shows responses by parents of children with unilateral microtia/atresia (*n* = 12; one participant with unilateral microtia/atresia did not begin a trial of a bone anchored hearing system). Panel B shows responses by parents of children with bilateral microtia/atresia (*n* = 3). Average weighted score (W) was calculated where the sum of scores (*Never* = 0, *Rarely* = 1, *Sometimes* = 2, *Often* = 3, *All the time* = 4) was divided by the number of responses.

hearing support centers," "people from Hands & Voices," "parent guide," "parents I met at BC Family Resource Center [sic] baby groups," "SLT [Speech Language Therapist] at BCFRC [BC Family Resource Centre]," "joint discussion," "we gathered info on internet prior to appt [appointment] with audiologist." Participants of children with bilateral m/a reported that the discussion about BAHS as an option for their child was initiated by their audiologist (n = 2) or was jointly brought up (n = 1).

Most of the parents of children with unilateral m/a felt their audiologist had influenced their learning about BAHS for their child to a *moderate* or *great extent* but some felt their audiologist had influenced their learning about BAHS *very little*, *to some extent*, or *not at all* (average weighted score = 3.1; see **Figure 2A**). The top three most influential "other" sources of information were early intervention agencies, other parents of children with m/a, and the internet (average weighted scores = 2.8, 2.5, 2.2, respectively). The parents of children with bilateral m/a rated the internet as the most influencing factor (average weighted score = 4.0; see **Figure 2B**), followed by their audiologist, other parents of children with m/a, and their early interventionist (average weighted scores = 3.7, 3.3, 2.7, respectively).

Although the three parents of children with bilateral m/a all reported being informed about BAHS as an option within 6 months and all felt amplification was recommended to a *great extent* by their audiologist, there was variation in when families of children with unilateral m/a were informed and to what degree these parents felt amplification was recommended. The earlier the audiologist informed parents about BAHS being an option for their child, the more likely and earlier they began a BAHS trial; the eight families who were informed about BAHS being an option for their child within 6 months of diagnosis were fit with a BAHS between 6 and 18 months (M = 8.8, SD = 3.9). This compares to three families who were informed about BAHS being an option for their child between 6 months and 1 year after diagnosis, who were fit with a BAHS between 13 and 33 months (M = 23.3, SD = 10.0). The one family who was not informed of this option by their audiologist did not begin a trial.

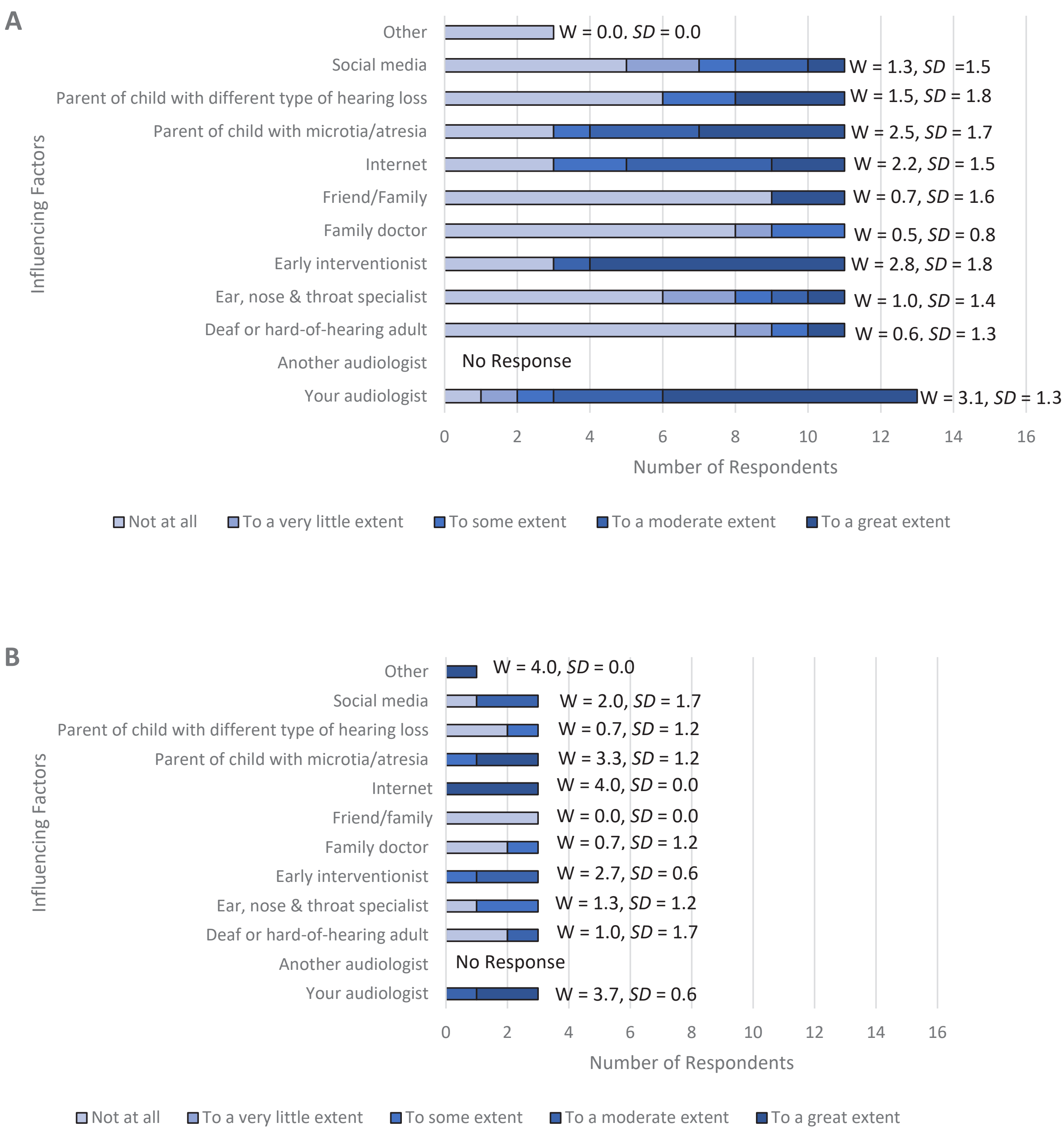
Moreover, parents of children with unilateral m/a who reported the BAHS was recommended to a *moderate* or *great extent* generally trialed the BAHS and did so earlier than families who felt that a BAHS was only recommended to a *very little extent*, or who were not informed about BAHS as an option. Eight families who reported BAHS being recommended to a *great extent* were fit with a BAHS between 6 and 24 months (M = 11.5, SD = 6.5) and three families who reported BAHS being recommended to a *moderate extent* were fit with a BAHS between 6 and 8 months (M = 7.2, SD = 1.0). This contrasted with one family who reported the BAHS was recommended to a *very little extent* and the BAHS was fit at 33 months, and the single participant who was not informed of this option by their audiologist and did not begin a trial.

The three parents of children with bilateral m/a all reported achieving full-time use of BAHS. Parents of children with unilateral m/a tended to report greater ongoing usage of the BAHS by their child and more commonly reported full-time use (or working towards full-time use) of BAHS by their child when their child's audiologist informed them about BAHS as an option earlier (**Figure 3A**) and recommended BAHS to a greater extent (**Figure 3B**). The eight families who were informed about BAHS being an option for their child within 6 months of diagnosis reported BAHS use between 11.5 and 84.0 hr per week (M = 47.4, SD = 25.5). This compares to the three families who were informed about BAHS being an option for their child between 6 months and 1 year after diagnosis, who reported BAHS use between 3.5 and 42.0 hr per week (M = 28.2, SD = 21.4). The one family who reported being "unsure" when BAHS was recommended reported BAHS use as 0 hr per week.

The eight families who reported BAHS being recommended to a *great extent* reported BAHS use between 3.5 and 84.0 hr per week (M = 41.3, SD = 29.7); the three families who reported BAHS being recommended to a *moderate extent* reported BAHS use between 0 and 52 hr per week (M = 31.5, SD = 27.7); one family who reported the BAHS being recommended to a *very little extent* reported BAHS use of 31.5 hr per week; and, one family who was not informed of this option (and thus it was not recommended) by their audiologist reported 0 hr of BAHS use. Overall, the older children with unilateral m/a in our study were less likely to achieve full-time use or the respondents were more satisfied with part-time use compared to the younger children with unilateral m/a (**Figure 3C**).

Parents of children with unilateral m/a reported varying degrees of influence from factors such as cost, risk of not amplifying, benefit, child's acceptance of the device, and appearance on their decision to trial a BAHS (**Figure 4A**). The perceived benefit and the child's acceptance of the BAHS were the two strongest influences overall (average weighted scores = 3.3, 2.6, respectively), followed by risk, cost, and appearance (average weighted scores = 2.3, 1.9, 1.1, respectively). Parents of children with bilateral m/a rated risk and benefit as strong influences (average weighted scores = 4.0, 3.7), while acceptance, appearance and cost were all rated much lower and well below the scores of the parents of children with unilateral m/a (average weighted scores = 0.7, 0.3, 0.0; **Figure 4B**).

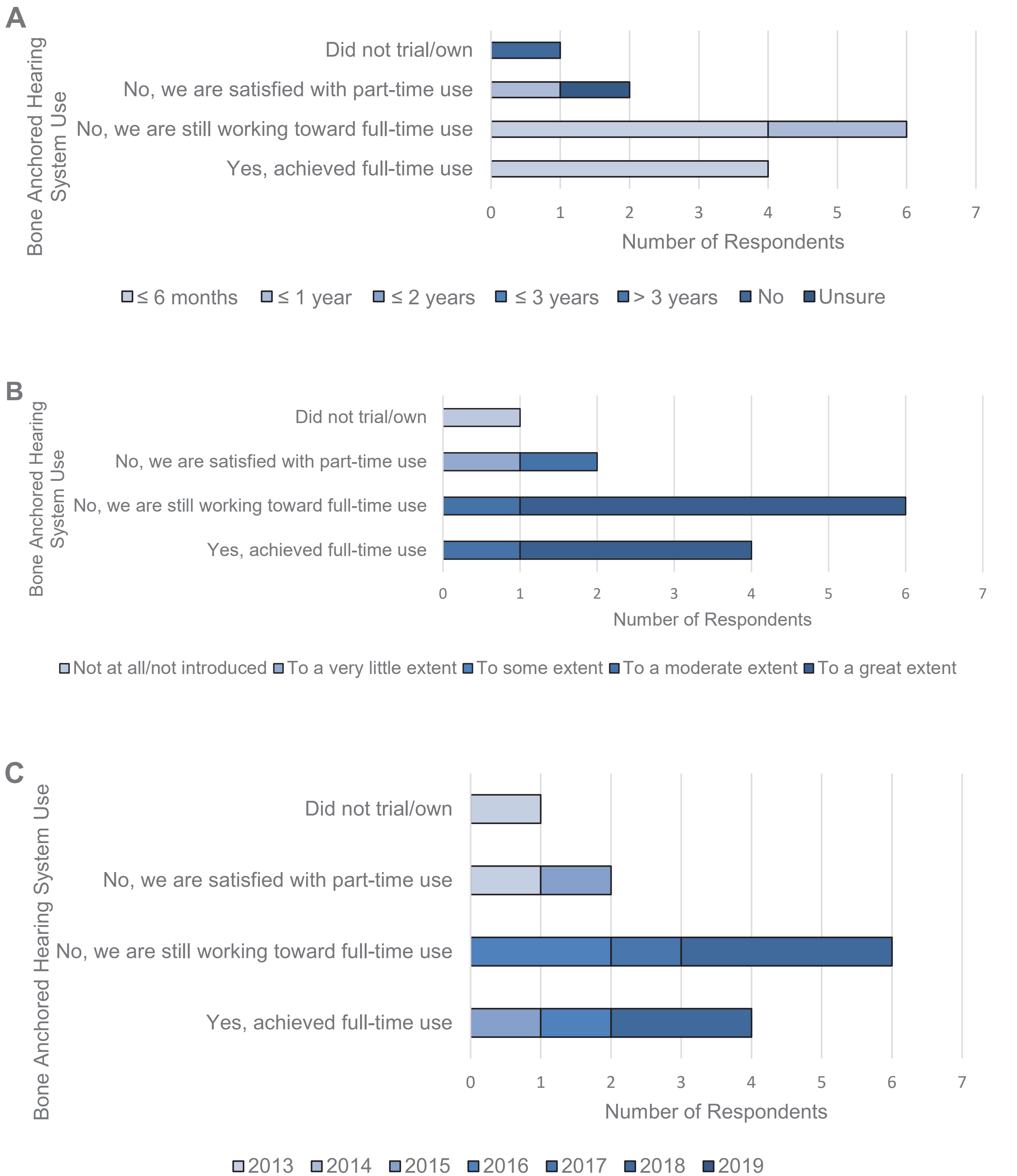
Figure 2



Factors influencing learning about bone anchored hearing systems as an option

Note. Panel A shows responses by parents of children with unilateral microtia/atresia (n = 12; one participant with unilateral microtia/atresia did not begin a trial of a bone anchored hearing system). Panel B shows responses by parents of children with bilateral microtia/atresia (n = 3). Average weighted score (W) was calculated where the sum of scores (*Not at all* = 0, *Very little* = 1, *Some* = 2, *Moderate* = 3, *Great extent* = 4) was divided by number of responses.

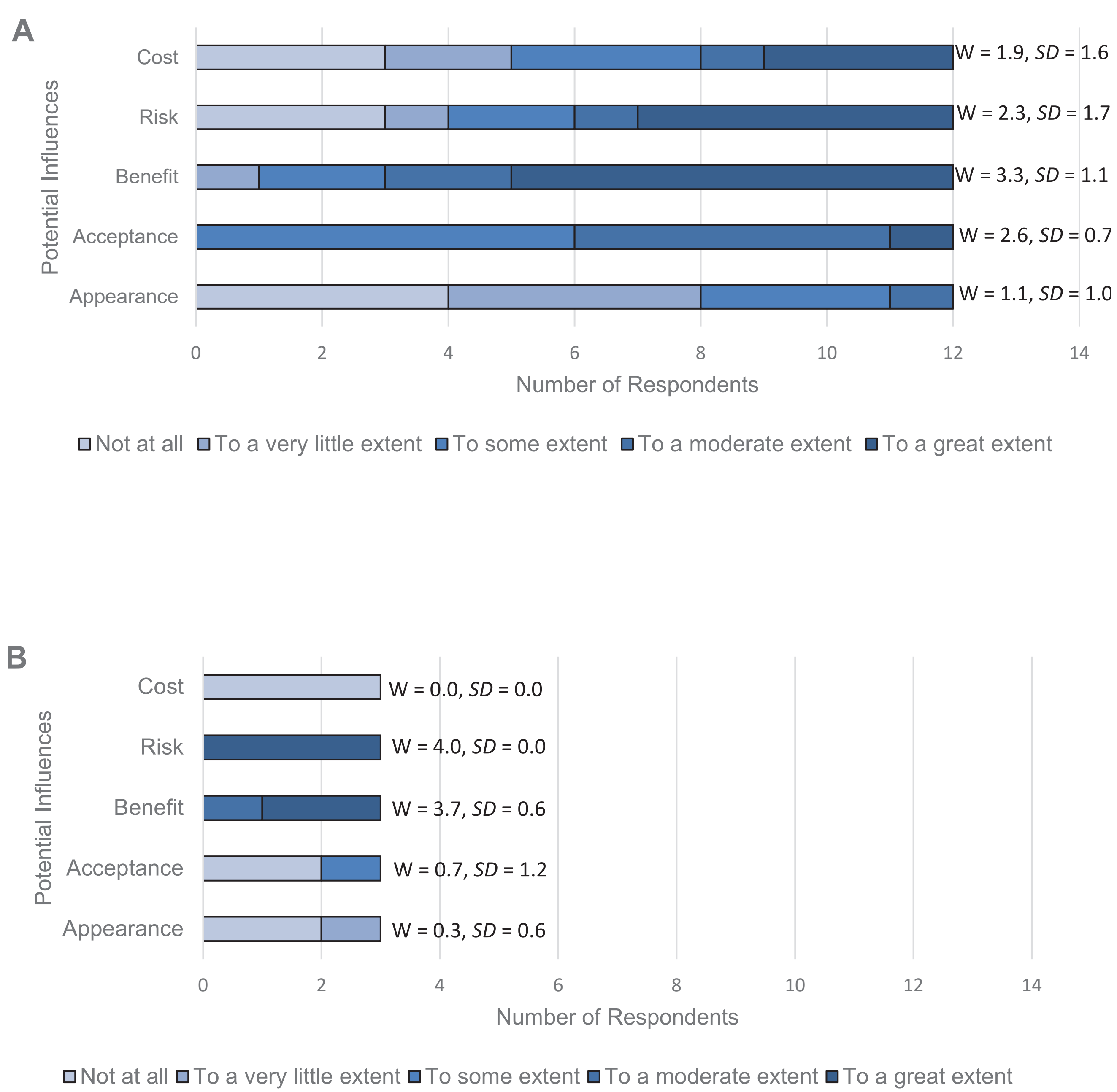
Figure 3



Extent of full-time use of bone anchored hearing systems by children with unilateral microtia/atresia

Note. Panel A shows the timeline parents were informed about bone anchored hearing systems (BAHS) being an option for their children. Panel B shows the extent to which BAHS were recommended to parents by an audiologist. Panel C shows the birth year of the children (*n* = 13).

Figure 4



Extent that potential risks and benefits influenced parents of children with microtia/atresia to trial bone anchored hearing systems

Note. Panel A shows responses by parents of children with unilateral microtia/atresia (n = 12; one participant with unilateral microtia/atresia did not begin a trial of a bone anchored hearing system). Panel B shows responses by parents of children with bilateral microtia/atresia (n = 3). Average weighted score (W) was calculated where the sum of scores (*Not at all* = 0, *Very little* = 1, *Some* = 2, *Moderate* = 3, *Great extent* = 4) was divided by the number of responses.

Responses to Open-Ended Questions and Opportunities for Comment

The survey included opportunities for parents to include comments after several of the questions. Comments were shared related to what options parents were given for owning their own BAHS, how they felt their child benefited from wearing a BAHS, the extent to which various factors and people influenced their decision to first try or not try a BAHS, and any final comments they wanted to share. Two parents of children with unilateral m/a commented about the decision-making process: "I honestly didn't think much. I wanted to offer every possible therapeutic options [sic] for my child. Back in those days, I remember just going to an appointment as if checking off the list of things to do," and, "I would be very interested in knowing more about the impacts of wearing a BAHS on a unilateral m/a child . . . we made our decision mostly based on the fear that she could be impacted negatively if she didn't wear one."

The parent of the child who did not try a BAHS reported that she "didn't like the idea of the headband for the baha," and her "husband and I agreed to just see what happens with his hearing without a baha." However, she also commented, "Now that my son is in school he has trouble hearing with all the different sounds going on."

Other comments from parents of children with unilateral m/a expressed uncertainty about the benefit their child was receiving: "As her hearing is typical in the right ear, it is very difficult to know what the benefits to speech and language are," and, "I'm not sure of the benefit yet. She's a very happy baby to begin with, and vocal as well." In contrast, when asked about benefit of having a BAHS, the three parents of children with bilateral m/a were more confident in their assertion of the benefit: "He has never refused them and always wants them on," and, "Our son wears his BAHS constantly. He is very protective of his 2 Ponto 3 Superpowers. He is very good about telling us when the batteries need changing."

The survey also contained open-ended questions addressed specifically to parents of children with bilateral m/a, asking them to describe their experiences with bilateral BAHS, the benefits of wearing two versus one, and their decision-making process for getting a second BAHS. All three participants reported improved auditory access when their child started wearing a second BAHS: "Improved sound quality," "can hear very quiet sounds/speech much better with 2," and, "My daughter received her second Ponto BAHA when she was around 1 year old. We noticed an improvement with her overall hearing levels."

Two of the three participants commented on the importance of having two BAHS for localization. One parent noted "it is imperative for helping her to locate sounds," and "her sound location ability became apparent." Another parent observed that "directional sound is so much greater with two. He can easily locate where sound is coming from." One participant reported an impact on clarity of speech: "One broke and we were without for a week and actually noticed his speech wasn't as clear. Was quite amazing when he got the second one back."

Two participants commented on the head shadow effect: "There is an argument that 1 BAH [sic] stimulates both Cochlea. But if there is no microphone on one side of the head to pick up any sounds there it becomes what is known as head shadow. Where they miss out on sounds being produced on the non-aided side," and, "Logically there is a shadow effect where sound will not be as easily amplified with one versus 2 aids."

Parents described their child's preference for two BAHS: "He loves wearing both and is sad if one breaks;" "I see a huge change in bilateral boy when he's wearing one vs two or if a battery is running low;" "She also states she can hear better with two;" and "She will let us know when one is not working and wants it fixed, and she is only 3."

Last, all three participants stated their belief that two BAHS should be standard for children with bilateral m/a: "I strongly feel 2 aids should be offered and the norm! I am ready to advocate as we are approaching abutment time and I will be again ensuring my son remains bilaterally aided;" "2 bahs is necessary in my opinion. . . . The cost sadly is outrageous for bahs and it would be great if it was covered fully for two ongoing for kids with bilateral microtia and atresia;" and, "We feel that two is far superior. . . . I feel that both hearing aids should be covered in the BC Early Hearing Program."

Discussion

The present study examined the way information about amplification was offered to parents of children with m/a and how this may have affected both their decision-making process to get a BAHS for their child and their ability to achieve full-time use of the BAHS. By investigating parents' perceptions of what was shared with them by professionals (and others) in their children's early years, this study gives insight into how the process could be improved, so that future parents of children with m/a receive clear and consistent information that allows their children to maximally benefit from early amplification.

Our results demonstrated that the experiences of parents of children with unilateral m/a are inconsistent with respect to receiving clear information and recommendations about the need for and the benefits of a BAHS for their children as an intervention option. These parents reported varied experiences with their audiologists in terms of when information was shared, who initiated the conversation, the degree to which a BAHS was recommended, and the degree to which their audiologist influenced their decision. In contrast, the group of parents of children with bilateral m/a, while small, showed striking consistency in their reports of their early experiences with their audiologists. This is concerning, given Kanzara et al.'s (2020) observation that "it is likely that that parents' decisions are influenced by the suggestions made by the healthcare practitioner they access" (p. 75).

Although 12 of the 13 parents of children with unilateral m/a chose to have their child use a BAHS, three quarters of the children had not achieved full-time use, with their parents reporting they were either still working towards full-time use or were satisfied with part-time use. There are several factors that may contribute to this. First, older children were less likely to have achieved full-time use, or their parents were more satisfied with part-time use compared to the parents of younger children. This may be related to the change in the amplification protocol that was released in BC in 2017, recommending early amplification as the standard for children with unilateral m/a (McCreery et al., 2017/2019). The years of birth for children being reported in this survey spanned the date of release for the changed protocol; the six parents of children with unilateral m/a born after the new guidelines rolled out likely received more consistent recommendations than the seven whose children were born prior to 2017.

Second, the age of the child at the time of survey completion could be a factor, as almost half of the children with UHL were still under 2 years of age. Given that the children with unilateral m/a started trialing equipment at an average age of 12.2 months (n = 12), some may not have had sufficient time to achieve full-time use, especially considering the challenge of keeping such a device on children at an age when they spend a considerable amount of time being held, lying in supine, and in car seats (Alexander et al., 2020).

Finally, four of the parents of children with unilateral m/a indicated that English was not their native language. It is possible that these parents did not understand the information and recommendations shared with them as easily as the native English speakers. It is also possible that cultural influences (e.g., levels of social stigma related to hearing loss and device use) impacted families differently.

Parents of children with unilateral m/a reported varying degrees of influence on their decision to trial a BAHS from factors such as cost, risk of not amplifying, benefit, child's acceptance of the device, and appearance. Although the perceived benefit of the BAHS was rated as the strongest influence on the initial decision, parents' comments indicated they found it difficult to know how much benefit their child was actually getting from the device. In contrast, parents of children with bilateral m/a expressed their views very clearly about the benefits of bilateral hearing using bilateral BAHS. They reported improved auditory access, speech perception, and localization of sounds, and described the need for two BAHS to counteract the head shadow effect. They also noted how their young children clearly showed or expressed a preference to wear both BAHS. These parents advocated for bilateral BAHS being the standard for children with bilateral m/a and advocated that the cost of purchase for a second device should be covered by government funding. It is worth noting that all three of these families acquired a second BAHS for their child even though they had to pay for it themselves or secure funding through an alternate source.

Professionals have previously had less evidence and fewer guidelines on which to base their recommendations for amplification for children with unilateral m/a compared to bilateral m/a and other types of hearing loss, so it logically follows that their messaging to families may be perceived as less strong or urgent. Nevertheless, professionals must be aware that the way in which information is shared can impact parents' understanding of their children's hearing status, as well as their approach towards taking crucial next steps (Fitzpatrick et al., 2016; Kanzara et al., 2020; Porter et al., 2018). As stated in the Speech-Language & Audiology Canada position paper on UHL in children, "The provision of information to families regarding the potential impacts of UHL, including speech, language, academic, and social issues, is an important component of the care process. Families need an understanding of how auditory deprivation and binaural advantages can impact their child's development" (Speech-Language & Audiology Canada, 2020, p. 2). Unfortunately, a possible unintended consequence of inconsistency or uncertainty amongst professionals about the recommendations for amplification for children with UHL is that parents may not view amplification as being critically important for their child (Fitzpatrick et al., 2016). As a result, they may be less motivated to get started with amplification with their baby, and ultimately less likely to achieve full-time use and maximal benefit.

Our results suggest that audiologists and other sources of information such as the internet, other parents of children with m/a, and early intervention agencies have an important role to play in helping parents of children with unilateral m/a understand the long-term risks and benefits related to amplification. Indeed, the influence the audiologist may have on a family's decision to use a BAHS and the extent to which it is used was evident. The earlier the audiologist informed caregivers about BAHS being an option for their child, the more likely and earlier caregivers began a BAHS trial for their child with unilateral m/a. Also, those parents who reported the BAHS was recommended to a great extent generally trialed the BAHS and did so earlier than families who felt they were recommended to a lesser extent or were not informed. Furthermore, parents who were informed earlier and perceived the recommendation from the audiologist as being stronger reported better usage of the BAHS by their child.

There is a need for greater consistency in terms of what information and recommendations parents receive, as well as when and how they receive it. As was suggested by Kanzara et al. (2020), it is important that the variety of professionals involved with these children and their caregivers, not only the audiologist, establish a united multidisciplinary approach so that the messaging they provide to parents is clear and consistent. The BC Early Hearing Program has made efforts to implement a standardized protocol since 2017 (McCreery et al., 2017/2019). Citing McCreery et al. (2013) and Moodie et al. (2017), Speech-Language & Audiology Canada (2020) also shared general guidelines related to fitting amplification for this population, recommending a hearing aid "if the degree of hearing loss on the affected side permits the child to receive appropriate speech audibility from either an air or bone conduction hearing aid" (p. 3). There is still a need, however, for more detailed universal guidelines specific to fitting BAHS for children with unilateral m/a.

Limitations and Confounding Factors

Due to the low incidence of children with m/a and the population of BC, it was anticipated that the sample size of the current study would not be large. Despite the 16 survey responses we obtained representing a significant portion of this population (approximately 17.6%–25.4% based on an estimated 9–13 children born with m/a each year in BC), this sample size precludes statistical analysis and, thus, limits generalizing our findings to a larger population. In particular, the high ratio between bilateral and unilateral m/a groups (a consequence of their relative incidences in the general population) limits comparative quantitative analyses, a challenge that could be addressed in a larger scale study. This study is, however, intended as preliminary and qualitative in nature. It is hoped that the results will lead to further exploration of recommendations made for amplification with children who have unilateral m/a, as well as parents' perceptions of those recommendations.

The present study is vulnerable to participation bias, as parents were relied upon to self-select. It is possible that parents who were motivated to complete the survey were also more motivated to actively explore intervention and amplification options for their children, and so the present sample may not accurately reflect the range of attitudes and experiences of all caregivers of children with m/a. BC is culturally and linguistically diverse, but the present study was advertised exclusively in written English and the survey was only offered in written English. This likely limited the number of families who were able to participate in the study. There were, however, four respondents who noted that English was not their first language.

Last, the survey collected information about parents' perceptions and recollections of their experiences. Clinical records were not accessed to confirm accuracy, nor were audiologists or other professionals asked for their recollections of what and how information was shared. It is possible that there was information offered by professionals that caregivers could not later recall due to both the passage of time and the stress and emotional upheaval that is commonly experienced by caregivers when making decisions about amplification (Kurtzer-White & Luterman, 2003).

Conclusions and Future Directions

Investigating parents' recollections of what was shared with them by professionals in their children's early years is an important first step in working towards standardized, evidence-based recommendations, so that children who have unilateral m/a will have the opportunity of getting maximal benefit from early amplification. This study suggests that parents of children with unilateral m/a may benefit from early, clear, and consistent information and recommendations about amplification in order to achieve maximum benefit from amplification. Our results also suggest that more research is needed to determine the impact of part-time versus full-time BAHS use for children with unilateral m/a and the optimal timing of fitting of a BAHS for these children. In conclusion, standardized protocols and guidelines on intervention and amplification recommendations for young children with unilateral m/a would benefit from collaborative development between various stakeholders including parents as well as professionals, such as audiologists and early interventionists, in BC and beyond. Furthermore, education about such protocols and guidelines should be provided across disciplines, including to medical professionals who are often the first contact for families when their baby is born and m/a is diagnosed.

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Effects of a Professional Development Program Designed by Speech-Language Pathologists Targeting the Use of Vocabulary Strategies in Preschool Teachers: A Pilot Study

Les effets d'un programme de développement professionnel conçu par des orthophonistes et ciblant l'utilisation de stratégies soutenant l'apprentissage du vocabulaire chez les enseignants du préscolaire : une étude pilote

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Abstract

This study focuses on the ways speech-language pathologists can teach preschool teachers to implement vocabulary learning strategies in the Lebanese multilingual context. A multiple-baseline single-case experimental design was applied with direct individualized on-site intervention with four teachers. Specific individualized targets in vocabulary strategies were assessed across the implementation through an interactive book-reading activity. The results showed (a) a low use of vocabulary strategies during the baseline phase among preschool teachers, confirming the need for support in the field; (b) a change in the teachers' use of strategies taught by speech-language pathologists, highlighted by the immediate increase in the use of vocabulary strategies; and (c) the impact of the intervention, illustrated by the lack of increase in nontargeted strategies. Our findings therefore help in promoting the implementation of language support programs actively involving speech-language pathologists and preschool teachers in collaborative work to support children in learning new words.

Abrégé

La présente étude porte sur les moyens pouvant être utilisés par les orthophonistes pour amener les enseignants du préscolaire à mettre en œuvre des stratégies d'apprentissage du vocabulaire dans le contexte multilingue libanais. Un devis expérimental à cas unique et à niveau de base multiple a été mis en œuvre afin d'évaluer l'impact d'une intervention directe et individualisée offerte sur place à quatre enseignants. Des cibles spécifiques et individualisées de stratégies d'apprentissage du vocabulaire ont été évaluées tout au long de la mise en œuvre du programme de développement professionnel au moyen d'activités de lecture interactive. Les résultats ont montré (a) une faible utilisation de stratégies soutenant l'apprentissage du vocabulaire chez les enseignants du préscolaire avant la mise en œuvre du programme de développement professionnel (confirmant ainsi le besoin de soutien sur le terrain), (b) un changement dans la pratique des enseignants qui était spécifique aux stratégies enseignées par les orthophonistes (utilisation augmentée et immédiate des stratégies de vocabulaire) et (c) un impact de l'intervention qui s'illustrait par une utilisation non augmentée des stratégies n'ayant pas été ciblées dans le programme de développement professionnel. Les résultats de l'étude contribuent donc à promouvoir le travail collaboratif et la mise en œuvre de programmes de soutien langagier impliquant la participation active d'orthophonistes et d'enseignants du préscolaire, et ce, afin d'aider les enfants à apprendre de nouveaux mots.

Oral language is considered critical in early childhood development to prepare children for school readiness. More specifically, vocabulary plays a major role in developing conceptual knowledge in all children and is known to be a strong predictor for learning to read and reading comprehension (Ramsook et al., 2019). Moreover, in preschoolers at risk of developmental language disorder, vocabulary size predicts treatment effects and outcomes (Kapa & Erickson, 2020). There is also considerable evidence that vocabulary remains one of the most difficult areas to learn, especially for children growing up in multilingual contexts (Hamayan et al., 2013). Exposure to different languages by teachers on one hand and caregivers on the other hand amplifies the difference in vocabulary size in each of the children's languages. Some words may only be encountered at home, in one language, and others may only be used at school, in the school language (Bialystok et al., 2010). Therefore, children from multilingual backgrounds may not have equivalents for every word in their languages (Bialystok et al., 2010), especially for academic content-related words (sciences, mathematics, social sciences, etc.). Thus, for preschool dual language learners (DLLs), who are still developing their first language while acquiring a second language (L2) which is the language of instruction (Goldenberg et al., 2013), learning words in L2 takes a considerable amount of time and requires repeated exposure to both frequent and infrequent words. Hence, preschool teachers (pre-KTs) must intentionally support vocabulary learning among DLLs in their L2 to better prepare them for reading and comprehension in their L2, and to enable them to learn new words through reading (Carlo et al., 2004). Moreover, when given appropriate instruction at preschool, DLLs are able to learn new words easily and even sometimes faster than monolinguals, especially when provided with various strategies to develop their vocabulary (Silverman, 2007).

Book Reading as a Recognized Approach for Enhancing Vocabulary Learning

Shared book reading is a commonly used classroom activity. It helps to support vocabulary learning in preschoolers and is usually associated with language gains (Mol & Bus, 2011). It can be adapted to match the language needs of heterogenous groups of children and can also support a strategic integration of new vocabulary in DLLs (Fitton et al., 2018). Indeed, classroom-based book-reading activities give children contextually embedded exposures to new words, where teachers are likely to engage in interactive talk about words using several strategies: selecting a word and providing a definition or a synonym, repeating words to emphasize them, asking children to repeat a word together, asking referential questions to elicit a predetermined word and inferential questions relating words to the children's own experiences, and prompting sentence completion (Biemiller & Boote, 2006; Dunst et al., 2012; Gerde & Powell, 2009; Milburn et al., 2014). Thus, a shared book-reading approach helps children to engage in verbal interactions with their teachers, enabling the latter to use teaching strategies that support connections between new words and the children's own experiences, and, therefore, to accelerate content-related vocabulary learning (Neuman & Dwyer, 2011). Such strategies are effective at optimizing vocabulary growth within planned instruction, even in small doses (Goldstein et al., 2016), and at various developmental stages (Zipoli et al., 2011). The use of interactive strategies to support vocabulary learning in the language of instruction is also effective for children with limited oral language abilities (Cabell et al., 2019), as was the case for a large number of children in our study.

Challenges of Using Vocabulary Strategies in Preschools

There is a growing concern that preschool children receive less than the optimal amount of vocabulary exposure during their school day. Many pre-KTs fail to provide high-quality language practices, despite access to training and instructional tools (Dickinson & Porche, 2011). Current teacher practices do not appear to be designed to promote exposure to a rich vocabulary, that is, teachers often do not use strategies that introduce young children to new words and "engage them in meaningful contexts through semantically related activities" (Neuman & Dwyer, 2009, p. 384). Descriptive studies carried out in preschools showed that teachers produce directive language, which provides few opportunities for children to engage in meaningful dialogue (Dickinson, 2011). Research has also shown that early childhood teachers spend an average of only 5 min per day on explicit vocabulary instruction (Beck & McKeown, 2007; Cunningham et al., 2009), which leaves little opportunity to involve children in learning a new, literary, and enriched vocabulary. In a paper presented by Gillanders et al. (2014), teachers usually asked open-ended questions. However, they did not engage the children in conversations that would increase their opportunities to use the vocabulary they had heard or talk about their ideas. The children were therefore unable to discuss concepts and new words that would have expanded their knowledge or helped support their vocabulary growth. Children effectively need repeated and meaningful exposure to words to learn them. Repeating words in isolation and memorizing them in insignificant contexts is not enough. Thus, young children should be given the opportunity to be exposed to new words, multiple times, in meaningful contexts, so that they can associate a word with its meaning and understand how to use it to communicate with others (Biemiller & Boote, 2006; Hoff, 2003).

This situation also becomes more challenging when the language of instruction in school is not the home language, especially when the children come from a variety of language contexts and the teachers have little knowledge of the children's sociocultural experiences. Given the various demands in bilingual preschools, it is not so easy to focus on language use (Gillanders et al., 2014). This is also the case when it comes to teaching in an L2. Teachers' possible lack of proficiency in the language of instruction may hamper their ability to improvise or to meet children's language needs to increase their word knowledge, or it may prevent useful digressions (Richards et al., 2013). Thus, DLLs, who come from a more isolated linguistic environment, may receive their first exposure to complex and conceptual words in their language of instruction only in preschool (Figueras-Daniel & Barnett, 2013). It is therefore important for DLLs, who are mainly in their first year of schooling, to be provided with both an explicit teaching of words (e.g., selecting and defining words and providing visual prompts) and developmentally appropriate incentive practices for learning vocabulary. Hence, they can be supported in their L2 within contexts where pre-KTs can provide multiple opportunities to hear and learn more complex words (Milburn et al., 2014).

Multilingual Challenges of Preschools in Lebanon

The Lebanese school context is characterized by considerable linguistic diversity. Although Lebanese is spoken by most children in preschools, all children are DLLs and their teachers are usually bilingual. Lebanese is usually their first language and the school language of instruction their L2. At the start of preschool, academic content learning is provided in the L2, that is, English or French, and sometimes both, along with modern standard Arabic, which is usually not used for everyday communication. Hence, preschool children usually receive 22 to 23 hr of exposure a week to their L2, and 7 to 8 hr to modern standard Arabic. Considering the multilingual/bilingual instruction, children and their teachers must adapt to challenges related to L2 learning to optimize literacy attainments and academic achievements. First, children must develop a sufficiently broad vocabulary in their L2 to be efficient readers and communicators. Second, Lebanese pre-KTs must be proficient enough in using language strategies in their L2 to be able to provide high-quality language input. However, major disparities in language teaching levels that affect the use of appropriate language practices are reported among Lebanese schools. Differences are related to shortcomings in the teachers' level of language proficiency and training (Shaaban, 2013; Sreih & Azar, 2020). They often must interact with children in the L2 (French or English) even though they have not mastered it. Poor language proficiency among teachers results in more directive language practices and less diverse vocabulary use (Esseili, 2014). Therefore, multilingual schools in Lebanon provide a unique context for studying vocabulary learning in preschool DLLs who would benefit from vocabulary learning opportunities through meaningful interactions between children and their teachers.

Strengthening Pre-KTs' Skills to Support Vocabulary Development

Given the heterogeneity of language support practices used by teachers (Wasik & Hindman, 2020) and the shortcomings in the domain of language and communication observed during their initial training (Moats, 2009), teachers clearly require support to enable them to implement integrated strategies in interactive reading activities that allow children to develop their vocabulary. Therefore, professional development (PD) programs have been set up to help teachers improve their practices that support the development of vocabulary (e.g., Hindman & Wasik, 2015). This approach consists of facilitated teaching and learning experiences designed to support the acquisition of knowledge and skills and their application in practice (Elek & Page, 2019). Teacher training in supporting vocabulary learning through meaningful increased vocabulary-enhancing behaviours (asking open-ended questions, providing definitions and meaningful feedback), is therefore a priority (Wasik & Hindman, 2020). This is particularly relevant in multilingual contexts where teachers tend to use limited language support with low word complexity (Ping, 2014). For teachers to promote vocabulary learning among DLLs, they have to be aware of the language they use. They must provide multiple occasions for learning new and specific words and make explicit connections with the experiences of DLLs (Gillanders et al., 2014).

The literature has identified active ingredients that are important for effective PD programs to help teachers learn strategies for supporting vocabulary in DLLs. These programs also support the development of reflective practice in teachers and change in their perceptions of themselves and their practices (Bleach, 2014). It is important for teachers to "step out of being a teacher" by reconsidering their role as a communication and language partner (Boyd, 2014, p. 441). Considering the above-mentioned requirements, it is therefore necessary to know more about how teachers interact with children and, more importantly, how to support their students in practice (Pence et al., 2008), especially when they need to make intentional efforts in the way they talk in the language of instruction (Gillanders et al., 2014).

One key feature of effective interventions is to combine modalities aimed at enhancing the use of language techniques to promote language learning in children (e.g., courses, workshops, on-site coaching, communities of practice; Markussen-Brown et al., 2017), and to provide teachers with facilitators who can scaffold their attempts to understand new ideas and use new language strategies (Cunningham et al., 2015). Many authors (Rogers et al., 2020; Schachter et al., 2019) have identified key elements for the successful outcome of a PD program: (a) programs should be based on a participatory active learning process where the teachers' involvement is requested during a knowledge and content-sharing session; (b) program content should be consistent with teachers' knowledge and instructional needs as well as their linguistic environment, with specific time allocated to reflection and feedback; (c) interventions must be built on real contexts; and, finally, (d) the duration, frequency, and intensity of the intervention must be sufficiently high (up to 30 hr but not less than 10–14 hr; Jensen & Iannone, 2018). Although a 14-hr PD program was not found to bring about any changes in teachers' practices in some cases (Yoon et al., 2007), further work has demonstrated that around 20 hr of PD can be effective when the training dosage is spread over time rather than given in one go, thus allowing teachers time to practice strategies in their own environments (Desimone, 2009). Although there is limited research on the most effective dosage of PD needed to bring about changes in teachers' practices (Weber-Mayrer et al., 2018), it can be argued that it is necessary to engage in continuous PD programs that provide teachers with the best opportunities to learn and practice new skills.

Coaching is therefore one form of individualized professional learning that has become increasingly documented in the literature (Pianta et al., 2021; Wasik & Hindman, 2020), with the potential to improve both teachers' practices and children's outcomes (Snyder et al., 2015). Coaching interventions usually involve a more experienced professional providing individual on-site support for a teacher within a collaborative partnership. Elements of coaching usually include modelling, feedback, reflection, and goal setting in a collaborative and nonjudgmental partnership. In this context, a study by Neuman and Wright (2010) examined the impact of two forms of PD programs including coursework (30 hr) and on-site coaching (3 hr a week for 10 weeks). Analyses revealed significant substantial improvements in the on-site coaching group. On-site coaching allowed teachers to engage in self-reflection and engage critically in new content and its relevance for their daily language practices. The study also highlighted two core elements of coaching: (a) the importance of a collaborative practice between the coach and the teacher, and (b) shared mapping actions (planning, implementing, and engaging jointly in analyzing outcomes of selected targets).

Hence, in a preschool context, experienced language professionals, such as speech-language pathologists (S-LPs), could also play a key role in delivering PD sessions to teachers to support their use of language development strategies. The pre-KTs could then implement these strategies themselves (Archibald, 2017). S-LPs' expertise in monolingual or multilingual development and disorders would perfectly complement the pre-KTs' expertise in curriculum activities, classroom organization, and child learning management. The implementation of a PD program targeting pre-KTs, delivered by S-LPs, would meet the need for increased focus on appropriate language interactions in early childhood. It would provide the opportunity for S-LPs' indirect interventions to be grounded in naturalistic contexts with all children (Ebbels et al., 2019).

Studies have already demonstrated the effectiveness of PD programs targeting language practices delivered by S-LPs to teachers, many of which use book-reading activities (e.g., Girolametto et al., 2012; Namasivayam et al., 2015; Rezzonico et al., 2015). Although coaching is widely used and considered an effective adult-learning strategy, especially when it is combined with performance feedback, several areas warrant further exploration.

First, a deep understanding of coaching features and how they function to reflect a change is required. Second, content strategies remain unclear, as well as coaching processes and their dosage (Biel et al., 2020). Moreover, there are still few studies on PD programs targeting language skills in multicultural and multilingual contexts. Most studies have been conducted with English-speaking monolinguals or DLLs (Neuman & Dwyer, 2011); hence, the promotion of effective vocabulary strategies has been carried out in English (in most published studies) among teachers who were mostly native speakers. To date, we have little data on how to support teachers in the use of vocabulary strategies in the language of instruction for DLLs. This seems to be particularly challenging for teachers. Studies reveal that the limited support DLLs receive in their language of instruction may sometimes be partly attributed to teachers' low language expectations and less opportunity for higher order thinking within their interactions with DLLs (Langeloo et al., 2019) as well as the teachers' proficiency in the language of learning (Richards et al., 2013). It is therefore worth exploring the question of transferring or adapting studies conducted in other contexts (e.g., American) and in English, to other linguistic and cultural environments. Consequently, identifying consistent implementation practices adapted to various contexts is needed. Optimizing S-LPs' intervention productivity in real contexts would help to determine the most effective procedures or combination of procedures targeting language practices in preschools (Biel et al., 2020).

Supporting Vocabulary Development Through Indirect S-LP Intervention

The program we designed sought to support language development in DLLs through a preventive tier-one type intervention (Ebbels et al., 2019). Its implementation consisted of S-LPs teaching pre-KTs specific targets in vocabulary-promoting strategies, which the teachers would then be able to use to enhance vocabulary learning in DLLs. The goal was to target language development in children.

In our study, two S-LPs tested instructional training targeting vocabulary strategies for pre-KTs in situ. The design used the four coaching functions described by Biel et al. (2020): (a) sharing information (why and how to use intervention techniques), (b) modelling intervention techniques in situ, (c) guiding or prompting the use of the techniques and, (d) providing feedback on the accuracy of use of the targeted technique. A participatory active learning process allowed pre-KTs to reflect on their practice, think critically about the new content, and coidentify specific PD targets (Dunst & Trivette, 2009). The aim of this process was to allow teachers to use the targeted vocabulary strategies they were taught during the monitored story-reading activities and generalize them to other situations and curricular activities in class.

Aims of the Study

The aim of the intervention was to increase the pre-KTs' use of the vocabulary development strategies with DLLs. The expected outcomes would then be analyzed in terms of pre-KT frequency of use of the strategies and their satisfaction with the program. The following research questions were addressed within a single-subject multiple-baseline design study:

- Is this implementation effective in increasing pre-KTs' use of taught vocabulary strategies?
- Do the intervention's effects extend to strategies that the pre-KTs have not been taught?

Method

Participants

Four pre-KTs (referred to as participants [Ps], P1–P4) were recruited on a voluntary basis from two private Lebanese French schools, one in the heart of Beirut and the other located 35 km north of Beirut. Pre-KTs and their classrooms were selected according to a sample of convenience. The four female teachers ranged from 27 to 47 years of age. Three of them – P2, P3, and P4 – were bilingual in Lebanese and French (with French as their L2) and had a teaching diploma (2-year course), and one teacher (P1) was only French-speaking and had a university degree in sociology (see **Table 1**). They had between 2 and 25 years of preschool teaching experience. They were all teaching in French. However, only P4 stated having equal proficiency in Lebanese and French. Most children were Lebanese bilinguals, with French as their language of instruction.

Two experienced S-LPs, both bilingual (Lebanese/French) and fluent in French, delivered the training program to the teachers. They each had over 20 years' experience in clinical practice as well as adult education.

Design and Procedure

This study used a multiple-baseline design across participants and met the single-case design standards as explained by Kratochwill et al. (2010). It was approved by the Research Ethics Board of Saint Joseph University of Beirut (# USJ-2017-62) and University of Liège (# 1718-28).

Table 1

Characteristics of Pre-KTs and Their Classrooms

Pre-KT	Age (years)	Experience (years)	Holds teaching diploma	First/second language	Grade	Number of children
P1	40	2	No	French	KG2	20
P2	47	25	Yes	Lebanese/French	KG2	27
P3	46	26	Yes	Lebanese/French	KG1	23
P4	27	5	Yes	French/Lebanese	KG1	23

Note. P = participant; Pre-KT = preschool teacher; KG1 = Kindergarten 1 (for children aged 3–4 years); KG2 = Kindergarten 2 (for children aged 4–5 years).

Due to the small sample size, this study followed a basic single-case within-subject design, with repeated measures, across two conditions referred to as phases (baseline [BL] and intervention phases; Kratochwill et al., 2010). Each participant was considered a case for data analysis and acted as their own control for comparison purposes. This design represented a clinically straightforward option to combine practice with research. It was also applicable to our implementation process through its staggered introduction across a particular parameter. Outcome variables (vocabulary strategies) were measured repeatedly within and across different conditions, where each one was considered independently. The first phase of the design, prior to the introduction of a specific variable, which would be the BL later on, permitted information to be gathered about the pre-KTs' use of specific targets (Kratochwill et al., 2010). This experimental design helped determine whether a link existed between an independent variable (research-manipulated intervention targets) and dependent variables (changes in participants' frequency of use of vocabulary strategies in our study). Considered as flexible and adaptive, the single-case design was driven by our research questions and was particularly appropriate for understanding the responses of one or more cases, considering the heterogeneity of practices and participants as well as the novelty of this kind of intervention for both S-LPs and pre-KTs in the Lebanese context.

Prior to implementation, a 3-hr workshop about how to promote general positive language strategies was provided to all pre-KTs in each school. Afterwards, S-LPs met the volunteer participants individually to explain the purpose of the study. They also visited the targeted classrooms in order to better understand their organization and to allow the children to familiarize themselves with the presence of the S-LPs. Afterwards, S-LPs met pre-KTs individually to schedule the intervention.

The intended design of the study was initially scheduled over 14 weeks, including pretest and posttest measurements (BLs, Week 1, and Week 14), as well as six coaching cycles per teacher (Weeks 2–13). Each cycle lasted approximatively 2 hr for a total estimated duration of 24 hr (2 hr a week over 12 weeks). However, the intervention was interrupted after 10 weeks due to the Covid-19 crisis.

Implementation was conducted in French, the school's language of instruction, over four to five coaching cycles per teacher. Each target strategy was separately taught by S-LPs following several instructional steps. The choice and organization of the instructional steps within a cycle were based on Dunst's (2015) and Biel et al.'s (2020) metasynthesis of in-service PD programs. Findings from their studies identified four teaching functions that were used for each cycle: sharing information, modelling the targeted strategy, guiding/scaffolding the target strategy's execution and providing feedback about the performance, and reflecting on observations with the teacher. Their purpose was to draw the pre-KTs' attention to the specific targets, to help them be aware of their own language behaviour, to identify links between changes in their use of language strategies and the children's engagement, and to analyze alternatives to some language behaviours. Specific components of the procedures and time allocated for each stage are detailed in **Table 2**. Field notes were also used to record information on the teachers' practices, perceptions, and insights during information-sharing and feedback stages. Implementation was initially designed over 14 weeks, including BL sessions followed by 12 weeks of intervention.

Book and Word Selection

The books used contained narrative French stories, close to Lebanese children's interests and cultural knowledge, selected at the appropriate level from the Minimax collection published by *l'école des loisirs*. They had at least four story elements (out of settings, characters, problem, goal, solution, and end), comparable in terms of text complexity, length, and illustrations: Each book was approximately 20 pages long, with at least 12 opportunities to elicit the target strategy. A script was prepared by S-LPs for each strategy per book to ensure accuracy in modelling it with preselected words and to guarantee fidelity to this aspect of the implementation. However, scripts were not given to the teachers. Participants had the freedom to choose the words for instruction.

The vocabulary strategies were selected based on a review of the literature on interactive practices to promote new word learning in preschoolers (Biemiller & Boote, 2006; Gerde & Powell, 2009; Milburn et al., 2014): defining a new word, repeating, promoting child chiming, completing prompts, and indirect strategies including literal questions, inferential questions, and relating words to children's experience (**Table 3**). The strategies targeted during the implementation varied from teacher to teacher and were selected according to individual performance on the BL.

Data Collection

Prior to intervention, BL data were collected during three book-reading sessions in each classroom, over three successive days. During the BL phase, each teacher was asked to "read the story how she normally would." The pre-KTs were asked to choose the book for the first BL session (BL1). For BL2 and BL3, books were provided by the S-LPs

Table 2

Example of a Coaching Cycle Procedure (Cycle 1 for Strategy 1)

Week 1 – Meeting 1 (Time)	Week 2 – Meeting 2 (Time)
Sharing information (20 min)	**Sharing information (15 min)**
The S-LP • presents the target strategy to the teacher, • shares information about the use of this specific strategy, • guides the pre-KT through explicit instructions on why and how to use the strategy and its relevance for the children's language learning, e.g., "Choose the word, stress it, define it (or provide a synonym), put it in a sentence, mime it (if possible)," • provides examples from the book and suggests trials to the teacher, and provides support cards illustrating targeted strategies. At the end, the teacher is asked to formulate the process of performing the strategy.	The S-LP • reminds the teacher about last week's target strategy, • re-shares information about the use of this specific strategy, • reminds the teacher, through explicit instructions, why and how to use the strategy, and • asks the teacher about examples from the book and suggests some trials. At the end, the teacher is asked to formulate the process of performing the strategy.
Modelling (25 min)	**Guiding/Scaffolding (25 min)**
S-LP models the strategy during a story reading to the whole group. Teacher observes.	S-LP returns to the classroom to assist the teacher while practicing the strategy with the same book as in Week 1. The S-LP provides the teacher with oral and/or nonverbal prompts (eye contact, gestures, direct examples, etc.) to perform the strategy. They usually agree on the modality of scaffolding the strategy prior to the session.
Feedback (15 min)	**Feedback (20 min)**
Teacher is invited to reflect on: the teaching strategies, children's observed outcomes related to the strategies, and vocabulary items selected. S-LP and pre-KT review the strategy using words from the book. S-LP answers all pre-KT's questions. The teacher is asked to practice the use of the strategy with the same book, or during other activities, for 1 week. S-LP also provides written instructions to perform desired behaviour (cards, texts, messages).	The teacher is invited to analyze her performance, to identify difficulties, and to reflect on children's outcomes related to the strategy. S-LP answers all pre-KT's questions. The teacher is then asked to practice the use of the strategy during other activities.

Note. S-LP = speech-language pathologist; pre-KT = preschool teacher.

Table 3

Description of Targeted Vocabulary Strategies

Strategy	Description (The teacher ...)	Example
Define a word	Selects a word and provides a definition or synonym.	T: This is a ladybug. A ladybug is a small red or yellow beetle with black spots.
Repeating the word	Repeats a targeted word to emphasize it.	T: Aldo is a crocodile. ... A crocodile.
Chiming	Asks children to repeat a word together.	T: All together, "Crocodile."
Completion prompts	Asks the children to fill in a word in a sentence.	T: Janice went up the ... Ch: [hill]
Literal questions	Asks questions to elicit a predetermined word.	T: Where is she hiding? Ch: In the [closet].
Inferential questions	Prompts the child to use preselected words that were not explicitly present in the text.	T: How do you think he is feeling? Ch: [upset].
Relating	Relates a targeted word to the children's experience or real world.	T: It's Teddy Bear's [cake]. Ines, what did you put on your birthday [cake]?

Note. T = teacher; Ch = child.

who made sure that they were not familiar to the teachers. We sought to determine the variety of strategies in the pre-KTs' respective repertories and to identify whether their use was facilitated by the teacher's familiarity with the book. All BL sessions were video recorded. Because reading activities were based on the teachers' normal practices, the length of BL observations varied depending on how they usually approached this activity. Strategy occurrences were then recorded in order to calculate the average use for each strategy per book. The pre-KTs were eligible to start the intervention when they exhibited a stable baseline on the majority of targeted strategies (Kratochwill et al., 2010).

The pre-KTs' performance for each strategy was assessed at the end of one cycle through a video-recorded book-reading activity. For each measure, the teachers were supposed to read a story as they had previously done with the respective S-LPs. Strategies that were employed during the session were coded in a coding form developed for the purpose of collecting data on the teachers' use of interactive language to promote vocabulary development. It included three broad categories of utterances, that is, "a word or stream of words that conveys a single unit of thought" (Gerde & Powell, 2009, p. 219): (a) vocabulary-promoting interactive strategies including all targeted strategies (see **Table 3**), (b) responsive language strategies (including referential and inferential comments, responses to child language, and praise), and (c) behaviour-focused utterances (verbal or nonverbal redirections to a child's behaviour such as "shush," "please sit," or "stop it"). Each teachers' utterance was coded to fit in one strategy within a category. Some statements were coded as two utterances, because they contained two strategies, for example, defining a word and relating it to children's experiences: "A hamster is a very small animal with a round body, short tail, and large pouches in its cheeks. Remember Georgio brought his hamster to school yesterday, what did we give him to eat?" A cutoff score of nine occurrences was used to determine whether a strategy was effectively employed by the participant, in reference to the minimum level of exposure to a word leading to vocabulary acquisition as identified by Storkel et al. (2019) in children with developmental language disorder. For each sequence, the moment a strategy appeared was accurately reported in minutes and seconds. The coding form was developed by the first author and assessed by four experts, who were all experienced S-LPs with an expertise in coaching practices and language development. It was then piloted in two classrooms that were not participating in this study. Based on the results, wording was clarified and various examples were provided in order to make the strategies more easily observable in a specific coding guide.

Two graduate student coders, who were blind to the purpose of the experimental conditions for each pre-KT, independently coded and derived data on the teachers. They used a copy of the books employed during BLs and measures for easy identification of the pre-KTs' contributions beyond the text. Subsequently, three reliability checkers conducted observations on 20% of the selected sessions. Reliability was calculated for each strategy with at least 80% agreement prior to the study, meaning that observers had to agree on the effective use of the strategy to be able to code it as an agreement. Discrepancies were solved by consensus until obtaining 100% agreement.

The pre-KTs' satisfaction was assessed using a rating scale based on the satisfaction rating for mothers by Tsybina and Eriks-Brophy (2010). It consisted of seven statements where teachers estimated if they enjoyed the PD program, if it helped them improve children's language skills, if the strategies were easy to learn, and if they would use them in other book-reading activities or would apply them in any other classroom activity. Items were rated on a 4-point Likert scale, ranging from 1, *strongly disagree*, to 4, *strongly agree* (they were also free to leave comments in open boxes).

Data Analysis

We examined whether our intervention had an effect on the pre-KTs' use of vocabulary strategies in the language of instruction (French in this case). Based on single-case design standards (Kratochwill et al., 2010), we examined the level (average of occurrences among data points) and variability (upper and lower limit across data points) of the number of strategy occurrences per book within each condition. Immediacy of the effect was determined by a sudden rise of at least three occurrences for a strategy above the observed BL level (a cutoff score chosen according to the definition of immediacy provided by Kratochwill et al., 2010). To compare results across conditions, we calculated the nonoverlap of all pairs statistic (NAP; Parker & Vannest, 2009), consisting of the percentage of nonoverlapping points between the two phases (BLs vs. implementation). It also helped to assess the intervention effect even when the targeted behaviour had already started to improve before the actual intervention, as was the case for some targeted strategies in our study. NAP was calculated using all the points of measure per participant during implementation. An NAP between 32% and 84% suggests a moderate effect and an NAP equal to or above 85% suggests the implementation had a significant effect (Manolov et al., 2016; Parker & Vannest, 2009).

Results

The results are presented in four sections: pre-KTs' use of vocabulary strategies prior to intervention; pre-KTs' use of targeted strategies; pre-KT's use of nontargeted strategies; and pre-KTs' overall satisfaction during the implementation phase.

Pre-KTs' Use of Vocabulary Strategies Before Implementation

Table 4 shows pre-KTs' mean scores of vocabulary strategy use as calculated across all three sessions of the BL condition prior to implementation. Pre-KTs exhibited stable data on vocabulary strategies. Stability is defined as limited variability in the number of strategies the pre-KTs used during the reading sessions. Although they read the text from the book without using varied strategies to enrich vocabulary, they all tended to prompt children to retrieve information in the text by asking literal questions. This made their score on literal questions higher than the predetermined cutoff score of nine. Thus, strategies aimed at enriching vocabulary in children such as defining, repeating, etc., were rarely used comparatively to literal questions, which justified the intervention.

Table 4

Score Means and Standard Deviations of Strategy Use (Number of Occurrences Per Book) for Each Pre-KT, Calculated Over Three Baseline Sessions

	DEF		REP		CHI		CP		LQ		IQ		REL		Total	
Pre-KT	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
P1	0.67	1.15	0.67	0.58	0.33	0.58	1.00	1.73	5.33	3.79	0.33	0.58	1.00	1.73	9.34	7.92
P2	0.67	0.58	4.00	0.00	0.00	0.00	5.67	2.31	**<u>32.00</u>**	12.12	4.33	0.58	1.00	0.00	47.66	9.81
P3	1.00	0.00	5.00	7.00	0.00	0.00	3.60	1.67	3.60	1.67	0.58	0.33	0.00	1.00	13.72	22.99
P4	1.67	1.53	6.00	0.00	0.00	0.00	1.67	2.08	1.67	6.51	0.33	0.58	1.00	1.73	22.99	3.09

Note: Means equal to or above the criterion level of 9 occurrences are indicated in bold and underlined. P = participant; pre-KT = preschool teacher; DEF = defining a new word; REP = repeating; CHI = promoting child chiming; CP = completing prompts; LQ = literal questions; IQ = inferential questions; REL = relating words to children's experience.

Based on BL scores, and in consultation with the pre-KTs, we identified the primary strategy to be taught to each participant. For P1 and P2, we started with literal questions then inferential questions that were emerging in the BL without exceeding the criterion level score of nine occurrences. This choice was also driven by the teachers' ease at using this strategy and their desire to better employ it in an effort to enrich vocabulary. For P3 and P4, we started with defining words. This strategy also emerged in the repertories of P3 and P4. For the following cycles, with our aim of individualizing the training, we sought to select new strategies based on teachers' preferences. However, P3 expressed her wish to improve on literal questions targeting vocabulary even though she used them more than the expected level of nine occurrences. In fact, she was using this strategy almost exclusively, often without targeting specific word learning as initially intended.

Pre-KTs' Outcomes on Targeted Strategies

Table 5 displays the pre-KTs' BL and intervention frequencies of use of strategies as well as the number of coaching cycles for each one. The number

Table 5

Pre-KT Scores on Targeted Strategies During Baseline and Intervention

TS	BL1	BL2	BL3	I1	I2	I3	I4	I5	*M*(BL)	*M*(I)	NAP (%)	*p*
P1												
LQ	1	7	8	**37**	**34**	15	25	–	5.33	27.75	100	.03*
DEF	0	0	2	2	4	**6**	**13**	–	0.67	6.25	95	.05*
P2												
IQ	4	4	5	**37**	9	6	3	1	4.33	11.20	60	.65
DEF	1	1	0	2	**8**	**12**	3	14	0.67	7.80	100	.02*
REL	1	1	1	3	4	8	**9**	4	1.00	5.60	100	.02*
CP	7	7	3	4	9	2	6	**40**	5.67	12.20	53	.88
P3												
DEF	0	1	2	**14**	1	2	1	–	1.00	4.50	70	.37
LQ	43	73	67	16	**29**	19	4	–	61.00	17.00	0	.03*
IQ	0	1	0	1	3	**29**	0	–	0.33	8.25	79	.21
REL	0	0	0	1	0	0	**12**	–	0	3.25	100	.17
P4												
DEF	0	3	2	**5**	**10**	2	1	8	1.67	5.20	76	.23
LQ	6	19	12	0	8	**42**	14	6	12.33	14.00	43	.76
IQ	0	1	0	0	2	9	**10**	4	0.33	5.00	86	.10
REL	3	0	0	2	3	11	2	**11**	1.00	5.80	83	.13

Note: Scores are presented for 3 baseline (BL) sessions, up to 5 implementation (I) sessions, and means for BL and I. For participant (P)1 and P3, testing was interrupted in I4 because of the Covid-19 health measures, so no data was collected for I5. The nonparametric nonoverlap of all pairs (NAP) statistic was calculated using implementation scores (I1 to I4 or I5) and the associated *p* value. Measures of targeted strategies (TSs) are indicated in bold. DEF = defining a new word; CP = completing prompts; LQ = literal questions; IQ = inferential questions; REL = relating words to children's experience; pre-KT = preschool teacher.
**p* ≤ .05

of cycles per strategy varied from one teacher to another because not everyone took the same time to effectively use the strategy. P1 needed two cycles for both literal questions and word definitions. Even though she exhibited data on literal questions higher than the cutoff score after the first cycle, she expressed her need to have another cycle targeting this specific strategy. P2 and P4 both needed two cycles for defining new words because they did not reach the cutoff score after the first coaching cycle.

Data displayed in **Table 5** suggest that the four pre-KTs showed a sudden rise in targeted strategies immediately after the specific teaching cycle. However, their number considerably decreased when a new strategy was introduced. The observed changes in strategy use were significant for two of two strategies for P1, two of four for P2, one of four for P3, and no statistically significant effect for P4. However, for the latter, the strategy of relating words to children's experiences had an NAP of 83% and inferential questions an NAP of 86%, suggesting a moderate to significant effect of intervention.

Pre-KTs' Use of Nontargeted Strategies

We analyzed the pre-KTs' use of strategies that were not addressed directly in the program to assess the specificity of the implementation (**Table 6**).

Interestingly, as shown in **Table 6**, upon implementation, the number of occurrences of nontargeted strategies did not exhibit a significant increase except for P1, who demonstrated a rise in the use of inferential questions (NAP = 95%, p = .05) and word repetition (NAP = 100%, p = .03). Overall, nonsignificant changes in the frequency of most strategies suggest that the effect of the implementation did not extend to all nontargeted strategies.

Pre-KTs' Satisfaction

The pre-KTs' evaluations and comments showed their overall satisfaction with the implementation, despite it being cut short by the Covid-19 lockdown. Mean and median ratings of responses to items on the satisfaction questionnaire were calculated. Results displayed in **Table 7** indicated that they were satisfied overall. The training facilitated their learning of new strategies (Items 4 and 5 rated 3.75/4), which they would be able to incorporate in book-reading activities (Item 6 rated 3.75/4). In the teachers' opinions, the intervention also positively impacted children's engagement as well as their language abilities (Items 2 and 3 rated 4 and 3.25/4 respectively). They may also "continue using these strategies during other classroom activities" (Item 7 rated 3/4).

Discussion

This pilot study sought to show if a contextualized PD program provided by S-LPs could help improve pre-KTs' use of taught strategies to promote vocabulary learning in French DLLs. Implementation was based on four teaching functions: sharing information, modelling, guiding/prompting, and feedback (Biel et al., 2020). Findings led to three major results. First, they revealed pre-KTs' need for training with the aim of improving vocabulary development strategies: BL observations showed limited variability in the use of strategies. Aside from literal questions, other strategies did not achieve the predetermined cutoff score of nine occurrences. Second, the individualized and structured implementation process targeting one strategy at a time led to a significant increase in the use of this specific strategy. Finally, the effect of the implementation did not significantly extend to all nontargeted strategies. The increase in use of strategies was therefore likely the result of the S-LPs' specific coaching process. Although the program was conducted in Lebanese preschools, its underlying principles may be transferable to other contexts.

The pre-KTs used a limited variability of strategies during the BL observations compared with the outcomes during the implementation phase. This finding was also highlighted in previous studies (Hsieh et al., 2009). Moreover, the pre-KTs did not scaffold the vocabulary of the children by engaging them in learning complex words. Thus, it is possible that there was a mismatch in perception rooted in the pre-KTs' pedagogical expectations regarding book-reading language goals. It is often considered as an instructional activity in preschools to enhance school readiness in children. Hence, pre-KTs may find it difficult to prioritize complex vocabulary learning through interactive practices with DLL children during an activity they consider as mainly instructional. Thus, tailored, individualized and contextualized PD programs to support language practices in pre-KTs is particularly needed in the Lebanese multilingual context. Although PD programs have already been developed by preschools and the ministry of education, further adaptation efforts should be made in order to meet pre-KTs' needs in their real-world contexts (Markussen-Brown et al., 2017).

Following our implementation program, three of our four participants significantly increased use of several taught interactive language strategies to promote vocabulary learning, albeit in a heterogenous way. Thus, short, contextualized, and specific training could help increase teachers' use of target vocabulary techniques, as

Table 6

Pre-KTs' Scores on Nontargeted Strategies During Baseline and Intervention Conditions

NTS	BL1	BL2	BL3	I1	I2	I3	I4	I5	*M*(BL)	*M*(I)	NAP (%)	*p*
P1												
IQ	0	1	0	1	6	3	7	–	0.33	4.25	95	.05*
REL	0	0	3	0	1	0	2	–	1.00	0.75	50	1.00
CP	0	0	3	2	3	0	4	–	1.00	2.25	61	.66
REP	0	1	1	5	**12**	2	4	–	0.67	5.75	100	.03*
CHI	0	0	1	0	0	0	0	–	0.33	0.00	33	.47
P2												
LQ	**25**	**25**	**46**	**32**	**13**	7	**25**	**9**	32.00	17.20	20	.17
REP	4	4	4	**25**	2	3	1	**12**	4.00	8.60	40	.65
CHI	0	0	0	2	1	0	0	0	0.00	0.60	70	.37
P3												
CP	1	1	1	5	2	0	0	–	2.67	1.00	33	.47
REP	4	4	4	**25**	2	3	1	–	5.00	9.00	79	.21
CHI	0	0	0	2	1	0	0	–	0.00	0.00	50	1.00
P4												
CP	4	1	0	0	6	**15**	**11**	3	1.67	7.00	76	.23
REP	6	6	6	1	**18**	2	3	**35**	6.00	11.80	40	.65
CHI	0	0	0	0	1	0	0	0	0.00	0.20	60	.65

Note: Number of occurrences are presented for 3 baseline (BL) sessions, up to 5 implementation (I) sessions, and means for BL and I. Scores equal to or over the cutoff of 9 occurrences are indicated in bold. For participant (P)1 and P3, testing was interrupted in I4 because of the Covid-19 health measures, so no data was collected for I5. The nonparametric nonoverlap of all pairs (NAP) statistic was calculated using implementation scores (I1 to I4 or I5) and the associated *p* value. REP = repeating; CHI = promoting child chiming; CP = completing prompts; LQ = literal questions; IQ = inferential questions; REL = relating words to children's experience; pre-KT = preschool teacher; NTS = nontargeted strategies.
$^{*}p \leq .05$

also highlighted in other studies (Justice et al., 2018). However, participants did require differing amounts of coaching to learn these vocabulary techniques.

Although the pre-KTs' results showed that they had mastered the targeted strategies that were taught, differences appeared in the number of cycles teachers needed for the effective use of a strategy. For example, P1 needed two cycles to be comfortable with literal questions and definitions, but P3 effectively employed each target strategy after each cycle. Both P2 and P4 also needed two cycles for defining words, but not for the rest of their targeted strategies. Given these differences, it is therefore necessary to consider individual patterns, such as professional experience, initial training, linguistic beliefs (Hsieh et al., 2009), and L2 proficiency (Richards et al., 2013), as well as the nature and complexity of

Table 7

Satisfaction Questionnaire Results

Item	P1	P2	P3	P4	Median
I enjoyed this program.	4	4	4	4	4.0
Children in my classroom enjoyed this program.	4	4	4	4	4.0
The program helped to improve children's language.	3	4	2	4	3.5
It was easy to learn new strategies.	3	4	4	4	4.0
I learned something new from this program.	4	4	3	4	4.0
I feel I can apply the strategies in book-reading activities in the future.	3	4	4	4	4.0
I will continue using these strategies during other classroom activities.	3	3	3	3	3.0

Note: Participants (P1–P4) ranked statements on a Likert scale from 1 = *strongly disagree* to 4 = *strongly agree*.

the strategy, when reflecting upon teaching it to pre-KTs. First, professional experience is worth considering when reflecting upon individual performance and the nature and the dosage of support provided to professionals (Hsieh et al., 2009). P2 and P3 were more experienced teachers and had more language strategies in their repertories prior to the intervention. However, some relevant strategies were not used at all. Thus, the training was helpful to improve their use of defining words, inferential questions, and relating words to children's experiences, in light of the importance of those strategies for DLLs. Improvement in P2's and P3's use of language strategies suggests that a behaviour may be modified, even among more experienced professionals. Bearing in mind the shortcomings in teachers' professional preparation and initial training in language development and language support practices in Lebanon (Sreih & Azar, 2020), providing them with contextualized and targeted language training will hopefully meet their needs and expectations. Poor teacher preparation is also reported in international literature, such as in Burchinal (2018).

Moreover, it is worth noting individual differences in strategy learning. It seems that acquiring a strategy is not related to its specific nature, but to individual differences in pre-KTs. Although P1 and P2 significantly increased their use of defining words, this was not the case for P3 and P4. Also, the frequency of literal questions was significantly higher for P1 but not for P4. To better analyze individual differences, it is worth mentioning the pre-KTs' individual dosage with regard to acquiring certain strategies. For example, on several occasions, P1, P2, and P4 missed opportunities to define and explain complex words. They may have found it hard to quickly and clearly define words for various reasons. First, the strategy required language skills that the teacher did not necessarily have, as was the case for P2. During the feedback session, she expressed her struggle to spontaneously find appropriate definitions and synonyms for some words in French. Learning to use a language technique also depends on the language proficiency of the teacher (Richards et al., 2013). This raises questions about pre-KTs' own language skills in L2 while providing instruction to DLLs (Langeloo et al., 2019). Second, when definitions are used spontaneously, pre-KTs may have trouble formulating an accurate definition, especially for abstract terms (Dickinson et al., 2019). Third, it is also possible that defining words is a strategy that may not correspond to pre-KTs' beliefs about complex vocabulary learning in young DLLs. Therefore, P1 and P4, who were both native French speakers, found it hard to adjust to L2 children. Extending vocabulary beyond simple words has been more frequently observed among monolinguals than bilinguals (Mesa & Restrepo, 2019).

Concerning the specificity of the implementation, the findings suggested that it had no significant effect on the strategies that were not directly taught within the process (Mesa & Restrepo, 2019, for parents, and Milburn et al., 2014, for educators), except for the strategies of repeating words and asking inferential questions for P1. This may be explained by the fact that P1 had a nearly flat BL. Over the course of the training, her language behaviour became more natural, allowing her to vary her occurrences by using more questions and alternative strategies such as repeating the targeted word in order to emphasize it (Hsieh et al., 2009). However, the observed increase in the frequency of use of repeating words for P2, P3, and P4 would suggest levers for the use of some strategies over others: that is, follow-up repetition after defining words. Although these levers differ from one teacher to another, it is important to consider the leverage effect when choosing strategies for individualized PD.

Significant differences between the BL and implementation conditions were not observed for all the targeted strategies. Moreover, when a specific strategy was addressed, all the pre-KTs exhibited a considerable decrease in the use of the others. This can be explained by the fact that there may only be so many opportunities to use these strategies during book reading, and so, by increasing the use of one strategy, there may be a corresponding decrease in others. An additional explanation may be the amount of cognitive effort required to learn a new practice (Milburn et al., 2015), which leads to a decline in the use of other practices. There are a number of plausible explanations for these findings. First, a process of change in practices may have been engaged through the implementation of each strategy without being reflected significantly in all pre-KTs' results. This might be related to the relatively small numbers of trials and measures, but it might also be explained by the challenges that teachers face to quickly implement specific learning content in their real-life situations (Markussen-Brown et al., 2017). Our participants all stated that this program helped them discover new strategies they were not using before and that they were aware of their importance and their transferability to other activities within the classroom. However, it was not easy for them to adopt them consistently. Sadly, the curtailment of the study did not allow further trials, or a return to BLs in order to better understand our findings. Also, P3 and P4 both reported concerns about children's behavioural excitement if they engaged them in interactive talking, which perhaps hampered their spontaneous use of taught strategies. Thus, understanding pre-KTs' perceptions about their classroom interactions is crucial for designing effective PD programs. In addition, it is also possible that the changes occurred at other levels such as the pre-KTs' use of communication-facilitating behaviours, also known as strong predictors of vocabulary growth (Justice et al., 2018). To this end, it would be interesting to consider the measurement of the use of these behaviours as well as the frequency of responsive statements.

In light of the available knowledge, it is not yet clear how teachers can combine and generalize strategies in order to positively impact vocabulary development in French DLLs. To better understand this issue, it would be useful to consider the initial modalities of the training program in our study. The program was based on an active, reflexive, and collaborative process (Dunst, 2015) in the teachers' own classrooms. This may have facilitated their involvement in their own learning, with direct observable changes in their language practices (Hsieh et al., 2009). In addition, it was known that the systematic combination of various teaching functions was the best way to teach language strategies (Rogers et al., 2020; Schachter et al., 2019), leading to observable increases in pre-KTs' use of vocabulary strategies. The modalities that were used may have facilitated reflection and active learning through modelling and feedback and encouraged self-learning through live guidance sessions with oral or nonverbal prompting in guided-practice opportunities, resulting in improved use of the vocabulary strategies: Verbal explanations and demonstrations were adapted to pre-KTs' individual background knowledge and language (Biel et al., 2020).

The strength of this program resides in the fact that it is based on a guided practice following a modelling/observation sequence, which led to a real involvement of both the trainer and the teacher and not a simple transmission of knowledge from the S-LP to the pre-KT. [Comment from P4 in the satisfaction rating scale free comment box]

The pre-KTs also appreciated the program's ability to show behavioural modifications and results in situ (Friedman et al., 2012). Additional studies should focus on comparing and adjusting the dosage applied for each coaching modality within each cycle, in order to better understand which component affected the results. Dosage may be considered as one factor responsible for improvement (Landry et al., 2009).

Finally, the implementation model applied in this pilot study provided a practical example of S-LP–pre-KT collaboration. Participants indicated that they were able to reuse the strategies during book-reading activities as they found them easy to learn. This did not require specialized equipment, more time, or specific resources that were not available to teachers. In their satisfaction comments, they all agreed on the important focus that the training put on interactive language practices which led to some observable acquisition of new and complex words in French DLLs. Thus, training teachers may enable them to feel empowered to create a difference within their classrooms, without any further requirements in terms of time or resources.

Limitations

This pilot study should be considered within the context of its limitations. First, our results should be approached with caution regarding their effectiveness overall. The study ended early, owing to the Covid-19 crisis, preventing postimplementation measurements from being performed as well as testing and returning to BLs. This would have helped us better understand how targeted strategies were used after training. Moreover, an NAP with all time points as the same measure (e.g., teaching strategy) was used in the calculation which may have penalized outcomes for strategies introduced later on. Second, our participants knew about the purpose of the study and also about the strategy that was being observed. It was part of the training. Hence, this study did not address the possibility of S-LPs using the training to help pre-KTs to combine more targeted strategies. Moreover, every participant received the same training so it is not known whether other forms of coaching (e.g., without an S-LP) would have led to the same results. Future studies should examine appropriate dosage and include both planned and unplanned observations and more measures to significantly highlight the gains for each strategy, as well as additional testing (e.g., posttraining and follow-up assessments) with more participants from various school contexts, prior to implementation. It would also be worth considering varying tasks to better identify the constraints related to a specific task (e.g., difficulty of telling a story with too many interruptions). Thus, teachers could use a fixed number of strategies (when adding a new one, they could decrease the use of the old one). This would also help us better understand constraints related to cognitive load. We could solve this issue by adding a joint play activity for follow-up.

Finally, regarding the single-subject design itself, although there are advantages provided by the design, such as assessing the feasibility of an intervention, or refining individual outcomes to overcome interindividual heterogeneity, it also presents limitations regarding results generalization. Moreover, our study, which was interrupted at the end, only allows correlational conclusions and does not allow causal inferences to be obtained. However, replicating several studies with the same design will help increase the level of evidence required for evidence-based practice and will also help address the issues of a small sample size and limited generalization effect (Alnahdi, 2015).

Conclusion

This study illustrates how pre-KTs of DLLs can benefit from a PD design that promotes vocabulary learning, even in the case of L2 instruction. The design allows pre-KTs to focus on a learning trajectory aimed at a particular strategy being taught rather than on a broader range of strategies. The findings have implications for the future implementation of language support programs: An S-LP coaching process which includes sharing information, modelling, guiding, and providing feedback, actively involving teachers in their real-world context, is likely to make a change in their language practices. Hence, the S-LP's role should focus on an individualized instructional approach to PD but also on reflexive practices with pre-KTs. Therefore, future research should tackle S-LPs' preparation to be able to conduct PD programs in optimal conditions.

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An Investigation Into the Clinical Utility of Speech Reception Threshold, Bone Conduction, and Word Recognition Scores in the Standard Audiological Test Battery

Évaluation de l'utilité clinique du seuil de réception de la parole, de la conduction osseuse et des scores de reconnaissance de mots dans la batterie de tests utilisée en audiologie

KEYWORDS
HEARING ASSESSMENT
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VALUE-ADDED TESTS

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Abstract

The purpose of this study was to examine the functional utility of the speech reception threshold, bone conduction, and word recognition score measurements which are generally used in the audiological test battery. In this retrospective single-observation study, pure-tone audiometry and speech audiometry findings were compared with objective hearing assessments, that is, tympanometry, acoustic reflex threshold, and distortion product otoacoustic emissions. Data were retrieved from records of 134 patients; of these, 57.5% had sensorineural hearing loss, and 12.3%, 24.6%, and 5.6% had normal hearing, mixed hearing loss, and conductive hearing loss, respectively. The results showed that the values of distortion product otoacoustic emissions were abnormal among a significant number of people diagnosed with normal hearing according to pure-tone audiometry. The correlations between the degree of hearing loss and the speech reception threshold and the word recognition score were moderate and low, respectively. Furthermore, an air-bone gap greater than 10 dB was present in approximately 25% of patients with findings of normal tympanogram, acoustic reflex threshold, and distortion product otoacoustic emissions. In several cases, the use of bone conduction, speech reception threshold, and word recognition score added only a limited diagnostic value. In conclusion, this study suggests that rather than having a fixed number of tests in the test battery, case-based inclusion of tests that add specific value to diagnosis can simplify the standard audiological test battery, leading to overall enhancements in the hearing assessment process.

Abrégé

L'objectif de la présente étude était d'examiner l'utilité fonctionnelle de mesures généralement incluses dans la batterie de tests utilisée en audiologie, soit le seuil de réception de la parole, la conduction osseuse et les scores de reconnaissance de mots. Dans cette étude observationnelle rétrospective monocentrique, les résultats d'audiométries tonales et vocales ont été comparés aux résultats de mesures objectives de l'audition, soit la tympanométrie, la mesure des réflexes stapédiens et les émissions otoacoustiques par produit de distorsion. Les données provenant des dossiers de 134 patients ont été récupérées. Parmi ces 134 patients, 57,5 % avaient une perte auditive neurosensorielle, 12,3 % avaient une audition normale, 24,6 % avaient une perte auditive mixte et 5,6 % avaient une perte auditive conductive. Les résultats ont montré que les valeurs des émissions otoacoustiques par produit de distorsion étaient anormales pour un nombre important de personnes ayant une audition normale selon les résultats de l'audiométrie tonale. Les corrélations entre le degré de l'atteinte auditive et le seuil de réception de la parole et les scores de reconnaissance de mots étaient modérées et faibles, respectivement. De plus, un écart aérien-osseux supérieur à 10 dB a été constaté pour environ 25 % des patients chez qui le tympanogramme, le seuil de déclenchement du réflexe stapédien et les émissions otoacoustiques par produit de distorsion étaient normaux. Pour de nombreux individus, l'évaluation par conduction osseuse et l'utilisation du seuil de réception de la parole et du score de reconnaissance de mots ont contribué de façon limitée au diagnostic. En conclusion, cette étude suggère qu'il est possible de simplifier la batterie de tests utilisée en audiologie en incluant au cas par cas les tests qui contribuent concrètement à la pose d'un diagnostic, au lieu d'utiliser le nombre prédéterminé de tests inclus dans la batterie. Cela conduit à une amélioration générale du processus d'évaluation de l'audition.

According to the World Health Organization, by 2050, more than two billion people are projected to have some degree of hearing loss, and at least 700 million people will have disabling hearing loss (World Health Organization, 2021). The impact of hearing loss on quality of life is significant and multifaceted; however, the degree of difficulties associated with hearing loss and its impact on quality of life is subjective (Gatehouse & Noble, 2004). Therefore, an early and accurate hearing assessment can substantially help in the effective and timely clinical management and rehabilitation of patients.

A number of assessment tools exist to evaluate the extent of hearing loss; however, there is a lack of consensus among researchers on the adequacy of these tests. Hearing assessment generally involves an audiological test battery consisting of otoscopy, pure-tone audiometry, speech reception thresholds (SRT) obtained in quiet, and word recognition scores (WRS) obtained in quiet (Emanuel et al., 2011; Taylor, 2004). Because this test battery is generally used in all cases regardless of the diagnostic efficacies of the individual tests in the battery, there is concern that such indiscriminate use could burden patients with unnecessary medical costs and procedure time.

Pure-tone audiometry is the most common auditory technique used to determine air conduction (AC) and bone conduction (BC) thresholds (Convery et al., 2014). In pure-tone testing, frequencies covering almost the entire speech spectrum (250–8000 Hz for AC and 250–4000 Hz for BC) are used to determine if the patient's hearing threshold falls within normal limits. AC thresholds are the softest audible acoustic signals that travel through the external, middle, and inner ears using headphones or earphones, and BC thresholds are the audible acoustic signals that vibrate the skull to stimulate the inner ear (cochlea) using a bone vibrator. The air-bone gap (ABG), which is defined as the difference between AC and BC thresholds, is frequently used to determine the type of hearing loss (conductive, sensorineural, or mixed; Margolis & Saly, 2008; Tanna et al., 2021). In conductive hearing loss, AC is abnormal, but BC is normal or near normal (from −10 to 15 dB hearing level [HL]), and the ABG is greater than 10 dB HL. If the AC and BC thresholds fall in the abnormal range, but the ABG is less than or equal to 10 dB HL, the loss is defined as sensorineural hearing loss. A mixed-type hearing loss has components of both conductive and sensorineural origin, that is, if both AC and BC are abnormal and the ABG is greater than 10 dB (Scarpa et al., 2020), the loss is defined as a mixed hearing loss. Although many clinicians rely on the audiogram for the diagnosis of hearing loss, a false ABG can result in inappropriate diagnosis and case management (Margolis, 2010; Studebaker, 1967). Therefore, additional tests are generally included to reach a more definitive diagnosis of hearing loss and provide appropriate recommendations for clinical management (**Table 1**; Gelfand, 2016; Hall, 2017; Schlauch et al., 2014).

In hearing assessment, speech audiometry tests, SRT, and WRS complement pure-tone audiometry and provide critical information about an individual's ability to understand speech. SRT represents the lowest sound level at which 50% of the stimuli used in the test are clearly recognized by an individual (Gelfand, 2016). It has a significant association with pure-tone average (PTA; Toledo dos Anjos et al., 2014), and the variances between SRT and PTA are usually less than 10 dB (Gelfand, 2016). SRT may add value in hearing-aid fitting (Van Tasell & Yanz, 1987). SRT provides an index of the hearing sensitivity of speech and assists in ascertaining the starting position for other suprathreshold tests such as WRS. The WRS is also termed a speech discrimination score. It is a measure of the percentage of words repeated correctly, providing information about the phonemes and the respective intensity level that the patients do not correctly identify (Billings et al., 2016). It is obtained at a suprathreshold level, with the patient repeating phonetically balanced single-syllable words presented in quiet, usually in lists of 25 words. The purpose of WRS is to provide information about word discrimination abilities and to estimate communication difficulties (McRackan et al., 2016). Typically, WRS is performed with the intent of obtaining information about speech neural processing, as retrocochlear pathologies exhibit abnormally low WRS.

In most audiology clinics, AC, BC, and SRT in quiet are performed with almost all patients, and WRS in quiet is evaluated at only one presentation level. Objective tests such as tympanometry, acoustic reflex threshold (ART), and otoacoustic emission (OAE) measurements offer direct and sensitive measurement of middle ear function (Jerger, 1970). A survey examining the diagnosis and intervention protocols used by audiologists revealed that audiologists perform four hearing tests with most patients: pure-tone audiometry in 100%, tympanometry in 97%, SRT in 92%, and WRS in quiet in 90% (Emanuel et al., 2011). The same study also pointed out that other speech and objective auditory tests such as ART, OAE, WRS, acoustic reflex decay, and phonetically balanced functions tests are performed less frequently. Recently, Windmill and Freeman (2019) reported data on audiological procedures performed in the hearing assessment of older adult patients in the United States. Data were derived from the current procedural terminology code used for health insurance payments. The study found

Table 1

Clinical Conditions Where BC, SRT, and WRS May or May Not Add Value in the Diagnosis and Management of Hearing Loss

Test	Adds value with	Does not add value with	Other tests that add more value
BC	History of middle ear disorders	Normal hearing sensitivity Normal otoscopy Normal findings on tympanometry and OAE Sloping hearing loss	Tympanometry OAE
SRT	Flat hearing loss Nonorganic hearing loss Age ≤ 18 Age ≥ 65 Difficult to test populations	Normal hearing sensitivity Sloping hearing loss Patients between 19 and 64 years	Auditory brainstem response Acoustic reflex tone decay Words-in-noise tests Sentences-in-noise tests Dichotic listening tests Pure-tone Stenger for nonorganic hearing loss Performance intensity phonetically balanced function test
WRS	Suspected retrocochlear pathology Noise-induced hearing loss Hyperacusis Asymmetric hearing loss	Normal hearing sensitivity	

Note. With information from Gelfand (2016) and Schlauch et al. (2014). BC = bone conduction; SRT = speech reception threshold; WRS = word recognition scores; OAE = otoacoustic emission.

that AC, BC, SRT, and WRS were performed for 90% of audiology referrals; tympanometry alone was performed for 81%, tympanometry and ART were performed for 18.5%, and OAEs were performed for 11.5% of audiology referrals. These studies reflect that in most audiology clinics, AC, BC, and SRT in quiet are performed indiscriminately, without much consideration of the diagnostic value added by a specific test to a particular case.

Given the diversity of auditory dysfunctions, it is not likely that all tests included in the traditional test battery will contribute equally or even substantially to the diagnosis of hearing loss. However, no reports have been published that examine the clinical utility of BC, SRT, and WRS in audiological evaluation. The current study aims to address this issue by performing a comprehensive evaluation of the clinical utility of BC, SRT, and WRS in assessing the type and severity of hearing loss. This study also compares the results of these tests with the findings of objective tests such as tympanometry, ART, and OAE. Finally, based on the results, recommendations for the case-specific selection of audiological tests are presented.

Methods

This single-observation retrospective study was approved by the Institutional Review Board at Bloomsburg University of Pennsylvania (#2018-59). Demographic data, case history, and hearing test results were retrieved from files of 134 patients (71 men and 63 women) who underwent an initial audiological evaluation between 2010 and 2018 at the Bloomsburg University Speech-Language and Hearing Clinic. The median age was 63.5 years, with an age range of 8 to 89 years, and only 9 (6.7%) patients were less than 18 years old. Records of patients tested with AC, BC, SRT, WRS, tympanometry, ART, and OAEs were included.

Outcome Variables

The data extracted from the files were age, sex, year, type of test, test procedure, and the instrument used. The key outcome variables included normal and abnormal findings in AC, BC, SRT, WRS, tympanometry, ART, and OAEs among patients with different types of hearing loss. The following sections provide additional methodological information and definitions of the data retrieved in this study.

Test Procedures and Definitions

The tests were performed with clinical audiometers (Grason-Stadler 61, Grason-Stadler Audiostar Pro, Madsen Astera). The equipment was calibrated annually by a certified technician using the American National Standards Institute S3.6-1996 and S3.39-1987 standards (American

National Standards Institute, 1987, 1996). The transducers used were E-A-R tone 3A insert earphones, Telephonics TDH-50P/TDH-39P headphones, and a B-71 bone vibrator. AC thresholds were measured at frequencies of 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. BC thresholds were measured at frequencies of 500, 1000, 2000, and 4000 Hz. Thresholds were estimated using the American Speech-Language-Hearing Association procedure using +5 dB after an incorrect response and −10 dB steps after a correct response (American Speech-Language-Hearing Association, 2005). Thresholds at frequencies of 750 and 1500 Hz were measured in cases where the interoctave threshold difference was greater than 20 dB HL.

Normal hearing sensitivity was defined as thresholds of 25 dB HL or lower at pure-tone frequencies from 250 to 8000 Hz (Moncrieff et al., 2013; Rosen et al., 2010). *Asymmetric hearing loss* was defined as a threshold difference of 15 dB or more at two or more frequencies between 250 and 8000 Hz (Cueva, 2004). The configuration of hearing loss was determined using average interoctave differences (Katz, 1978; Katz et al., 2014) with the following criteria: *sloping* is 5 dB or more; *rising* is −5 dB or less; and *flat/other* is between −5 and +5 dB. The type of hearing loss was determined from the findings of pure-tone audiometry and classified using criteria reported by Gelfand (2001, 2016) and Kramer and Brown (2018). *Sensorineural hearing loss* was defined by abnormal AC and BC with ABG of 10 dB HL or less. *Conductive hearing loss* was defined by abnormal AC and normal BC with an ABG of more than 10 dB HL at at least one frequency. *Mixed hearing loss* was defined by abnormal AC and BC with an ABG of more than 10 dB HL at at least one frequency.

SRT was measured monaurally in quiet using recorded spondee words and was determined via the modified American Speech-Language-Hearing Association (1988) ballpark estimate procedure. The recorded spondee words were delivered from lists available on the Grason-Stadler Inc. (GSI) Audiostar Pro and Madsen Astera. Participants were evaluated with the GSI 61 audiometer. Spondees materials (Harris, 1991) were delivered via a Denon compact disc/MP3 player routed through the speech channels of the audiometer.

WRS in quiet was measured using recorded phonetically balanced word lists at one intensity level for the majority of patients using Central Institute for the Deaf W-22 materials (Hirsh et al., 1952). The level of presentation of the WRS was selected based on the recommendations of Guthrie and Mackersie (2009), specifically with reference to the pure-tone AC threshold for 2000 Hz: using 25 dB sensation level (SL) if the threshold is less than 50 dB HL, 20 dB SL if the threshold is 50 to 55 dB HL; 15 dB SL if the threshold is 60 to 65 dB HL, 10 dB SL if the threshold is 70 to 75 dB HL, or presenting the words at 5 dB below the uncomfortable level.

Tympanometry was performed with a 226 Hz probe tone with either a GSI 33, GSI Tympstar, or a GSI Tympstar Pro aural immittance device. Pressure change was set from +200 to −400 daPa with a sweep rate of 600/200 daPa/s. Tympanometry was classified as normal based on the following criteria: static admittance between 0.27 and 1.7 mmho, peak pressure +100 to −150 daPa, and ear canal volume 0.9 to 2.0 ml for adult participants and 0.3 to 0.9 ml for participants under the age of 10 years (Gelfand, 2001; Martin & Clark, 2018; Oeding et al., 2016; Roeser, 2013). Using a 226 Hz probe tone, ipsilateral ARTs were measured with a visual inspection for pure-tone stimuli of 500, 1000, and 2000 Hz. A criterion of repeatable admittance changes of 0.02 mmho or greater was used to determine the ART (Katz, 1978). If the ART was abnormally elevated (≥ 105 dB HL) or absent for at least one frequency, it was classified as abnormal according to normative data reported by Gelfand et al. (1990).

Distortion product otoacoustic emissions (DPOAEs) were measured for f2 frequencies of 842, 1001, 1184, 1416, 1685, 2002, 2380, 2832, 3369, 4004, 4761, 5652, 6726, 7996 Hz using the Otodynamics–ILO V6. The test protocol included L1 = 65 dB and L2 = 55 dB, and f2/f1 ratio = 1.22. Distortion product (DP)-gram was measured only once with multiple sweeps across frequencies. DPOAE findings were classified into three groups based on the normative (Dhar, 2011; Gorga et al., 2002; Hall, 2017). *Present and normal* was defined as a 6 dB difference between the DP amplitude and noise floor at approximately 70% of the collected data points, absolute DP amplitude within the normal range for the patient's age range, and a noise floor less than −10 dB SPL. *Present but not normal* was defined by more than 6 dB difference between the DP amplitude and noise floor, the absolute DP amplitude below normal limits for the patient's age, or the present DPOAE at less than 70% of the collected data points. *Absent* DPOAEs were defined as DPOAE amplitude less than 6 dB above the noise floor at all frequencies.

PTAs ($PTA_{0.5\text{-}2}$ and $PTA_{0.5\text{-}4}$) are good predictors of speech reception and recognition, respectively (Toledo dos Anjos et al., 2014). $PTA_{0.5\text{-}2}$ was the mean of thresholds for test frequencies of 500, 1000, and 2000 Hz, whereas $PTA_{0.5\text{-}4}$ was the mean of thresholds for frequencies of 500, 1000, 2000, 3000, and 4000 Hz. The degree of hearing loss was median SRT, the WRS values were further compared with the different types, and the degree of hearing loss was defined in different severity levels depending on the PTA values. Hearing loss was considered *normal, slight, mild, moderate, moderately severe, severe,* and *profound* for hearing thresholds of less than15 dB HL, 16–25 dB HL, 26–40 dB HL, 41–55 dB HL, 56–70 dB HL, 71–90 dB HL and greater than 91 dB HL respectively.

Statistical Analysis

Data were analyzed using descriptive statistics and frequency analysis with IBM SPSS Statistics for Windows (Version 26.0). Abnormal findings were compared among diagnostic test procedures, including tympanograms, ART, DPOAEs, SRT, WRS, and ABG. Furthermore, the findings of diagnostic tests were compared between the ears of participants with and without a history of hearing loss. The utility of SRT and WRS was evaluated by determining the relationship between pure-tone audiometry, SRT, WRS, and age. Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to check for normality of the distribution of scores.

Results

Hearing Loss Type

The PTA findings revealed that most of the participants had sensorineural hearing loss (*n* = 154, 57.5%, **Table 2**). Almost 25% of the participants had mixed hearing loss, and conductive hearing loss was diagnosed in only 5.6% of the participants. About 12% of the participants had normal hearing. Based on $PTA_{0.5\text{-}4}$ levels, the degree of hearing loss was severe or worse in only 3.3% of the participants. Evaluation on the basis of $PTA_{0.5\text{-}2}$ yielded a slightly different degree of hearing loss (**Table 3**).

Objective and Behavioural Tests

Table 4 presents the findings of objective and behavioural tests for participants identified with different types of hearing loss. Among 33 cases diagnosed with normal hearing based on pure-tone audiometry data, almost 50% had abnormal or present but abnormal DPOAE. Similarly, 40% of patients with conductive hearing loss were classified as normal on the basis of DPOAE. However, for patients with mixed or sensorineural hearing loss, only one participant had normal DPOAE, although present but abnormal was observed for an appreciable number of participants. In the majority of patients with normal hearing (97%), the tympanograms were normal; however, they were also normal in more than 80% of cases of conductive, mixed, or sensorineural hearing loss. In the ART examination, more than 70% of the participants with conductive, mixed, or sensorineural hearing loss were diagnosed as normal. Interestingly, none of the participants with conductive hearing loss were found to be abnormal in SRT, and for mixed or sensorineural hearing loss, more than 40% of the participants were also identified as normal. Furthermore, a greater number of

Table 2

Distribution of Type and Degree of Hearing Loss Based on Pure-Tone Audiometry

Parameter	*n* (%)
Type of hearing loss	
NH	33 (12.3%)
SNHL	154 (57.5%)
MHL	66 (24.6%)
CHL	15 (5.6%)
Degree of hearing loss in dB HL [a]	
Normal (−10 to 15)	34 (12.7%)
Slight (16 to 25)	53 (19.8%)
Mild (26 to 40)	84 (31.3%)
Moderate (41 to 55)	66 (24.6%)
Moderately severe (56 to 70)	22 (8.2%)
Severe (71 to 90)	7 (2.6%)
Profound (91+)	2 (0.7%)

Note. NH = normal hearing; SNHL = sensorineural hearing loss; MHL = mixed hearing loss; CHL = conductive hearing loss; HL = hearing level.
[a] Based on $PTA_{0.5\text{-}4}$ = pure-tone average at 500, 1000, 2000, 3000, and 4000 Hz.

Table 3

Degree of Hearing Loss Based on $PTA_{0.5-2}$

Degree of hearing loss in dB HL	*n* (%)
Normal (−10 to 15)	54 (20.1%)
Slight (16 to 25)	60 (22.4%)
Mild (26 to 40)	85 (31.7%)
Moderate (41 to 55)	49 (18.3%)
Moderately severe (56 to 70)	11 (4.1%)
Severe (71 to 90)	8 (3.0%)
Profound (91+)	1 (0.4%)

Note. $PTA_{0.5-2}$ = pure-tone average at 500, 1000, and 2000 Hz; HL = hearing level.

Table 4

Distribution of Normal (N) and Abnormal (A) Findings Among Different Type of Hearing Loss Based on Pure-Tone Audiometry

Parameter	Normal hearing (*n* = 33)	SNHL (*n* = 154)	MHL (*n* = 66)	CHL (*n* = 15)	Total (*N* = 268)	*p*
Age						< .001
Median age in years	32.0	67.0	65.5	25.0	63.5	
(Q1, Q3)	(15.0, 55.0)	(59.0, 75.0)	(52.0, 73.0)	(10.0, 42.0)	(51.0, 72.0)	
Tympanogram						.176
N	32 (97.0%)	130 (84.4%)	53 (80.3%)	13 (86.7%)	228 (85.1%)	
A	1 (3.0%)	24 (15.6%)	13 (19.7%)	2 (13.3%)	40 (14.9%)	
ART						.719
N	27 (81.8%)	113 (73.4%)	47 (71.2%)	11 (73.3%)	198 (73.9%)	
A	6 (18.2%)	41 (26.6%)	19 (28.8%)	4 (26.7%)	70 (26.1%)	
DPOAE [a]						< .001
N	17 (51.5%)	1 (0.6%)	0 (0.0%)	6 (40.0%)	24 (9.0%)	
Ab	12 (36.4%)	127 (82.5%)	54 (81.8%)	7 (46.7%)	200 (74.6%)	
P/A	4 (12.1%)	26 (16.9%)	12 (18.2%)	2 (13.3%)	44 (16.4%)	
SRT						< .001
N	32 (97.0%)	69 (44.8%)	28 (42.4%)	15 (100.0%)	144 (53.7%)	
A	1 (3.0%)	85 (55.2%)	38 (57.6%)	0 (0.0%)	124 (46.3%)	
SRT- $PTA_{0.5-2}$						.341
N	31 (93.9%)	134 (87.0%)	59 (89.4%)	15 (100.0%)	239 (89.2%)	
A	2 (6.1%)	20 (13.0%)	7 (10.6%)	0 (0.0%)	29 (10.8%)	
SRT- $PTA_{0.5-4}$						.007
N	31 (93.9%)	110 (71.4%)	44 (66.7%)	14 (93.3%)	199 (74.3%)	
A	2 (6.1%)	44 (28.6%)	22 (33.3%)	1 (6.7%)	69 (25.7%)	

Note. Continuous variables are presented as median (Q1, Q3), and categorical variables as number (*n*) and percentage (%). Categorical variables were examined by chi-square test and continuous variables by the Kruskal-Wallis test. ART = acoustic reflex threshold; DPOAEs = distortion product otoacoustic emissions; SRT = speech reception threshold; $PTA_{0.5-2}$ = pure-tone average at 500, 1000, and 2000 Hz; $PTA_{0.5-4}$ = pure-tone average at 500, 1000, 2000, 3000, and 4000 Hz; SNHL = sensorineural hearing loss; MHL = mixed hearing loss; CHL = conductive hearing loss.
[a] DPOAE findings were classified as normal (N), present but abnormal (P/A), or absent (Ab).

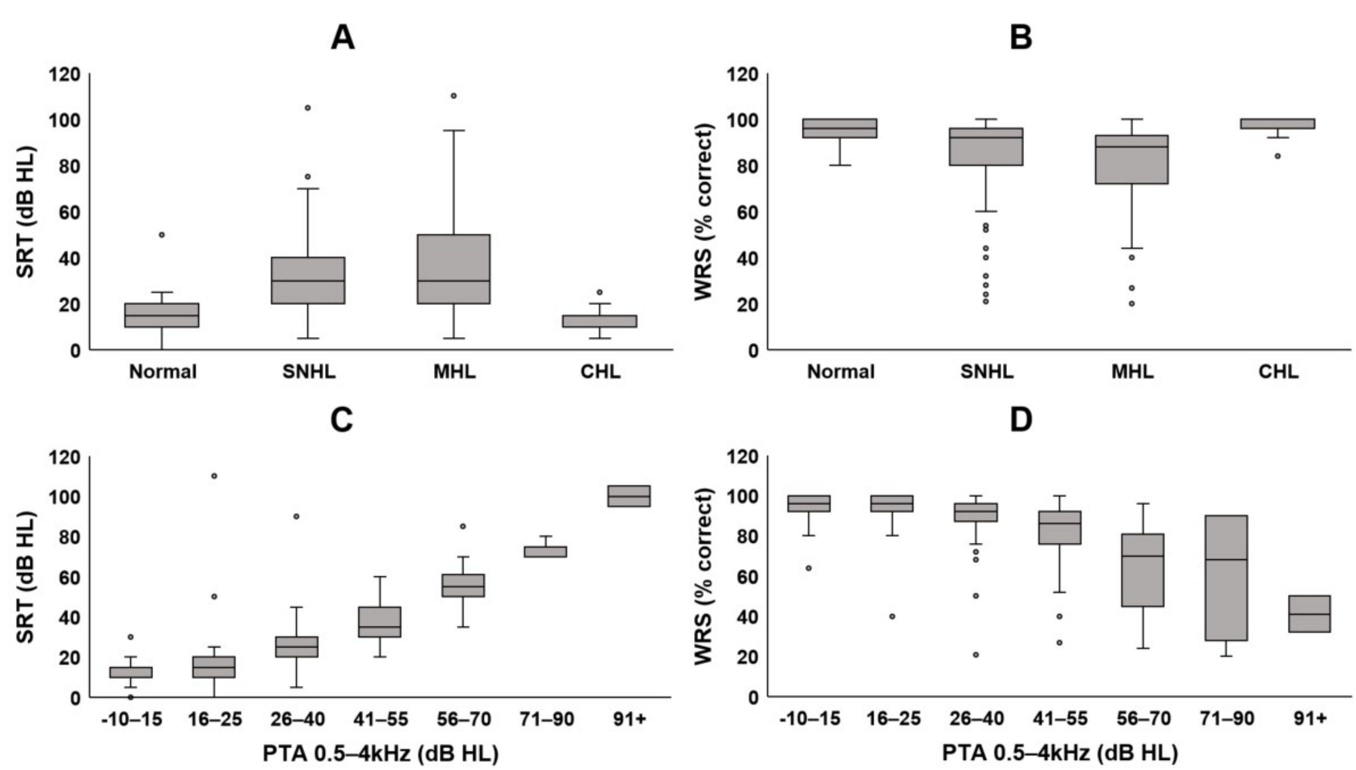
patients showed abnormal values of $PTA_{0.5-4-SRT}$ compared to $PTA_{0.5-2-SRT}$. With respect to the discriminating ability of SRT and WRS, differences in their median values were analyzed in different types of hearing loss.

Figure 1A–B depicts the median values of SRT and WRS in individuals with different types of hearing loss. It is obvious that the values in the mixed and sensorineural hearing loss groups are significantly different from the values in the normal hearing group. With an increase in the degree of hearing loss, there was a systematic increase in the SRT values and a decrease in the WRS values (**Figure 1C–D**). In patients with normal hearing or conductive hearing loss, the median SRT was l5 dB HL, and for those with mixed or sensorineural hearing loss, the median value was 30 dB HL. The WRS values were more than 90% up to 40 dB of $PTA_{0.5-4}$ (**Figure 1D**).

To determine the value added by SRT and WRS in predicting the degree and type of hearing loss, an ordinal logistic regression was performed. SRT predicted the degree of hearing loss using $PTA_{0.5-2}$ with McFadden $R^2 = .64$, $p < .01$, and $PTA_{0.5-4}$, $R^2 = .58$, $p < .01$. On the other hand, WRS was a poor predictor of the degree of hearing loss using $PTA_{0.5-2}$, $R^2 = .18$, $p < .01$ and $PTA_{0.5-4}$, $R^2 = .20$, $p < .01$. Neither SRT or WRS predicted the type of hearing loss.

A total of 25 patients (measurements in 50 ears) reported a history of disorders of the outer or middle ear, including otologic surgery, otalgia, otorrhea, otitis media, or aural fullness. Of these, the findings of DPOAE were abnormal in 70% and present but abnormal in 10% (**Table 5**). However, among patients without a history of ear disorders, the DPOAE findings were abnormal in 75.7% and present but abnormal in 17.9% of cases due to some degree of hearing loss. Furthermore, in patients with a history of hearing disorders, abnormal findings on tympanometry, ART, and SRT were 22%, 46.0%, and 42%, respectively. And in participants with no history of ear disorders (109 patients, 218 ears in which measurements were conducted), abnormal findings in tympanometry, ART, and SRT were 13.3%, 21.6%, and 47.2 %, respectively.

Figure 1



Type of hearing loss and SRT (A) and WRS (B); degree of hearing loss based on the magnitude of $PTA_{0.5-4}$ and SRT (C) and WRS (D)

Note. SNHL = sensorineural hearing loss; MHL = mixed hearing loss; CHL = conductive hearing loss; SRT = speech reception threshold; WRS = word recognition score; HL = hearing level; $PTA_{0.5-4}$ = pure-tone average of 500, 1000, 2000, 3000, and 4000 Hz in dB HL.

Table 5

Percentage of Ears With Normal (N) and Abnormal (A) Findings on Tympanometry, ART, DPOAE, and SRT for Participants With History of Ear Disorders

Parameter	No History of Ear Disorders (n = 218)	History of Ear Disorders (n = 50)	Total (N = 268)	p
Tympanogram				.120
N	189 (86.7%)	39 (78.0%)	228 (85.1%)	
A	29 (13.3%)	11 (22.0%)	40 (14.9%)	
ART				< .001
N	171 (78.4%)	27 (54.0%)	198 (73.9%)	
A	47 (21.6%)	23 (46.0%)	70 (26.1%)	
DPOAE[a]				.006
N	14 (6.4%)	10 (20.0%)	24 (9.0%)	
Ab	165 (75.7%)	35 (70.0%)	200 (74.6%)	
P/A	39 (17.9%)	5 (10.0%)	44 (16.4%)	
SRT				.502
N	115 (52.8%)	29 (58.0%)	144 (53.7%)	
A	103 (47.2%)	21 (42.0%)	124 (46.3%)	
SRT- $PTA_{0.5\text{-}2}$				.766
N	195 (89.4%)	44 (88.0%)	239 (89.2%)	
A	23 (10.6%)	6 (12.0%)	29 (10.8%)	
SRT- $PTA_{0.5\text{-}4}$				.964
N	162 (74.3%)	37 (74.0%)	199 (74.3%)	
A	56 (25.7%)	13 (26.0%)	69 (25.7%)	

Note. Categorical variables are presented as number (n) and percentage (%). Categorical variables were examined by chi-square test. ART = acoustic reflex threshold; DPOAEs = distortion product otoacoustic emissions; SRT: speech reception threshold; $PTA_{0.5\text{-}2}$ = pure-tone average at 500, 1000, and 2000 Hz; $PTA_{0.5\text{-}4}$ = pure-tone average at 500, 1000, 2000, 3000, and 4000 Hz.
[a] DPOAE findings were classified as normal (N), present but abnormal (P/A), or absent (Ab).

The results of objective tests, that is, tympanogram, ART, and DPOAE, were compared with the results of ABG, SRT, and WRS (**Table 6**). Among the patients with normal hearing, more than 40% were found to be abnormal on the SRT and WRS examinations, and 26.8% were abnormal according to the ABG test. Regarding abnormal tympanometry findings, ABG was normal in more than 60% of the cases. SRT and WRS were normal in 30% and 45% of the patients. In the case of ART, 70% of the normal findings were also normal in ABG, and close to 55% were normal in SRT and WRS. A substantial proportion of abnormal cases, as per DPOAE findings, were found to be abnormal in ABG, SRT, and WRS. In particular, 24 individuals were found to be normal according to the combined findings of tympanometry, ART, and DPOAE; however, in the SRT analysis, none of these were abnormal, and even in ABG and WRS, only 25% and 16.7% of the cases were abnormal.

Correlations Between Different Tests

Spearman correlation was performed to investigate the relationship between $PTA_{0.5\text{-}2}$, $PTA_{0.5\text{-}4}$, SRT, and WRS (**Table 7**); significance level alpha was set at .01. **Figure 2** represents the correlations between $PTA_{0.5\text{-}4}$ and SRT for different types of hearing loss. A positive correlation between $PTA_{0.5\text{-}4}$ and SRT was evident in all types of hearing loss. In the case of WRS and $PTA_{0.5\text{-}4}$, there was no correlation in the normal hearing group, but a negative correlation was clear in sensorineural and mixed hearing loss groups (**Figure 3**). $PTA_{0.5\text{-}2}$ was a better predictor and showed a stronger relationship with SRT (r_s (268) = .90, p < .01), whereas $PTA_{0.5\text{-}4}$ showed a moderate relationship with WRS (r^s (268) = –.55, p < .01). With age, SRT was positively related (r^s (268) = .56, p < .01) and WRS was negatively related (r^s (268) = –.33, p < .01). The relationship between SRT and PTA (SRT-PTA) was

Table 6

Comparison of Normal (N) and Abnormal (A) Findings on Tympanometry, ART, and DPOAEs for Participants with Abnormal ABG, SRT, and WRS.

Diagnostic tests (Number of ears)	ABG		SRT		WRS	
	N	A	N	A	N	A
Tympanogram						
N (228)	167	61	132	96	134	94
A (40)	25	15	12	28	18	22
ART						
N (198)	143	55	111	87	114	84
A (70)	49	21	33	37	38	32
DPOAE[a]						
N (24)	18	6	24	0	20	4
P/A (44)	30	14	35	9	34	10
Ab (200)	144	56	85	115	98	102
Tympanogram, ART, and DPOAE combined						
N (24)	18	6	24	0	20	4

Note. ART = acoustic reflex threshold; DPOAEs = distortion product otoacoustic emissions; ABG = air-bone gap; SRT = speech reception threshold; WRS = word recognition scores;
[a] DPOAE findings were classified as normal (N), present but abnormal (P/A), or absent (Ab).

Table 7

Correlation Between $PTA_{0.5\text{-}2}$, $PTA_{0.5\text{-}4}$, SRT, Age, and WRS

Parameter	$PTA_{0.5\text{-}2}$	$PTA_{0.5\text{-}4}$	SRT	WRS	Age
$PTA_{0.5\text{-}2}$		.94*	.90*	−.53*	.55*
$PTA_{0.5\text{-}4}$	.94*		.86*	−.55*	.61*
SRT	.90*	.86*		−.50*	.56*
WRS	−.53*	−.55*	−.50*		−.33*
Age	.55*	.61*	.56*	−.33*	

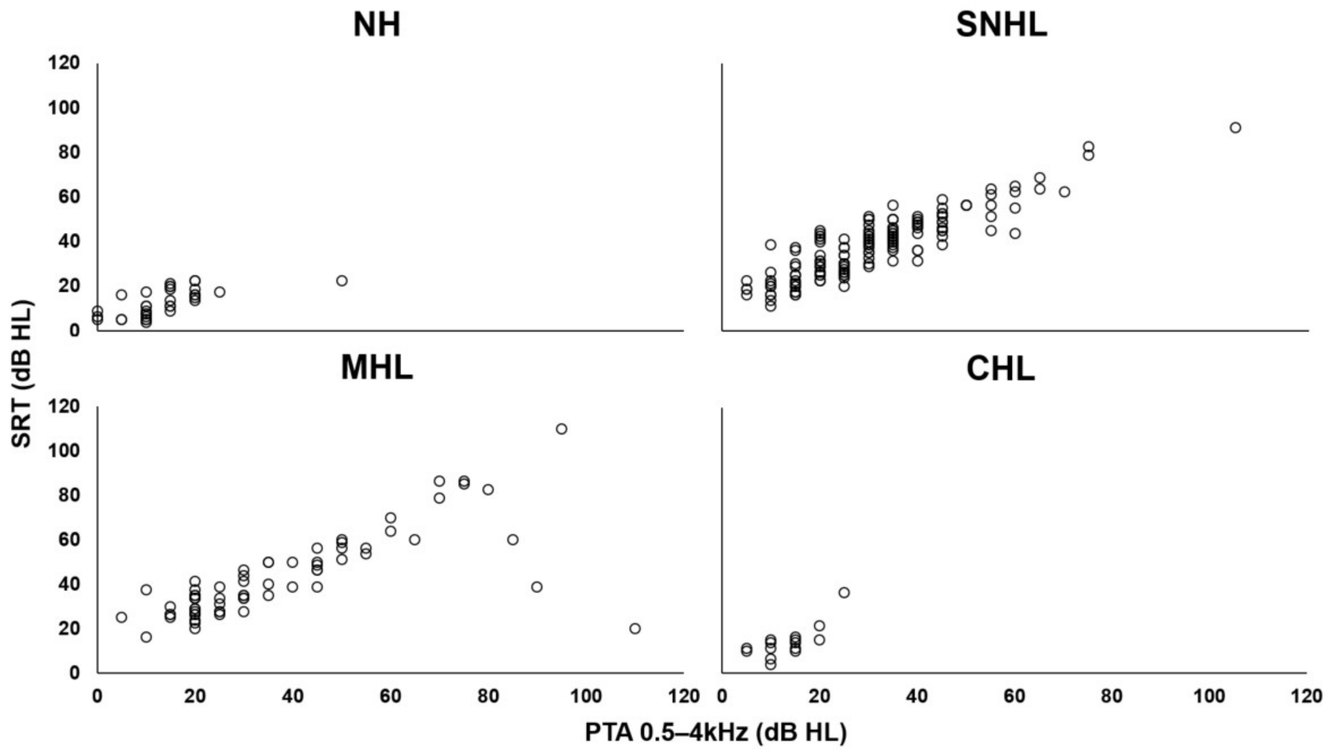
Note. $PTA_{0.5\text{-}2}$ = pure-tone average at 500, 1000, and 2000 Hz; $PTA_{0.5\text{-}4}$ = pure-tone average at 500, 1000, 2000, 3000, and 4000 Hz; SRT = speech reception threshold; WRS = word recognition score.
*Correlation significant at .01 level (2-tailed).

classified as abnormal if the difference between PTA and SRT was greater than 10 dB. With respect to SRT-$PTA_{0.5\text{-}2}$, 29 ears (19 ears sloping configuration) and with respect to SRT-$PTA_{0.5\text{-}4}$, 69 ears (60 ears sloping configuration) showed an abnormal relationship.

Discussion

This study analyzed the correlations and disagreements between the different tests used in the standard test battery. Pure-tone audiometry revealed that sensorineural is the most expected hearing loss category, followed by mixed hearing loss, normal hearing, and conductive hearing loss. Regarding the types of hearing loss, our findings were consistent with the reported values (Margolis & Saly, 2008; Tanna et al., 2021). However, among 33 ears diagnosed as normal hearing by pure-tone audiometry, substantial abnormal findings were observed in DPOAE (48.5%), ART (18.2%), and tympanogram examinations (3%), indicating that these tests are more sensitive to middle ear conditions and provide valuable information compared to pure-tone audiometry. Although ABGs are commonly observed in patients with conductive or mixed hearing loss (Scarpa et al., 2020), in our study, ABG alone could not differentiate

Figure 2



Type of hearing loss and correlation between SRT and $PTA_{0.5\text{-}4}$

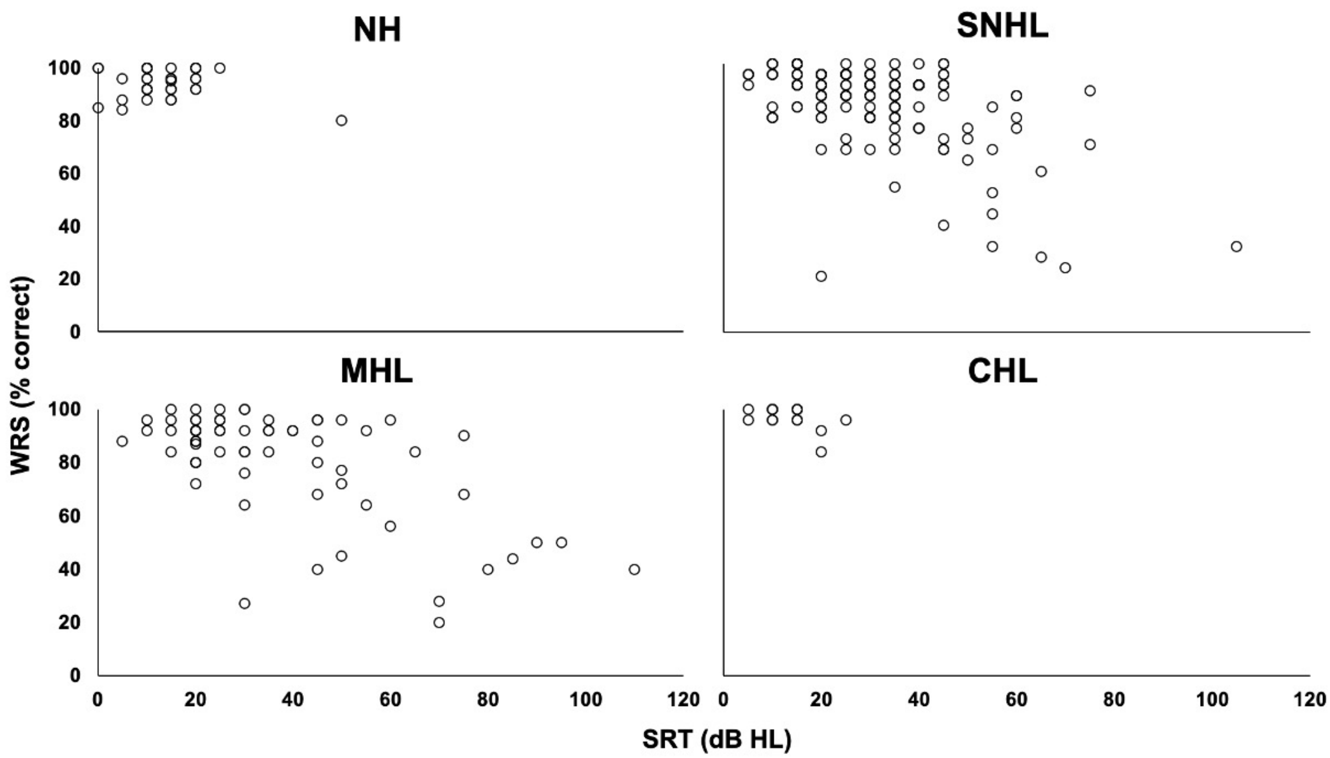
Note. NH = normal hearing; SNHL = sensorineural hearing loss; MHL = mixed hearing loss; CHL = conductive hearing loss; SRT = speech reception threshold; HL = hearing level; $PTA_{0.5\text{-}4}$ = pure-tone average of 500, 1000, 2000, 3000, and 4000 in dB HL.

between participants with and without a history of ear disorders. Notably, ABG more than 10 dB was present in approximately 25% of patients with normal tympanogram, ART, and DPOAE findings. These results support the opinion that ABG is not the sole predictor of middle ear pathologies (Margolis, 2010; Studebaker, 1967).

With SRT, $PTA_{0.5\text{-}2}$ had a higher correlation coefficient than $PTA_{0.5\text{-}4}$. These findings echo previous findings, in which a higher correlation coefficient between $PTA_{0.5\text{-}2}$ and SRT was reported, and therefore, $PTA_{0.5\text{-}2}$ was claimed to be an adequate estimator of the threshold for speech recognition (Toledo dos Anjos et al., 2014). In particular, SRT in quiet is useful in hearing aid evaluation only if speech material is appropriate to the hearing loss configuration and to the frequency response of amplification (Van Tasell & Yanz, 1987). Overall, SRT had a strong correlation with pure-tone audiometry, and the observed values of the correlation coefficient were in agreement with the reported values (Picard et al., 1999). However, in our study, SRT did not predict the type of hearing loss; in fact, in the case of conductive hearing loss, no patients had an abnormal SRT. For sensorineural and mixed hearing losses, 40% of the patients had normal SRT.

A weak negative correlation between PTA and WRS was consistent with previous findings (Toledo dos Anjos et al., 2014). WRS did not classify hearing as abnormal in a different type of hearing loss, and the median correct WRS was more than 90% in conductive and sensorineural hearing loss and close to 90% in mixed hearing loss. Thus, these results indicate that, as a standard component of the audiological test battery, WRS does not add much diagnostic value. Likewise, SRTs are generally used to cross-check pure-tone audiometry findings; our results suggest that if the testing is done for adults with reliable audiometric responses, SRT in quiet adds little value to assessing the severity and type of hearing loss. Due to the diversity of auditory dysfunctions and the limitations of individual tests, the audiological test battery generally includes a mix of tests. However, some of these tests may have limited diagnostic value in several cases (Margolis &

Figure 3



Type of hearing loss and correlation between SRT and WRS

Note. NH = normal hearing; SNHL = sensorineural hearing loss; MHL = mixed hearing loss; CHL = conductive hearing loss; SRT = speech reception threshold; WRS = word recognition score; HL = hearing level.

Saly, 2008). For example, most audiologists use AC, BC, SRT, and WRS in comprehensive evaluation (Stephens, 2018; Swanson, 2012). Based on the findings of the current study and the available literature, we provide the following recommendations to optimize the number of tests for specific scenarios.

Recommendations

In the diagnostic test battery for middle ear abnormalities, we recommend replacing BC, SRT, and WRS with tympanometry, ART, and DPOAE. In our assessment, with these replacements, audiologists can make more productive use of resources. More specifically, we recommend:

1. Participants with no history of ear disorders and with normal ARTs, tympanogram, and DPOAEs do not require a BC test to examine the conductive component.

2. Participants without a history of ear disorders, with bilaterally sloping hearing loss, and with mixed results – one test within normal limits and one abnormal – do not need a BC test.

3. SRT is not necessary for participants with normal DPOAEs and participants with bilateral sloping hearing loss (age < 65 years).

4. WRS in quiet at one presentation level does not add value for most patients.

The above recommendations can help optimize the resources and time typically involved in hearing assessment; however, further studies are needed to validate and extend these recommendations. The following limitations must also be acknowledged when interpreting our results.

Limitations

The findings of this study support the need to follow a more evidence-based approach to diagnostic audiology. This study made a strong case for using a case-specific and evidence-based approach in hearing assessment. The foremost limitation is the retrospective study design. A prospective study with well-defined objectives could more effectively examine the efficacy of a standard audiological test battery. Most notably, the fairly small pediatric population in our study necessitates additional confirmation with regard to this demographic. Furthermore, in our study, no subgroup analysis was performed with respect to sex, age, and other demographic variables; such an analysis could be helpful in making more specific recommendations. Finally, although we have given several recommendations for a structured assessment of hearing, we have not quantified the diagnostic efficacy under different scenarios. Another challenge in quantitative evaluation of the characteristics of cumulative diagnostic effectiveness is the absence of comparable gold standards for tests included in the standard audiological test battery. Future studies should focus on examining these aspects in more detail.

Conclusions

The current study investigated the clinical utility of tests commonly included in the standard audiological test battery. Our findings suggest that, in several cases, BC, SRT, and WRS do not offer substantial utility as part of the standard audiological test battery. None of the individuals with conductive hearing loss were found to have an abnormal SRT. SRT had a moderate correlation and WRS had a low correlation with the degree of hearing loss. To optimize the time and cost associated with audiological testing, it is essential to select a test or combination of tests with the highest clinical utility. In essence, our research indicates that, with careful consideration for the patient's needs, the use of tympanometry, ART, and DPOAE in lieu of BC, SRT, and WRS will boost the effectiveness of the standard audiological test battery. The findings of this study will help develop a more effective framework for hearing assessments.

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